MAIZE
Agri-Food Systems

PROPOSAL

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Table of Contents

Section 1: MAIZE AFS Phase-II 1
1.1 Rationale and scope 1
1.2 Goals, objectives, targets 4
1.3 Impact pathway and theory of change 11
1.4 Gender 14
1.5 Youth 19
1.6 Program structure and flagship projects 19
1.7 Cross CRP collaboration and site integration 22
1.8 Partnerships and comparative advantage 27
1.9 Evidence of demand and stakeholder commitment 30
1.10 Capacity development 31
1.11 Program management and governance 34
1.12 Intellectual asset management 36
1.13 Open access management 37
1.14 Communication strategy 37
1.15 Risk management 38
1.16 Budget summary 39

Section 2: Flagship Projects 42

FP1: Enhancing MAIZE's R4D Strategy for Impact 42
2.1 Rationale, scope 42
2.2 Objectives and targets 44
2.3 Impact pathway and theory of change 46
2.4 Science quality 52
2.5 Lessons learnt and unintended consequences 54
2.6 Clusters of activity (CoA) 55
2.7 Partnerships 59
2.8 Climate change 61
2.9 Gender 62
2.10 Capacity development 62
2.11 Intellectual asset and open access management 63
2.12 FP management 64
2.13 Budget summary 64

FP2: Novel Diversity and Tools for Increasing Genetic Gains 66
2.1 Rationale, scope 66
2.2 Objectives and targets 67
2.3 Impact pathway and theory of change 68
2.4 Science quality 74
2.5 Lessons learnt and unintended consequences 74
2.6 Clusters of activity (CoA) 74
2.7 Partnerships 79
2.8 Climate change 79

2.9 Gender 80
2.10 Capacity development 80
2.11 Intellectual asset and open access management 81
2.12 FP management 82
2.13 Budget summary 82

FP3: Stress Tolerant and Nutritious Maize 84
2.1 Rationale, scope 84
2.2 Objectives and targets 86
2.3 Impact pathway and theory of change 88
2.4 Science quality 94
2.5 Lessons learnt and unintended consequences 96
2.6 Clusters of activity (CoA) 97
2.7 Partnerships 101
2.8 Climate change 102
2.9 Gender 102
2.10 Capacity development 103
2.11 Intellectual asset and open access management 104
2.12 FP management 104
2.13 Budget summary 105

FP4: Sustainable Intensification of Maize-based Systems for Improved Smallholder Livelihoods 107
2.1 Rationale, scope 107
2.2 Objectives and targets 108
2.3 Impact pathway and theory of change 113
2.4 Science quality 116
2.5 Lessons learned and unintended consequences 118
2.6 Clusters of activity (CoA) 119
2.7 Partnerships 123
2.8 Climate change 124
2.9 Gender 125
2.10 Capacity development 125
2.11 Intellectual asset and open access management 126
2.12 FP management 126
2.13 Budget summary 127

FP5: Adding Value for Maize Producers, Processors and Consumers 128
2.1 Rationale, scope 128
2.2 Objectives and targets 130
2.3 Impact pathway and theory of change 132
2.4 Science quality 135
2.5 Lessons learnt and unintended consequences 138
2.6 Clusters of activity (CoA) 139
2.7 Partnerships 142
2.8 Climate change 143

2.9 Gender 144
2.10 Capacity development 145
2.11 Intellectual asset and open access management 145
2.12 FP management 146
2.13 Budget summary 146

Section 3: Annexes 148
3.1 MAIZE Accountability Matrix 148
3.2 Partnership strategy 155
3.3 Capacity development strategy 161
3.4 Gender strategy 166
3.5 Youth strategy 171
3.6 Results based management 176
3.7 Linkages with other CRPs and site integration 177
3.8 Staffing of management team and flagship projects 204
3.9 Open Access and Open Data Management 250
3.10: Intellectual Asset Management 255
3.11 Targeted abiotic and biotic stresses under MAIZE FP3 261
3.12 MAIZE target product profiles for Sub-Saharan Africa, Latin America and Asia. 262
3.13 MAIZE target nutritional traits under FP3 (CoA 3.3) 269
3.14 References 270
3.15 MAIZE Ongoing Projects (as of March 2016) 296
3.16 MAIZE Existing and Potential Partners (as of March 2016) 306
3.17 Technical Competencies of Selected Key Partners of MAIZE 338
3.18 MAIZE Performance Indicator Matrix (PIM) Tables 350
3.19 Flagship Budget and Analysis 379

Abbreviations

A4NH	CGIAR Research Program on Agriculture for Nutrition and Health
AAA	Affordable, Accessible, Asian Drought Tolerant Maize Project
ACIAR	Australian Centre for International Agricultural Research
AFS	Agri-food Systems
APAARI	Asia Pacific Association of Agricultural Research Institutions
AR4D	Agricultural Research for Development
ARC	Agricultural Research Centre, South Africa
ARI	Advanced Research Institute
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATA	Agricultural Transformation Agency
BARI	Bangladesh Agricultural Research Institute
BISA	Borlaug Institute for South Asia
BMGF	Bill and Melinda Gates Foundation
BMS	Breeding Management System
CBO	Community-based Organization
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CGIAR	Consultative Group for International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Center
CA	Conservation Agriculture
CFT	Confined Field Trial
CoA	Cluster of Activities
CRP	CGIAR Research Program
CSISA	Cereal Systems Initiative for South Asia
CSV	Climate Smart Villages
CTA	Technical Centre for Agricultural and Rural Cooperation
DArT	Diversity Array Technology
DH	Doubled haploid
DCL AFS	CGIAR Research Program on Dryland Cereals and Legumes Agri-food Systems
DT	Drought tolerant
DTMA	Drought Tolerant Maize for Africa project
DTMASS	Drought Tolerant Maize for Africa Seed Scaling project
EIAR	Ethiopian Institute of Agricultural Research
EMBRAPA	Brazilian Agricultural Research Corporation
ESA	Eastern and Southern Africa
FACASI	Farm Mechanization and Conservation Agriculture for Sustainable Intensification
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics Division
FP	Flagship Project
FtF	USAID Feed-the-Future program
GBS	Genotyping-by-sequencing
GENNOVATE	Cross-CRP Global Study on Gender Norms, Agency and Innovation in Agriculture and Natural Resource Management
GxExM	Genotype x Environment x Management
GHG	Greenhouse Gas
GIS	Geographic Information Systems
GIZ	German Agency for International Development
GLS	Gray Leaf Spot
GOBII	Genomics and Open source Breeding and Informatics Initiative
GS	Genomic Selection

GWAS	Genome-Wide Association Study
HTMA	Heat Tolerant Maize for Asia project
IA	Intellectual Asset
IBP	International Breeding Platform
ICAR	Indian Council of Agricultural Research
ICIPE	International Centre for Insect Physiology and Ecology
ICRAF	World Agroforestry Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	information and Communication Technology
IDO	Intermediate development outcome
IEA	Independent Evaluation Arrangement
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
IMAS	Improved Maize for African Soils project
IMIC	International Maize Improvement Consortium (IMIC)
INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias
IPCC	Intergovernmental Panel on Climate Change
IPNI	International Plant Nutrition Institute
IRRI	International Rice Research Institute
ISC	Independent Steering Committee
IWMI	International Water Management Institute
KALRO	Kenya Agricultural and Livestock Research Organization
KIT	Royal Tropical Institute
LA	Latin America
MAIZE	CGIAR Research Program on MAIZE
MARS	Marker-Assisted Recurrent Selection
MAS	Marker-Assisted Selection
MasAgro	Sustainable Modernization of Traditional Agriculture program
MCMV	Maize Chlorotic Mottle Virus
M&E	Monitoring and evaluation
MELIA	Monitoring, Evaluation, Learning and Impact Assessment
M ha	Million hectares
MLN	Maize Lethal Necrosis
MMC	MAIZE Management Committee
MMT	Million metric tons
MSV	Maize Streak Virus
NARES	National Agricultural Research and Extension System
NARO	National Agricultural Research Organization-Uganda
NARS	National Agricultural Research Systems
NGO	Non-governmental Organization
NPPO	National Plant Protection Organization
NUE	Nitrogen use efficiency
NuME	Nutritious Maize for Ethiopia project
OECD-FAO	Organization for Economic Co-operation and Development - Food and Agriculture Organization of the United Nations
ORNL	Oak Ridge National Laboratory
PPP	Public-private partnership
PVS	Participatory variety selection
PIM	CGIAR Research Program on Policies, Institutions, and Markets
PIM Tables	Performance Indicator Matrix tables
PVP	Plant Varietal Protection

QPM	Quality Protein Maize
QTL	Quantitative Trait Loci
R4D	Research-for-development
RBM	Results-based management
RCTs	Randomized control trials
RMS	Research Management System
RTB	CGIAR Research Program on Roots, Tubers and Bananas
SAGARPA	Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación
SDG	Sustainable Development Goal
SFSA	Syngenta Foundation for Sustainable Agriculture
SI	Sustainable intensification
SIMLESA	Sustainable Intensification of Maize-Legume cropping systems for food security in Eastern and Southern Africa project
SLO	System level outcome
SME	Small- and medium-sized enterprise
SRF	Strategy and Results Framework
SSA	Sub-Saharan Africa
STMA	Stress Tolerant Maize for Africa project
TAMASA	Taking Maize Agronomy to Scale in Africa
ToC	Theory of Change
TLB	Turcicum Leaf Blight
t/ha	tonnes per hectare
UAV	Unmanned Aerial Vehicle
UN	United Nations
USDA-ARS	United States Department of Agriculture–Agricultural Research Service
USAID	United States Agency for International Development
WEMA	Water Efficient Maize for Africa project
WHEAT	CGIAR Research Program on WHEAT
WLE	CGIAR Research Program on Water, Land and Ecosystems
WOCAN	Women Organizing for Change in Agriculture and Natural Resource Management
WUE	Water use efficiency

Section 1: MAIZE AFS Phase-II

1.1 Rationale and scope

Growing demand for maize

Maize is the global leading cereal in terms of production, with 1,016 million metric tonnes (MMT) produced on 184 million hectares (M ha) globally (FAOSTAT, 2013). Maize is produced globally across temperate and tropical zones and spanning all continents. The MAIZE agri-food systems CRP focuses on (sub-)tropical maize in the low- and middle-income countries that provide 64% of total maize production and where maize plays a key role in the food security and livelihoods of millions of poor farmers.

Maize is one of the three leading global cereals that feed the world (Shiferaw et al., 2011). Maize, together with rice and wheat, dominate human diets (Ignaciuk, 2014) and provide at least 30% of the food calories of more than 4.5 billion people in 94 developing countries. Maize alone contributes over 20% of total calories in human diets in 21 low-income countries, and over 30% in 12 countries that are home to a total of more than 310 million people. Of the 22 countries in the world where maize forms the highest percentage of calorie intake in the national diet, 16 are in Africa (Nuss and Tanumihardjo, 2011). Maize's central role as a staple food in Africa and Central America (**Figure 1.1**) is comparable to that of rice or wheat in Asia, with consumption rates being the highest in eastern and southern Africa (ESA). Maize accounts for almost half of the calories and protein consumed in ESA, and one-fifth of the calories and protein consumed in West Africa. In Mesoamerica, annual maize consumption exceeds 80 kg per capita in El Salvador, Guatemala, Honduras and Mexico (Shiferaw et al., 2011). Although direct maize consumption is lower in South and Southeast Asia, there are several areas in the highlands and tribal regions (e.g., Nepal, Bhutan, India, southern China, southwestern Bangladesh, Indonesia and the Philippines) where maize is a main staple (Prasanna, 2014). However, hunger remains widespread. Approximately 925 million people experience hunger (FAO 2010a): they lack access to sufficient of the major macronutrients (carbohydrates, fats and protein). Perhaps another billion suffer from "hidden hunger," where important micronutrients (such as vitamins and minerals) are missing from their diet (UN Standing Committee on Nutrition, 2004; World Bank, 2006a).

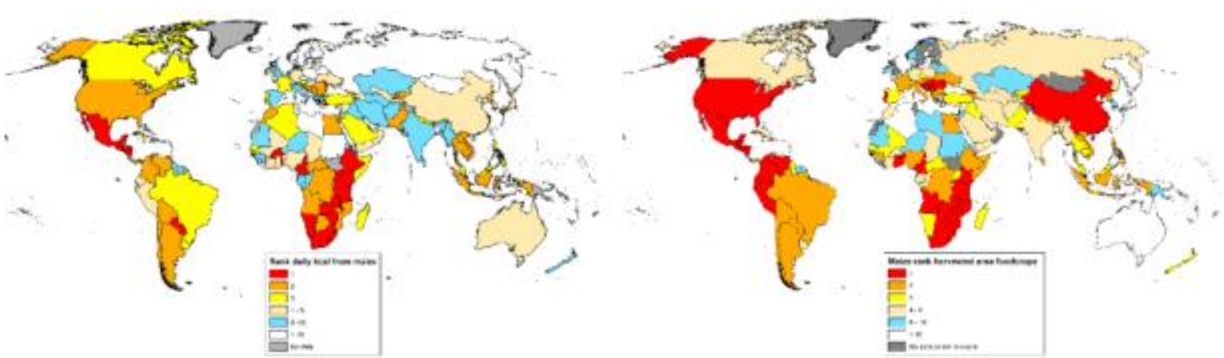


Figure 1.1: Rank of maize, globally, based on **(a)** daily kilocalories (kcal); and **(b)** harvested area of food crops.

With its multiple uses, maize is the world's most multi-purpose crop. Aside from its staple food use, it makes a significant contribution to animal feed (especially poultry) as well as bio-fuel and industrial uses. Population growth, changing diets and a rapidly growing poultry sector are contributing to a sharp increase in maize demand. During 1991-2011, total utilization of maize almost doubled in Asia. Global population will increase from nearly seven billion today to eight billion by 2030, and probably to over nine billion by 2050 (UK Foresight, 2011). Rising income levels and a growing urbanized population (especially in populous developing countries) that eats an increasingly diversified diet, will dramatically increase and change the demand for food and feed – and influence and compete with alternative uses such as industrial and biofuel. Global cereal production is expected to increase by almost 370 MT through the next decade, reflecting a growth of 15% by 2023 (OECD-FAO, 2014). By 2050, the global demand for maize could increase by 50% (Ignaciuk, 2014). Timsina et al. (2011) suggested that, by 2020, maize demand alone in Asia may increase by as much as 87%. Developing regions will account for more than 75% of additional agricultural output over the next decade (OECD-FAO, 2014).

While cereals will remain central to human nutrition (Ignaciuk, 2014) and thereby to feeding the growing population, particularly in least developed countries, for maize, feed demand is the fastest growing sector. In line with a diet shifting towards increased animal protein and milk consumption, global meat production is expected to increase by more than 58 MMT during the next decade, mainly in developing regions. Poultry continues to dominate the meat sector, as reflected in production growth of 27% by 2023 relative to 2014. This represents almost half of the additional meat that will be produced globally by 2023 (OECD-FAO, 2014). The production of pork and poultry relies on the intensive use of maize feed (OECD-FAO, 2014).

Constraints to maize production

The increasing demand for maize and its global advance implies that by 2023, maize will account for the greatest share (34%) of the total crop area harvested (OECD-FAO, 2014). This poses particular challenges to the global capacity to sustainably supply the volumes of maize needed – particularly in low- and middle-income countries. Indeed, rising demand has often expanded the maize area in these countries and brought new land into cultivation instead of sustainable intensification and increasing yields. Crop area thereby often expands into more marginal lands with potential threats to crop diversity, forests, and erodible hill slopes (Neumann et al., 2010). Across the developing world, maize production systems are increasingly diverse and present a gradient of extensive to more intensive systems, with varying implications and concerns in relation to soil erosion, soil fertility loss, land degradation (acidification and salinity), reliance on fossil fuel-derived energy for synthesis of nitrogen fertilizers and pesticides (UK Foresight, 2011), and rural transformation (e.g., competition for or lack of rural labor OECD-FAO 2014), all often aggravated by climate change induced by global warming.

Climate change poses significant risks to future crop productivity as temperatures rise, rainfall patterns become more variable and pest and disease pressures increase (Heisey and Rubenstein, 2015). Climate change affects the poorest populations most in terms of food security. The number of malnourished children in sub-Saharan Africa is expected to increase as the severity of climate change increases. Asia is also vulnerable to progressive climate change (Ignaciuk, 2014). Climate change models have suggested that average maize yields are likely to fall between 5% and 33% by 2050, depending on the severity of climate change (Nelson and Rosegrant, 2010), with the largest decrease in productivity occurring in the least developed countries (Ignaciuk, 2014). As a result of climate change, maize prices could increase by up to 30% (Ignaciuk, 2014).

Set against this backdrop, the future may look daunting. However, there are viable solutions that can be deployed to meet these significant challenges. While there are fewer opportunities for land expansion, there are significant avenues for improved germplasm and sustainable intensification to raise and stabilize yields and to close yield gaps (Foley et al., 2011). Sustainable intensification means simultaneously raising yields, increasing the efficiency with which inputs are used and reducing the negative environmental effects of food production. Improved agricultural technology is seen as an essential strategy for increasing agricultural productivity, achieving food self-sufficiency and alleviating poverty and food insecurity among farmers (UK Foresight, 2011).

What can MAIZE-AFS contribute to meeting the current and future demand for maize against the backdrop of significant challenges?

MAIZE Agri-Food Systems CGIAR Research Program (in short, MAIZE) focuses on the needs of the poor and disadvantaged in the maize agri-food systems in low- and middle-income countries, especially in sub-Saharan Africa, Latin America and Asia. Initiated in 2011, it is a collaborative effort between the CGIAR Centers engaged in maize research-for-development (R4D), together with over 350 public and private sector partners worldwide.

MAIZE has a tremendous area of influence. It develops and delivers germplasm to public and private sector institutions in 108 mostly (sub-) tropical countries. These recipient countries include 98% of all the poor (<US$ 1.25) that live in maize growing areas. **MAIZE is more than a commodity program**. Building on its own research into farm livelihood-focused approaches and incorporating part of the Humid Tropics CRP, FP4 works and links with other CRPs (see **Table 1.4** and **Annex 3.7**) as well as an array of public and private sector partners (**Annex 3.2**) on sustainable intensification and poverty reduction approaches in 24 focus countries (**Figure 1.2**) encompassing 76% of all poor in maize-based agri-food systems in low- and lower-middle-income countries.[1]

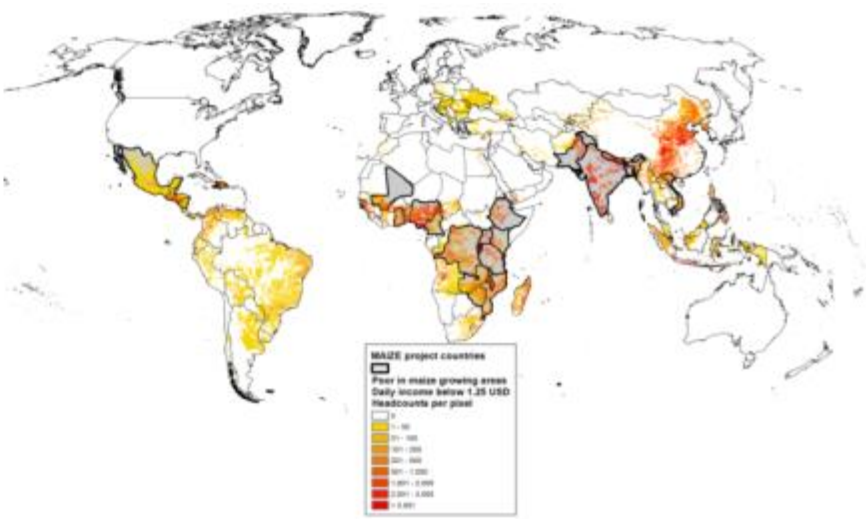


Figure 1.2: Countries where MAIZE focuses on sustainable intensification, mapped by poverty.

[1] Maize-based agri-food systems are defined as agricultural lands with more than 25% of maize in the crop rotation, and inhabited by 219 million poor (<US$ 1.25). Maize growing areas include all areas where maize is grown; these are inhabited by 977 million poor.

1.2 Goals, objectives, targets

MAIZE implements a strategic international research-for-development (R4D) approach, in collaboration with public and private sector partners worldwide, in order to:

1. Ensure maize-based systems in less developed countries are more profitable and sustainable by developing, adapting and scaling out systems approaches, including improved germplasm and sustainable intensification and diversification solutions.
2. Increase maize yield gains in the stress-prone environments of sub-Saharan Africa, Asia and Latin America, despite climate change and new pests and diseases.
3. Develop and deploy nutritious maize, and add value to maize-based producers, processors and consumers.

MAIZE focuses particularly on developing and deploying international public goods, which is its comparative advantage, and on strengthening resource-poor women and men farmers of different age groups and poor consumers in low- and middle-income countries. MAIZE, through its various Flagship Projects (FPs) and associated outcomes, directly and indirectly addresses several of the SRF Grand Challenges (**Table 1.1**).

***Goal**:* The specific goal of MAIZE is to increase incomes and food security for poor maize producers and consumers while enhancing the sustainability of maize-based production systems and the natural resource base. MAIZE will ensure that technological and institutional innovations are developed, tested and deployed to enable profitable and equitable integration of small-scale maize producers and processors in the expanding maize value chains. The promotion of robust maize value chains will create increased opportunities for women and youth and ensure a continuous and adequate supply of quality maize at affordable prices to poor urban consumers.

In doing so, MAIZE will contribute to the achievement of the Sustainable Development Goals (SDGs) outlined by the United Nations, in particular to: end poverty in all its forms everywhere (SDG 1); end hunger, achieve food security and improved nutrition, and promote sustainable agriculture (SDG 2); ensure healthy lives and promote well-being for all at all ages (SDG 3); achieve gender equality and empower all women and girls (SDG 5); ensure availability and sustainable management of water and sanitation for all (SDG 6); promote sustainable, inclusive and sustainable economic growth, full and productive employment and decent work for all (SDG8); ensure sustainable consumption and production patterns (SDG 12); take urgent action to combat climate change and its impacts (SDG 13); protect, restore and promote sustainable use of terrestrial ecosystems, halt and reverse land degradation and biodiversity loss to improve natural resource systems and ecosystem services (SDG 15); and strengthen means for implementing and revitalizing the global partnership for sustainable development (SDG 17). These SDGs are closely aligned with the System Level Outcomes and associated (sub-) IDOs of the CGIAR Strategy and Results Framework.

Objectives: MAIZE contributes to several Intermediate Development Outcomes (IDOs) of the CGIAR Strategy and Results Framework (SRF), most prominently:

1. Increased resilience of the poor to climate change and other shocks;
2. Increased incomes and employment;
3. Increased productivity;
4. Improved diets for poor and vulnerable people; and
5. Enhanced benefits from ecosystem goods and services.

Among the cross-cutting IDOs, MAIZE contributes to climate change adaptation and mitigation, greater equity and inclusion of women, and improves the enabling environment and capacities of national partners and beneficiaries (see **Table 1.1** below for FPs mapped onto SRF Grand Challenges).

Table 1.1: SRF Grand Challenges addressed by MAIZE Outcomes

Grand Challenges / Flagship Projects	**GC1**: Competition for land from multiple sources: food and feed crops, livestock, bio-fuels and biomaterials, forest products, conservation, urban expansion, and a host of other ecosystem services.	**GC2**: Soil degradation on land already farmed in circumstances where new lands brought into production are often poorly suited for intensive agriculture.	**GC3**: Overdrawn and polluted water supplies threatening social breakdown and rising levels of conflict.	**GC5**: Climate change threatening agriculture; at the same time, agriculture is a substantial producer of greenhouse gases.	**GC6**: Diminishing genetic resources. Between 7 and 25% of vascular plant species are under threat of extinction by 2050.	**GC7**: Nutritious and diverse agri-food systems and diets are becoming more important. Increased consumption of animal products, fruits and vegetables alongside traditional cereal staples offers scope to improve nutritional and health outcomes among the under-nourished.	**GC8**: Post-harvest losses of crop, livestock, fish, and tree products due to pests, spoilage and spillage are estimated at 30% to 50% globally. Reducing these losses offers considerable opportunities to improve the availability and affordability of food.	**GC9**: Employment and income opportunities created for men, women and youth as a result of the development of value chains for staple products and the provision of improved seeds, husbandry practices and small-scale mechanization.
FP1 Enhancing MAIZE's R4D Strategy For Impact		■		■		■	■	■
FP2 Novel Diversity and Tools for Increasing Genetic Gains	■			■	■	■	■	
FP3 Stress Tolerant and Nutritious Maize	■		■	■	■	■	■	■
FP4 Sustainable Intensification of Maize-based Systems for Better Livelihoods of Smallholders	■	■	■	■		■		
FP5 Adding Value for Maize Producers, Processors and Consumers	■			■		■	■	

Targets and value proposition: MAIZE provides substantive value for money – aided by its effectiveness as endorsed by the CGIAR IEA team report on MAIZE, its partnership network and its reach. Based on the importance of crops for poor producers and consumers in the developing world, it is possible to estimate targets to be achieved by MAIZE to meet the 2022 and 2030 targets of the SRF (**Tables 1.2 and 1.3**). With adequate, secure and strategic funding, MAIZE is set to provide a major contribution to the SRF targets – but for the respective contribution per CRP, methodologies for calculating such impacts must be aligned among the CRPs. Please see **Section 1.3** for more details on MAIZE's contributions to specific IDOs and sub-IDOs.

Targeted impacts and outcomes of MAIZE depend mainly on the level of donor investments and on the political support and economic investments of both public and private sector partners in the target geographies/countries. Against a background of uncertain funding, MAIZE outlines a value proposition based on two possible scenarios of donor investment: (1) a base investment scenario of USD$68 M /yr (all sources), with W1/W2 = USD$12.5 M ("Base budget"); (2) an uplift investment scenario of USD$102 M/yr, with W1/W2 = 18.75 M ("Uplift budget"). **Table 1.2** below presents the value proposition of MAIZE in terms of target contributions to the CGIAR SLOs, under the two investment scenarios (see **Table A** of **Annex 3.18 MAIZE Performance Indicator Matrix**, for more details). **Annex 3.6** (Results-based management) lists a set of indicators that will be used to monitor progress towards these targets. Detailed outcomes, milestones, and their associated costs are given in **Tables B-D** of the **Annex 3.18 MAIZE Performance Information Matrices (PIM)**, for the medium investment scenario. Outcomes and milestones for the low and high investment levels will be prepared in a modular way, so that MAIZE can adapt to any actual investment level and respond with associated budget adjustments. A detailed sample budget breakdown for the medium investment scenario is provided in the uploaded budget tables. In any given year, actual budgets will fluctuate in accordance with actual investments through W1, 2, W3, and bilateral projects.

Table 1.2: MAIZE value proposition under two investment scenarios, in terms of contributions to the CGIAR SRF targets (2022).

Investment Scenario:		**Base**	**Uplift**
Average annual budget (discounted for inflation; M US$/year Total/W1,2):		**68/12.5**	**102/18.75**
SRF indicators and targets for 2022	**MAIZE contribution indicators**	**MAIZE targets**	
SLO 1: Reduced poverty			
1.1: 100 million more farm households have adopted improved varieties, breeds or trees, and/or improved management practices	No. of farm households that have adopted improved maize varieties and/or practices, with 30-40% women farmer participation, and 10% women-headed households (million households)	15	19
1.2: 30 million people, of which 50% are women, assisted to exit poverty	No. of maize consumers and producers (men, women, children), of which 50% are female, assisted to exit poverty (<$1.25/day) (million people)	7.5	10
SLO 2: Improved food and nutrition security for health			
2.1: Improved rate of yield increase for major food staples over current (<1% to 1.2-1.5% per year)	Genetic gain (as measured in breeders' trials) in maize (%)	1.2	1.4
2.2: 30 million more people, of which 50% are women, meet minimum dietary energy requirements	No. of people (men, women, children), of which 50% are female, assisted out of hunger and meet minimum dietary energy requirements (million people)	5	7.5

2.3: 150 million more people, of which 50% are women, without deficiency of one or more of the following essential micronutrients: iron, zinc, iodine, vitamin A, folate, and vitamin B12	No. of people (in millions, including men, women, children), of which 50% are female, consuming biofortified maize Note: Figures refer to only QPM targets across consumption in in sub-Saharan Africa, Latin America and Asia; targets for provitamin A-enriched and high Zn maize in A4NH).	15	18
2.4: 10% reduction in women of reproductive age who are consuming less than the adequate number of food groups	No. of women of reproductive age in maize-based farming households consuming adequate number of food groups through farm diversification and increased expendable income (million women)	1.5	1.7
SLO 3: Improved natural resource systems and ecosystem services			
3.1: 5% increase in water and nutrients (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse	% increase in water- and/or nutrient-use efficiency through improved crop management practices in maize-based farming systems	1	1.2
3.2: Reduce agriculturally-related greenhouse gas emissions by 0.2 Gt CO2-e yr–1 (5%) compared with a business-as-usual scenario in 2022	Reduction in GHG emissions from maize-based farming systems through improved farm management practices	0.01	0.015

MAIZE is effective. The CGIAR IEA team report on MAIZE [FINAL REPORT: Evaluation of CRP on MAIZE] states: "*MAIZE is largely a coherent program, which because of the unique genetic resources at its disposal, its excellent research facilities, its considerable breeding capacity and its partnerships and global mandate, has a strong comparative advantage that is consistent with its goals, SLOs and the SRF of the CGIAR.*" The IEA Report also states that investments in maize research have had high returns, and MAIZE is well on target in its efforts to increase maize productivity in its target groups by 7% in 2020 and 33% in 2030. This would provide sufficient maize grain to meet the annual food demand of an additional 135 million poor consumers in 2020 and of 600 million consumers in 2030. The IEA team expressed confidence that MAIZE is ready to meet future challenges and will contribute substantially to the CGIAR targets for poverty alleviation, food security and sustainable management of natural resources [FINAL REPORT: Evaluation of CRP on MAIZE]. Based on the importance of maize for poor producers and consumers in the developing world, one can estimate MAIZE's potential contributions to 2030 SRF-SLO targets 2030 (**Table 1.2**). Additional benefits will arise through feed uses of maize and their impact on the price of animal produce. It is important that methodologies for calculating such impacts are aligned among the CRPs.

Table 1.3: MAIZE targets matched to CGIAR SRF-SLO targets by 2030 (further details in **Annex 3.6**).

__Assumptions__:

- One target matched to at least one sub-IDO, even if other sub-IDOs are relevant, to keep progress-towards-outcome monitoring manageable.
- Several sub-IDOs may have to be achieved to reach the SLO-level target.
- Several progress indicators may need to be monitored to assess progress toward one target and sub-IDO.

SRF Targets (2030)	Relates to SDG	MAIZE Strategic Goals & Targets by 2030	via MAIZE FP	Relates to CGIAR sub-IDO	Proposed Indicators
SLO1: Reduced Poverty 1. 350 M more farm households have adopted improved varieties, breeds or trees, and/or improved management practices 2. 100 M people, of which 50% are women, are assisted to exit poverty	2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	A. 26 M (out of 137 M farm households producing maize in low- and middle-income countries) adopt improved maize varieties and/or improved agronomic management practices. B. Annual genetic yield gains of 0.7>> 2.0% (under stress-prone tropical/subtropical environments) achieved via international partnerships and a steady flow of improved MAIZE germplasm to NARS and the private sector for testing and adaptation, resulting in enhanced adoption of genetically diverse stress tolerant varieties in sub-Saharan Africa (SSA), Asia and Latin America (LA). C. At least 15 M poor people, of which 50% are women, assisted to exit out of poverty through adoption of a combination of improved management/agronomy technologies in maize-based agrifood systems. D. At least 100 new stress-resilient (tolerant to drought, heat, waterlogging, acidity; resistant to major diseases, insect pests, and parasitic weeds), nutrient use efficient and nutritious	FP3 (aided by FP2), FP4, FP5 (aided by FP1)	Enhanced genetic gain *on-farm* (1.4.3) Increased value capture by smallholders (1.3.3) Reduced production risk and greater input use efficiency (land, labor, purchased inputs, water) (1.1.2) OR Reduced pre-, post-production losses (1.4.1)	• Global average yield increase, based on aggregation of national production and productivity statistics, reflecting on-farm gains • Location-specific crop yield gap (actual yield as % of attainable yield) • Kg/ha/year improvement in mean yield of improved MAIZE hybrids relative to baseline checks in optimum and stress-prone tropical environments • Number of MAIZE varieties released by seed enterprises and national programs • % change in replacement of old, less-productive cultivars • % change in income attributable to yield, yield stability, and quality traits, for first users/adopters • Change in agriculture-derived income in participating communities for different types of actors • Farm-level production and

		maize hybrids/varieties commercialized by seed company partners in target geographies, replacing the existing less-productive and 15+ year-old varieties. E. More than US$100 M per year value added, as women and men farmers across SSA, Asia and LA change to new, improved maize varieties every year (10% variety replacement rate of 15+ year-old varieties), during 2015-2030. F. By 2030, total harvest losses (yield, quality) avoided in the target regions in SSA, Asia and LA, by farmers' adoption of improved stress tolerant maize varieties (e.g., at least 20 MLN resistant varieties in SSA); benefits estimated at ca. $ 500 M (conservative estimate).			profitability increases resulting from integration of sustainable intensification options • Impact studies: Increased value capture at global/regional/country levels documented through macro-level MAIZE impact update • No more major crop failures due to MLN in SSA, and reduced impact of MLN on commercial maize seed sector
SLO 2: Improved food and nutrition security for health 1. 500 M more people (50% female) without deficiencies of one or more essential micronutrients	2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.	G. via A4NH (provitamin A enriched and high Zn maize targets) H. 20 M people across SSA, LA and Asia consume QPM-based food products by 2030.	Linking FP3 (CoA 3.2) with A4NH, besides FP5	Increased availability of diverse nutrient-rich foods (2.1.1)	**See A4NH** • Number of households consuming QPM-based food products in SSA, LA and Asia • Number of maize germplasm characterized and improved for quality and processing traits • Number of seed companies producing and delivering QPM maize varieties in SSA, LA and Asia • Number of value chains analyzed and nutritionally enhanced

SLO 3: Improved natural resource systems and ecosystem services 1. 20% increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems 2. Reduce agriculturally-related GHG emissions by 0.8 Gt CO_2 yr^{-1} (15%)	1. End poverty in all its forms 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture 6. Ensure availability and sustainable management of water and sanitation for all	I. 10-20% increase in water and nutrient use efficiency in targeted maize-based farming systems by 2030 (target to be finalized). J. A 15% reduction of agriculturally-related GHG emissions in maize-based farming systems, compared to business-as-usual scenario, in 2030.	FP4 & FP1	Agrisystems diversified, intensified in ways that protect soil and water (3.2.2) Reduced GHG emissions from agriculture, forests (A.1.1)	• % change in nitrate leaching, P losses • % change in herbicide/pesticide use per production unit • % change from baseline for soil C indices, erosion indices, soil biological properties • SDSN 12: [Nitrogen use efficiency in food systems] • Crop water productivity (tons of harvested product per unit irrigation water)

1.3 Impact pathway and theory of change

Maize agri-food systems are inherently complex, yet offer tremendous opportunities. Indeed, maize feeds the poorest of the poor, be it as a subsistence crop in marginal areas or as the cheapest energy source in urban slums, and offers a genuine opportunity to lift smallholders out of poverty wherever value chains are established. Maize supply is equally diverse, from the large-scale mechanized farms that supply global markets to the hillside farmer that barely produces enough to feed the family; from the hybrid seed that can yield over 10 tons per hectare (t/ha) with adequate management to an average yield of 1.4 t/ha in sub-Saharan Africa (SSA); from biotech high-end science to the lack of even the most basic crop management practices; and a cultivation footprint that spans the globe from the tropics to temperate environments. This diversity is a reflection of many realities. Particularly relevant here is that it reflects a demand for context-specific solutions. Multinational seed companies have no commercial interest in addressing such diverse market niches, and more than seed-based solutions are needed to increase productivity and reduce poverty. There are thus significant needs for public-sector agricultural R4D investment to address the areas neglected or less reached by the multinationals as well as areas where complementary public-private partnerships can bring greater impact on the livelihoods of the poor producers and consumers who depend on maize agri-food systems.

The MAIZE impact pathway (as presented in **Figure 1.3**) and associated Theories of Change (ToC) were developed during workshops with Flagship Program teams. A participatory approach was used to capture all views, experiences and known evidence. The impact pathway will serve as the CRP's hypothesis of the way by which change is expected to occur from output to outcome and impact.

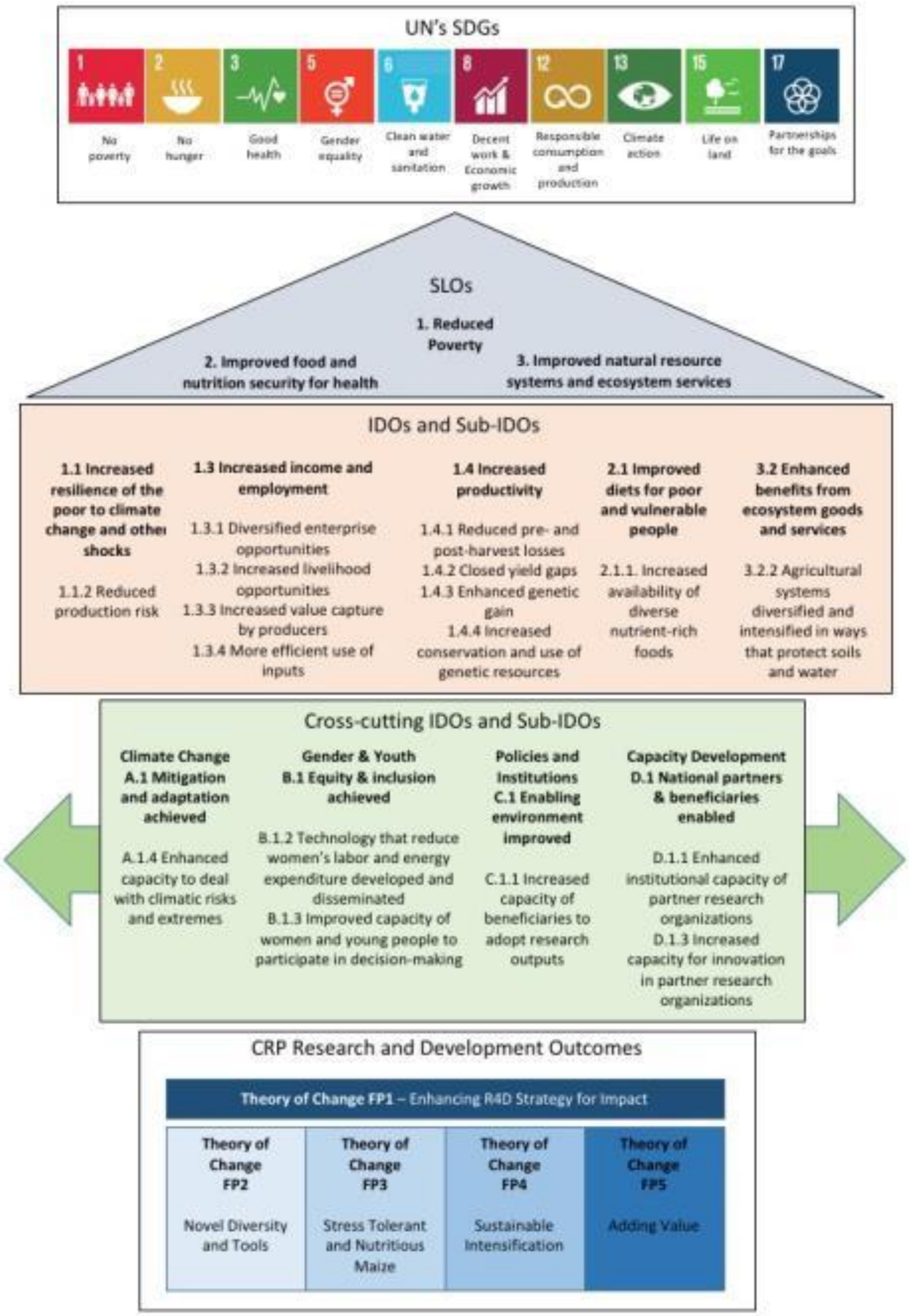
On the basis of the Flagship Programs' theories of change, the CRP will be focusing on eleven sub-IDOs and six cross-cutting sub-IDOs:

- 1.1.2 Reduced production risk;
- 1.3.1 Diversified enterprise opportunities;
- 1.3.2 Increased livelihood opportunities;
- 1.3.3 Increased value capture by producers;
- 1.3.4 More efficient use of inputs;
- 1.4.1 Reduced pre- and postharvest losses, including those caused by climate change;
- 1.4.2 Closed yield gaps;
- 1.4.3 Enhanced genetic gain;
- 1.4.4 Increase conservation and use of genetic resources;
- 2.1.1 Increased availability of diverse nutrient-rich foods;
- 3.2.2 Agricultural systems diversified and intensified in ways that protect soil and water;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated;
- B.1.3 Improved capacity of women and young people in decision-making;
- C.1.1 increased capacity of beneficiaries to adopt research outputs;
- D.1.1. Enhanced institutional capacity of partner research organizations; and
- D.1.3 Increased capacity for innovation in partner research organizations.

From these areas of focus and in line with the CGIAR Strategy and Results Framework (SRF), the CRP will contribute to reducing poverty (SLO 1), improving food and nutrition security for health (SLO 2), and improving natural resource systems and ecosystem services (SLO 3) by increasing resilience of the poor to climate change and other shocks (IDO 1.1), increasing income and employment (IDO 1.3), increasing productivity (IDO 1.4), improving diets for poor and vulnerable people (IDO 2.1), enhancing benefits from ecosystem goods and services (IDO 3.2), and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C) and capacity development (D).

The MAIZE impact pathway and associated Flagship Program theories of change respond and will contribute to the achievement of 10 Sustainable Development Goals outlined by the United Nations (SDGs 1, 2, 3, 5, 6, 8, 12, 13, 15 and 17, as detailed in **Section 1.2**).

Figure 1.3: MAIZE AFS Impact Pathway



Results-based Management and Monitoring, Evaluation, Learning, and Impact Assessment

MAIZE will develop and implement a comprehensive results-based management (RBM) framework based on six globally recognized RBM principles:

- A culture focused on outcomes;
- Strong leadership in RBM to model results orientation across the system;
- Participatory approaches at all levels, including partners and stakeholders;
- Learning and adaptation through the use of performance information;
- Accountability and transparency where program staff are accountable for appropriate levels of results that are acquired and reported in a transparent manner; and
- Utilization-focused and flexible operational system where RBM tools, procedures and practices can be adapted based on contexts and needs.

In order to effectively implement the RBM framework, it will be necessary to strengthen monitoring, evaluation, learning and impact assessment (MELIA) at both the project and program levels. A robust and strategic plan is proposed to support the CRP cycle of planning, budget allocation, and reporting. Operationalization of the plan will take place following submission of the proposal under the guidance of the CGIAR Monitoring, Evaluation and Learning Community of Practice.

For further details on the RBM framework and MELIA strategic plan, please refer to **Section 3.6**.

Impact-driven research strategies at the CRP level

MAIZE pursues three complementary research-for-development strategies, or pillars, to move along the impact pathway shown above and turn the Theory of Change into a reality for poor MAIZE consumers and producers. The three pillars that underlie the MAIZE program structure (see **Section 1.6**) are:

a) **Improved germplasm pillar:** Based on the comparative advantage and a partner network that reaches basically every major NARS and SME maize breeding program in the low and middle-income countries of sub-Saharan Africa, Asia and Latin America, MAIZE makes use of the advances in science and technology through precise phenotyping and genotyping that result in more efficient selections and shorter breeding cycles to generate stress-resilient and nutritious maize. Coupled with its emphasis on strengthening maize seed systems in the neglected areas and increasing adoption rates of improved MAIZE varieties, MAIZE contributes to sustained yield increases and greater yield stability in stress-prone tropical/subtropical environments.

b) **Sustainable intensification pillar:** The impact of MAIZE in terms of increased maize productivity on-farm can only be reached if improved maize cultivars and better agronomy come together in farmers' fields. This calls for strategic systems R4D that incorporates multi-scale innovation systems research, underpinned by a robust geospatial framework that includes biophysical and socioeconomic extrapolation domains and innovation platforms that bring together different actors to test, adapt and adopt combinations of technologies, while mainstreaming gender into specific contexts and scaling out technologies.

c) **Value addition pillar:** Within the context of agri-food systems, MAIZE aims for enhanced value addition – i.e., beyond the mere production of maize as a commodity. Its focus is on developing strategic value addition opportunities for maize value chain participants and consumers through novel and nutritious maize-based food and feed products, enhanced processing and reduced postharvest losses.

Five interconnected Flagship Projects (**Figure 1.4**) deliver international public goods (IPG), technologies and methods adapted to local/regional needs, thereby contributing to the SLOs 1, 2 and 3. The delivery mechanism for these IPGs will be driven by ToC related to FPs and partnerships (see **Sections 1.7, 1.8** and **Annex 3.2**), including by adapting research and developing concrete products. Theories will be tested, improved, used and disseminated. Partners have a key role in the research-to-development continuum and ensure feedback loops among researchers, development partners and users. Note that all FPs have referenced climate change-relevant sub-IDOs in their Impact Pathways and Theories of Change.

Overall, FP2 is the most upstream Flagship Project (e.g., germplasm characterization, developing novel tools/techniques to increase genetics gains, and bioinformatics). All the FPs incorporate upstream research, including translating R&D partners' and other CRPs' upstream research into developing country contexts: FP3's scope includes research on integrating faster and more precise selection methods in maize breeding pipelines, and adapting new methodologies for germplasm improvement. FP4 incorporates new approaches to multi-scale framework analysis, innovations at farm level (e.g., remote-sensing-based farmer-decision support, precision agriculture solutions) and innovative approaches to value chain development (e.g., business models). FP1's scope includes advanced foresight and targeting approaches, strategic gender research (e.g., multi-disciplinary approaches) and impact assessment innovations (e.g., DNA fingerprinting to assess variety adoption).

MAIZE FP's downstream research-for-development relies on cross-CRP collaboration and partnerships (see **Sections 1.7** and **1.8**). Within FP1, the focus is on site-specific understanding of farmer adoption and impacts, as well as gender mainstreaming. FP2 focuses on validation and scaling-out of new knowledge and methods to MAIZE and other researchers. FP3 focuses on partnerships to strengthen maize seed systems and elicit farmer feedback, to facilitate greater adoption of stress resilient and nutitious maize varieties. FP4 focuses on systems research and innovation systems to validate a combination of solutions with first users and innovation networks to scale-up/-out and faciliate greater adoption. FP5 focuses on developing value addition opportunties for maize value chain participants and consumers in target geographies.

1.4 Gender

The integration of gender and social inclusion in MAIZE is guided by the MAIZE Gender Strategy (http://maize.org/gender-strategy/). The point of departure for the way CRP addresses gender and social inclusion is to look at agriculture as a social practice (Fairhead and Leach 2005). This means paying attention to and analyzing the social context within which farming occurs, and which often enables or constrains opportunities and outcomes differently, for different social groups. Gender is a key part of that social context, often intersecting with other social identities such as age, caste and ethnicity.

New technologies are often targeted to reach poor farmers and consumers, especially women and youth. However, women and men adopters live and work in the midst of complex social relationships, for example, at household level, group and community level, market system level, and the wider society (**Figure 5**).

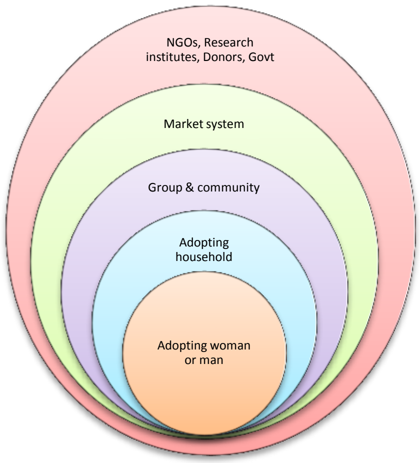


Figure 5: Gender amidst complex social relationships.

Power relations at each of these levels affect the extent to which women, and men, use and benefit from technologies. However, gender relations and the wider social institutional context (including norms, mindsets) are not fixed (Risman 2004, Martin 2004, Kabeer 1994). MAIZE recognizes that in order to design and undertake agricultural R4D that is both technically *and* socially robust, it is necessary to understand and take into account how agri-food systems operate across different social enabling environments.

The Relevance of Gender in Maize R4D

Gender relations are a key aspect of the real-life contexts within which agricultural technologies are deployed. They affect which results can be achieved, how, and for whom. Key constraint to maize production in the tropics include abiotic and biotic stresses, poor soil fertility, labor shortage, land degradation, insufficient institutional support, lack of knowledge, lack of affordability and access to fertilizer and other inputs, micro-finance, etc. Depending on the context, these constraints can all have significant gender dimensions (Doss and Morris 2001; Fisher and Kandiwa 2014; Hampton et al. 2009; IFAD 1999; Kassie et al. 2014; Morris et al. 1999; Ndiritu et al. 2014; World Bank, FAO and IFAD 2008).

Gender stereotypes and social restrictions often exclude certain groups (e.g., women) from research and extension programs, and from participating in farmer participatory experiments, demonstrations and field days. When men migrate and women are left in charge of the farm, labor production relations are affected. Women face several constraints when addressing these challenges, because of lack of access to technical knowledge and technologies that can reduce their drudgery and provide additional income (Bellon et al. 2002; Beuchelt and Badstue 2013; Mehra and Hill Rojas 2008; Quisumbing and Pandofelli 2009). Moreover, women's "triple roles"[2] are well acknowledged in the literature (Momsen 2010, Moser 1993). To the extent that domestic and caregiving responsibilities may limit their mobility, women often lose out on crucial opportunities for learning and interactions that could stimulate agency (empowerment) and innovation.

[2] Defined as women's reproductive, productive, and community activities (Moser, Caroline. 1989. Gender Planning in the Third World: Meeting Practical and Strategic Gender Needs. World Development Vol. 17, No. 2. pp. 1799-1825).

Traits and technology preferences

Both men and women maize farmers value grain yield and stress resilience, and varieties of different crop cycle duration (Banziger and de Meyer 2002). However, several studies show that women and men often rate maize characteristics differently and prefer different combinations of traits, because of the intended maize consumption objectives, e.g., for market, home consumption, food security, special dishes, feed etc. (Bellon 1996; 2002; Bellon et al. 2000; 2003; Deere 2005; Badstue 2006; De Groote and Kimenju 2008; De Groote et al. 2013; Hellin et al. 2010, Lunduka et al. 2012; Galie 2013). Men often prefer high-yielding varieties in view of the associated potential for selling of surplus production. In many cultures, women are traditionally regarded as the custodians of family diets. Women's reproductive roles can influence their priorities towards a focus on food security and/or varieties that are both palatable and nutritious and further meet processing and storing requirements (Smale et al. 1992; Smale and Heisey 1994, 1997; Smale 1995; Doss 2001; Bellon et al. 2003; Badstue 2006; Hellin et al. 2010). In addition to this, both in Mexico and Southern Africa, women farmers' varietal preferences are also linked to their productive role and represent an important source of female income generation, e.g., from the artisanal processing and sale of maize products (Doss 2001; Bellon et al. 2003; Badstue 2006). However, as has been pointed out earlier (Bourdillon et al. 2007), the bottom line is that gender-differentiated preferences cannot be assumed. Rather, they are influenced by crop use, local context and the gender division of labor.

Other gender differences in preferences, needs and constraints may apply to other types of technologies (e.g., related to post-harvest storage and labor-saving, crop or natural resource management practices) or manifest themselves differently under different circumstances. As documented by Paris and Pingali (1996), the same technology may have a positive impact in one context or for one social group, but not in another context or for another social group (see also Farnworth et al. 2015; Nyanga et al. 2012; Beuchelt and Badstue 2013). These examples present trade-offs related to agricultural technologies, which in general are associated with positive development impacts. However, it is not necessarily possible to predict how the introduction of new technologies may affect the labor, resource and land allocation patterns between men and women, or how this, in turn, may influence whether the new technology will be adopted or not, and who will benefit/lose. Both intended and unintended impacts can occur at individual, household and/or community level. The challenge of estimating potential consequences therefore relates both to gender considerations (Doss 2001), as well as to broader aspects of human and sustainable development.

Information and value chains

One of the greatest constraints that poor women farmers face is lack of access to new knowledge and reliable information on new technologies and practices (Aryal et al. 2015; Meinzen-Dick et al. 2011; Manfre et al. 2013). Information is important to women, whether or not they are the final decision makers on which seed, fertilizer or other inputs to buy. When deferring to their spouses, it helps for the women to discuss and debate from the standpoint of knowledge. On the same note, it is best when both spouses have adequate information and reach a consensus on farm decisions.

Maize is not only a crop that contributes to food security, but also an important cash crop in many contexts. However, with a few exceptions (e.g., Doss and Morris 2001), the literature on maize production and markets has paid limited attention to gender perspectives, and has often failed to identify the differences in constraints faced by women and men as producers, processors, traders, etc., and as knowledge seekers and buyers of inputs and services.

Vulnerability and risk

It has been argued that due to their socially constructed roles and responsibilities and various constraints that tend to weigh heavier on women, women are often particularly vulnerable as well as responsive to shocks, e.g., climate variability and change, and depletion of the natural resource base (Alston and Whittenbury 2014). For example, as custodians of household food security in many contexts, women have a lot more at stake when a season fails, because they bear the brunt of managing hungry, malnourished and sick children.

Female farmers as agents of change

Men and women both make significant contributions in maize-based farming systems and livelihoods, although gender roles in maize cultivation vary greatly across and within regions. On average, women comprise 43% of the agricultural labor force in developing countries, ranging from 20% in Latin America to 50% in Sub-Saharan Africa and East Asia (Quisumbing et al. 2014; FAO 2011). Their contribution to agricultural work varies even more widely, depending on the specific crop and activity. By their sheer numbers, these women farmers represent an important potential market that needs to be understood, taken seriously and served. Given recent trends of rural out-migration primarily by men, the proportion of women in farming has either remained stable or increased. Regardless of the variations across regions, women make up a large part of the world's small-scale maize farmers. As such, they are important agents for agricultural development and change.

Women maize farmers participate actively in the maize economy through their involvement in production, post-harvest and processing activities. They are also active participants in decision making about technology adoption: On one hand, some women manage whole farms as female household heads or in the absence of their husbands. On the other hand, women also manage individual plots within male-headed households, and most importantly, women provide significant inputs into the constraints and drivers for technology adoption, where farming is managed jointly.

Integrating Gender in MAIZE

The integration of gender in MAIZE is guided by the MAIZE Gender Strategy,[3] whose objective is to *promote equality of opportunity and outcomes for resource-poor farmers in maize-based systems, including women and men, youth and other social groupings.*

The MAIZE Gender Strategy follows a two-pronged approach: (1) integrative gender research via the application of gender analysis as part of other technical research, e.g., socioeconomic research, maize breeding or crop management; and (2) strategic gender research to further expand the knowledge base concerning gender specifically in relation to maize-based farming and livelihoods. Both of these avenues contribute to inform and deepen the relevance of other MAIZE research themes, as well as overall CRP priority setting and targeting, in order to enhance the impact of maize agri-food systems R4D.

Drawing on the recommendations from the MAIZE Gender Audit undertaken in 2013[4] and to stimulate and catalyze the process of integrating gender considerations in MAIZE across the various flagships and throughout the project cycle, gender research activities are complemented by additional investments to mainstream gender into program frameworks and procedures, as well as to strengthen the capacity of scientists and research teams to integrate gender into research. As results and lessons learned are

[3] For a brief overview of the MAIZE Gender Strategy, see Annex 3.4.

[4] http://maize.org/wp-content/uploads/sites/5/2014/11/FINAL-Gender-Audit-Summary-report-MAIZE-191114.pdf

incorporated in gender analysis and research implementation, these will provide feedback to the FP and CRP-based learning processes and contribute to further develop and adjust the programmatic frameworks, which, in turn, will inform the next generation of research projects and adjustments in FP implementations. As these dynamics progress and gain traction, the integration of gender in MAIZE continues to expand and improve.

The MAIZE Gender Strategy lays out the MAIZE gender impact pathway and includes an overview of key gender issues and research questions related to each of the five FPs, and of the details of the operational aspects related to integrating gender as a part and parcel of the MAIZE R4D.

Gender Issues Informing MAIZE Phase-II

Ensuring gender-responsive outcomes is an integral component of MAIZE's strategy for maximizing impact. The MAIZE Phase II proposal will be informed by gender research achievements from Phase I, which includes strategic and integrative gender research on small-scale mechanization (Eerdewijk and Danielsen 2015), improved post-harvest storage technologies (Kandiwa et al., forthcoming), conservation agriculture (Farnworth et al. 2015), participatory varietal selection (PVS), and seed sector development (Kandiwa et al., forthcoming). Similar progress has been achieved in relation to documenting gender aspects of technology adoption and impact assessments (e.g., Teklewold et al. 2013a; Gitonga et al. 2013; Rodney et al. 2013; Fisher and Kandiwa 2014; Ndiritu et al. 2014; Farnworth et al. 2015; Mutenje et al. 2016; Manda et al. 2016). Selected ongoing projects (e.g., SIMLESA, STMA, WEMA, FACASI, CSISA) include integrative gender research (e.g., gender responsive technology development and testing in SSA, for instance, integration of gender considerations in value-chain R4D and capacity building; gender responsive service provision and information diffusion in South Asia; assessing the life histories of women's and men's cultivated plots and how they have evolved over time in SSA; and action-oriented pilot projects in SSA to motivate and engage young adults in a range of improved crops, post-harvest processing and agribusiness opportunities, and to take agriculture as a viable business).

MAIZE is also a leading actor in GENNOVATE (https://gender.cgiar.org/collaborative-research/gennovate/), a cross-CRP comparative research initiative focusing on how gender norms and agency influence the ability of men, women and youth to learn about, try out, adopt and adapt new agricultural technologies. MAIZE findings from GENNOVATE will strengthen the key role of contextually grounded systems approaches and actions that are needed for the design and roll-out of equitable and efficient maize agri-food systems innovations. Reports and publications based on this work, as well as the study methodology, will fill an important gap in the existing gender and maize-based systems literature and contribute to MAIZE's strategic planning of Phase II by: (1) enhancing the gender responsiveness of MAIZE's targeting, priority setting and theories of change; (2) advancing gender transformative outcomes of maize research and development interventions at scale; and (3) building the evidence base and actions to address the role of gender norms in relation to adoption of improved maize technologies and related development processes.

Budget for Gender Work in MAIZE

Apart from maintaining the core team (FP1.3) with support from BMZ (CIM) linked to gender specialists in several bilaterally funded projects, the top investment priorities are: attracting funding for strategic research projects building on GENNOVATE, while building a critical mass of gender scientists (e.g., a cohort of Ph.D. students with Wageningen University, under an uplift budget), increasing the budget for gender mainstreaming (e.g., building capacity among a greater number of researchers) and integrating gender into the new scaling-out partnerships under FP4.4 (uplift budget).

1.5 Youth

Gender is a relational concept, intersecting with other social identities, including youth. As such, gender and youth are not mutually exclusive, but often intersect, depending on the specific context/situation. In MAIZE, the approach to gender is informed by the concept of social heterogeneity, i.e., men and women, boys and girls representing and experiencing diverse combinations of social identities and positionalities (for instance, belonging to different social or ethnic groups, different ages, etc.). As such, in MAIZE, gender research in principle also includes consideration of young men and women. Youth-focused research, on the other hand, *centers* on young men and women.

With increased focus on the role of youth in relation to agri-food systems development, MAIZE Phase-II will seek to increasingly address youth-centered research questions. In 2016 and in the first stage of Phase-II, MAIZE will develop a strategic framework for its engagement with young people and youth-related issues, as well as implement key standards for age-disaggregation in data collection and analysis. The rationale and overall approach of how MAIZE will address youth related issues in Phase-II are outlined in **Annex 3.5**.

1.6 Program structure and flagship projects

MAIZE contributes to the CGIAR Strategy and Results Framework (SRF) and Grand Challenges through a mutually reinforcing framework of five Flagship Projects (FPs) via five highly interrelated and reinforcing Flagship Projects or FPs (**Figure 1.5**). Each of these FPs develop and deliver MAIZE outputs and development outcomes through specific Clusters of Activities or CoAs (**Figure 1.6**).

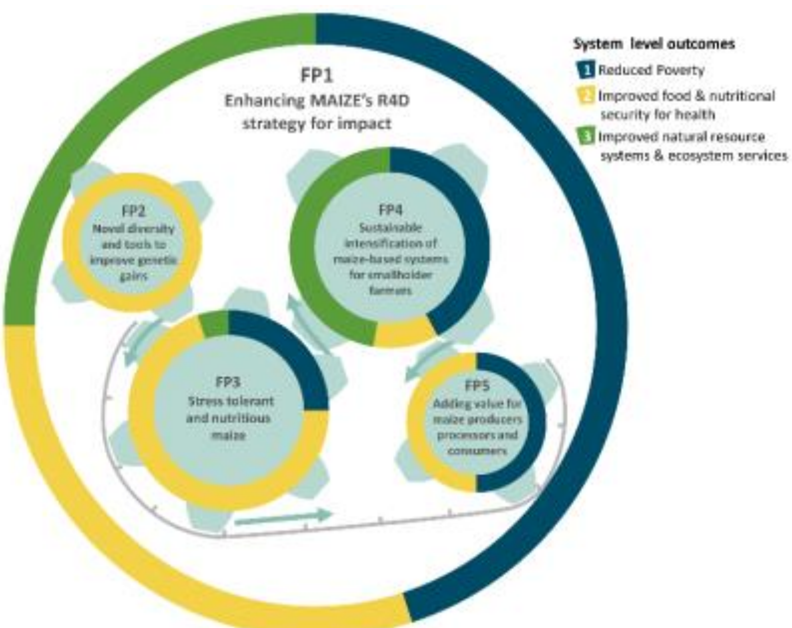


Figure 1.5: MAIZE R4D strategies implemented through five interconnected Flagship Projects (FPs).

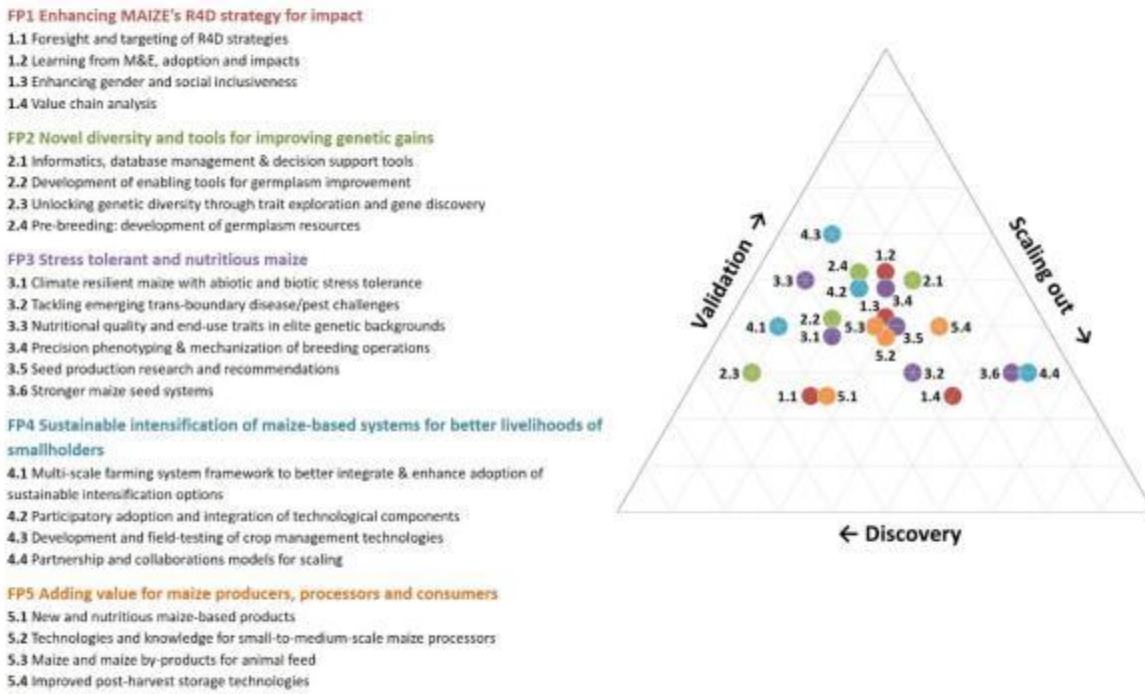


Figure 1.6: MAIZE Flagship Projects (FPs) and their Clusters of Activities (CoAs) in a discovery – validation – scaling-out continuum.

FP1 - **Enhancing MAIZE's R4D Strategy for Impact:** FP1 is key for both strategically informing (through foresight and identification of market/value chain opportunities) and targeting MAIZE research (natural and social science). It enhances MAIZE social inclusiveness by coordinating both strategic gender research and mainstreaming gender transformative research and action. It measures impacts of MAIZE technologies and informs future investments through impact assessment, evaluation and learning. FP1 integrates socioeconomic research with germplasm improvement (FP2 and FP3), systems agronomy (FP4) and value-addition (FP5).

FP2 - **Novel Diversity and Tools for Increasing Genetic Gains**: FP2 draws upon the foundation of diverse genetic resources held in trust in the Maize Genebank, and focuses on characterizing and identifying functional genetic diversity of unexploited landraces and wild relatives for traits of interest. This directly supports FP3 below both public and private sector breeders across the globe. MAIZE also uses its Genebank to characterize and exploit genetic resources to improve crop resistance and adaptability, and in doing so generates significant economic benefits for smallholder farmers in target geographies. Access to, and use of, this diversity and ensuing germplasm is unique to MAIZE and is a core comparative advantage. An equally key role of FP2 is development of novel tools and methods for characterizing (genotypically and phenotypically) maize accessions and breeding materials, which are then utilized in FP3 for enhancing genetic gains and breeding efficiency. In addition, FP2 shares (with public and private sector partners) novel enabling tools and technologies, which are used to increase the speed and accuracy, as well as reduce the cost, of maize breeding. FP2 invests in capacity strengthening of both public and private sector partners in target countries to enhance the utilization of these tools and technologies and germplasm resources. The identification of traits and development of novel germplasm resources are mainstreamed through FP3 in order to increase genetic gains.

FP3 - **Stress Tolerant and Nutritious Maize:** Guided by FP1, FP3 uses outputs from FP2 to develop farmer and consumer demanded high yielding, stress tolerant, healthy, nutritious and market-responsive maize varieties that are targeted at region-specific needs of the poor, and deployed in partnership with over 300 collaborators. The principal aim of FP3 is to facilitate an increased rate of genetic gain in farmers' fields through improved trait and product pipelines, capacity building of partners, and replacement of older/less productive varieties with new climate-resilient varieties. FP3 also lays emphasis on accelerating the impact of MAIZE through targeted demand-led support of the maize seed system (especially SME seed companies and community-based seed producers) in target markets. FP3 supports maize seed sector development of over 200 indigenous, small- and medium-sized enterprises to provide increasing access to the 40-50% of smallholders who are not reached by established seed companies. It leverages germplasm globally and among projects and contributes to climate change adaptation. FP3 targets stress-prone and other areas under-served by the private breeding sector and affected by maize diseases and pests that have a devastating impact on smallholder food production. New to FP3 is the intensification of multi-institutional efforts to effectively tackle new/evolving threats, such as MLN, aggressive weeds such as Striga, and highly damaging insect pests. MAIZE's rapid response to MLN was a clear demonstration of the capacity of CGIAR-led initiatives to respond quickly and effectively to a major challenge, and to galvanize and organize multi-disciplinary and multi-institutional efforts.

FP4 - **Sustainable Intensification of Maize-based Systems for Improved Smallholder Livelihoods:** FP4 focuses on the sustainable intensification of maize-based farming systems. Besides utilizing outputs from FP1 and FP3, FP4 analyzes system diversity, dynamics and livelihoods strategies to further target and enhance the sustainability of MAIZE interventions. FP4 generates and tests sustainable intensification options (such as integrated farming system technologies, diversification options, and institutional innovations) to improve farm livelihoods in maize agri-food systems with high poverty concentration. FP4 uses a better understanding of maize-based farming systems and associated ecosystem services to develop comprehensive, climate-smart G x E x M (Genotype x Environment x Management) solutions co-developed with local partners, farmers and value-chain participants, including young entrepreneurs. FP4 target groups are poor households in systems where maize is a major source of livelihoods and/or food security. Those farmers, characterized by great social heterogeneity, often depend on other commodities (cash crops, livestock) and off-farm income to sustain their livelihoods (Herrero et al., 2010). Through site integration, FP4 will link with other agri-food system CRPs in crop and whole farm diversification. FP4 scales up and out sustainable intensification practices through innovation platforms and other multi-stakeholder mechanisms. New to FP4 is an explicit focus on gaining a better understanding of scaling (up and out), development of scaling models/approaches, and strategic partnerships for scaling (e.g., with Syngenta Foundation for Sustainable Agriculture on maize germplasm and mechanization, and GIZ on enhancing scaling opportunities, including a focused CIM position).

FP5 - **Adding Value for Maize Producers, Processors and Consumers:** FP5 is a new addition to MAIZE. Building on the strengths of partners (e.g., Wageningen University), FP5 aims to identify, validate and deploy technologies that can potentially improve income, employment, and diets of poor and vulnerable people. In collaboration with development partners, FP5 focuses on the facilitation of added value for maize producers, local maize processing groups, and consumers. FP5 also offers linkage points for medium- and large-scale aggregators and processors to tap into local surplus production of maize. It also offers a great opportunity to better incorporate the needs of processors, retailers and consumers in the maize variety development and production processes. Based on analysis of pro-poor options for value-addition by producers and local processing groups, FP5 strengthens maize value chains from harvest-to-fork. It provides an entry point for incorporating the needs of processors, retailers and consumers in the developing world and offers linkages with aggregators and processors to tap into local surplus production of maize and reduce losses.

Cross-Cutting: MAIZE works to strengthen the capacity of national extension and private sector partners to ensure the spread and implementation of knowledge, technologies and best practices. Women and youth are particularly targeted in an attempt to enhance inclusiveness, income earning opportunities and productivity of maize-agrifood systems.

1.7 Cross CRP collaboration and site integration

Significant cross-center and cross-CRP site integration took place during Phase I. MAIZE Agri-Food Systems (AFS) CRP will therefore start from a strong base in Phase II. Most of the achievements in terms of site integration and existing cross-center collaborations are a direct consequence of large, multi-center W3/bilateral projects, particularly in Africa and Asia (see **Table 1.4** below). One of the key challenges AFS CRPs such as MAIZE, face, is defining appropriate “entry points” at the site/system level that define research questions (what are we trying to solve and at what scale?) and, hence, the necessary local, country and regional partnerships and frameworks that will drive integration and scaling on the ground at multiple levels. One key “entry-point” is livelihoods, primarily of farming households, but also including consumers, small-scale processors and other maize value chain actors. People ultimately make the decision on where to invest their human and capital resources within the context of their livelihood system.

MAIZE, in theory, is involved in 19 of the 20 CGIAR Site Integration Country Collaborations, which include all the six ++ countries (see **Annex 3.7**). MAIZE leads site integration in three countries (Nepal, Tanzania and Zambia), of which Tanzania is a ++ country. The process of site integration has just started, but initial discussions suggest the following priorities: (i) national-level integration to align CGIAR with national (and donor) agricultural development strategies in line with CGIAR/GCARD3 processes, and with country investment plans; (ii) identifying key AR4D issues including capacity development – where CGIAR and national programs can integrate their activities more closely; and (iii) improved integration on the ground of CRP and partner activities at well-defined and representative research sites. Site integration was also identified as a mechanism to ensure joint research funding and outputs, effective use of resources, capacity strengthening, and policy engagement, which should strengthen the enabling environment and offer significant opportunities to respond to acute development challenges (e.g., the recent emergence of MLN in eastern Africa and the current 2015/2016 drought in southern Africa).

To improve integration at ground level between MAIZE, other CRPs and partners, MAIZE will: (i) define areas of Interest and identify benchmark sites (learning from Humid-Systems CRP in Phase I); and (II) agree on governance structure and model(s) or plans for integration. In Bangladesh, a ++ country, CGIAR centers have already implemented an initial site integration model in partnership with the Bangladesh Agricultural Research Council, in order to align research objectives across centers and with NARS; (iii) map (geo-reference) and keep research sites, partners and activities updated so that all are aware of current activities; iv) build a database of previous activities and impactful results; and (iv) map innovation platforms (or networks) and other mechanisms for feedback and joint policy initiatives. Good progress has been made with CIAT in Central America towards stronger collaboration and coordination of R4D efforts in the region. A strong community of practice in the area of trade-offs, synergies, characterization, and targeting and livelihood analysis is evolving. This should subsequently assist the overall research design and help conduct participatory research with stakeholders, harmonize data collection, and improve curation, processing and exchange.

Table 1.4: Overview of MAIZE collaboration with other CRPs and Platforms: what MAIZE provides and receives.

	MAIZE				
	FP1. Enhancing MAIZE's R4D Strategy for Impact	**FP2. Novel Diversity and Tools for Increasing Genetic Gains**	**FP3. Stress Tolerant and Nutritious Maize**	**FP4. Sustainable Intensification of Maize-based Systems for Improved Smallholder Livelihoods**	**FP5. Adding Value for Maize Producers, Processors and Consumers**
AFS-CRPs	***Provides and Receives:*** Shared methods, tools and data in relation to foresight, impact assessment, gender, value chain/market analysis, MELIA *See also PIM below*	***Provides***: Tools, models and methods to support research and enhance genetic gains in other crops. Open-access databases, informatics tools, software and breeding support tools (e.g., real-time data curation tools). Cutting-edge biometrics models and methods for genomic selection and high-throughput proxy trait selection developed by MAIZE are widely useful across AFS CRPs. MAIZE's platforms for characterizing and enhancing the use of genetic resources serve as templates or at least serve to inform efforts by other AFS CRPs. High-throughput phenotyping methods and tools, as well as precision phenotyping hubs/sites will be useful to other AFS CRPs. ***Receives***: Similar, from other CRPs and from the Genetic Gains Platform.	***Provides***: Leveraging phenotyping competencies and best practices, with a view to rapidly translate insights of extensive genetics and breeding research undertaken in MAIZE on other relevant crops with lower research intensities. ***Receives***: Cross-commodity approaches, tools, best practices and knowledge for improving MAIZE breeding pipelines; better understanding of G x E x M in mixed cropping systems, where maize is an integral component; leveraging phenotyping facilities, strengths and partnerships of complementary AFS-CRPs (e.g., RICE, WHEAT, DCL).	***Provides***: Methodological approaches to analyze multi-commodity farming systems and target technical interventions within specific agro-ecological, socioeconomic and institutional environments. Agronomy know-how on maize and related technical innovations. Appropriate scale mechanization options. Precision agriculture approaches and nutrient/water management decision support. Framework for baselining and monitoring progress at farm and landscape levels. Business models for upscaling technologies. ***Receives***: Knowledge of other commodities (rice, wheat, legumes – specifically common bean and soybean in maize-based humid tropical ecologies – root and tubers, trees, livestock) to embrace multi-commodity approaches in maize-based systems. Know-how of innovation approaches from RTB. Sharing methodologies and approaches.	***Provides and Receives***: Shared methods, tools and data for analysis of value addition in agri-food systems/value chains; joint analysis of complementarities and interactions in AFS (including maize and its by-products for animal feed); advanced processing and postharvest technologies; shared network of partners (DCL, RTB and Livestock).

A4NH	***Provides and Receives**:* Drivers and trends of staples consumption, prices and food systems; joint impact assessment (biofortified crops)	***Provides***: Genetic diversity and knowledge/tools from gene discovery in MAIZE will accelerate progress in developing nutritious crops and foods. ***Receives***: Through partnerships, phenotypic data to enable the above.	***Provides***: Maize germplasm, markers and breeding tools for maize micronutrients; development of nutrition-dense maize; global network of breeders and SME for commercialization of biofortified maize. ***Receives***: Target areas and priority interventions, HarvestPlus network, including nutrition and scale-up partners.		***Provides and Receives***: Dietary patterns; tools for better data capture and integration; tools for food safety in agri-food systems; food system value addition and scaling-out opportunities. ***Receives***: Target areas and priority interventions, HarvestPlus network, including nutrition and scale-up partners.
CCAFS	***Provides and Receives**:* Improved foresight modeling, targeting (with other AFS-CRPs, PIM), analysis of climate smart innovations (including weather index insurance; drought/heat tolerance; conservation agriculture) ***Receives**:* Global level policy influencing	***Provides***: The key traits targeted by FP2 are climate change-related, e.g., heat, drought and diseases. FP2 also provides big data resources that enable modeling of climate change scenarios and their effects on crop productivity. FP2 provides the genetic resources and the data, without which CCAFS could not have real impacts. ***Receives***: Previous small support to biometrics, which funded research and modeling of climate change effects on crop productivity and trait prioritization for breeding, is no longer provided.	***Provides***: Improved abiotic and biotic stress resilient maize varieties that help farmers adapt to the changing climates in SSA, Asia and Latin America, and especially to drought, poor soil fertility, high temperatures, waterlogging, soil acidity, and pests and diseases. ***Receives***: Linking the environment characterization and crop modeling work under CCAFS, with the work on maize physiology and breeding under MAIZE FP3; participatory evaluation of improved abiotic and biotic stress-resilient maize cultivars within climate-smart villages under heterogeneous production and socioeconomic conditions; scaling-out strategies and partnerships; policy support.	*Provides*: Improve maize agronomy technologies in the context of climate change adaptation and mitigation. Facts, figures and proof -of-concept of adaptation and mitigation options in maize-based systems. Methodological contributions to assess mitigation and adaptation in maize-based systems. ***Receives***: Linkages of agronomy and system research to CC community and increased visibility of our work. Methodological support and know-how from CCAFS on analyses, CC-related data, modeling. Opportunities for W3/bilateral resource mobilization.	

PIM	***Provides and Receives****:* Shared methods, tools and data in relation to foresight, impact assessment, gender, value chain/market analysis; cross-CRP learning/communities of practice ***Receives****:* Gender, foresight, strategic research tools ***Provides****:* New knowledge, data for inter-CRP learning				***Provides and Receives***: Dietary patterns; tools for better data capture and integration; value addition and scaling-out opportunities. ***Receives***: Expertise in value chain analysis and supporting institutional innovations and policies.
WLE				***Provides***: Field- and farm-level knowledge of maize agronomy and systems analysis. Soil and water conservation technologies. ***Receives***: Framework to integrate at landscape level and beyond.	
Genebank platform		***Provides***: Genotypic and phenotypic characterization of genebank accessions, as well as informatics tools to extract knowledge from these data, ultimately enhancing the use and impact of genebank accessions. Knowledge about genebank accessions, including definition of core sets to enhance use of genebank accessions. Informatic tools to inform genebank decisions about gaps and duplications in the collections. Experience on intellectual property issues affecting the use of genetic resources. ***Receives***: Expert knowledge about genetic resources in the genebank. Scientific partnerships to collaborate in the research described above. Conserved and available genetic resources for the research described above. Under the proposed/expanded Genebank platform,	***Provides***: CIMMYT Maize Lines (CMLs) for distribution to public and private sector partners worldwide under SMTA; review of progress and bottlenecks for effective integration of pre-bred germplasm into MAIZE breeding pipelines. ***Receives***: High-value maize germplam (including landraces) that can potentially increase the genetic diversity in MAIZE breeding programs, for traits of interest.		

		leadership in addressing intellectual property issues affecting the use of genetic resources.			
Genetic gains platform		***Provides***: Tools, models and methods to support research and enhance genetic gains. Open-access databases, informatics tools, software and breeding support tools (e.g., real-time data curation tools). Cutting-edge biometrics models and methods for genomic selection and high-throughput proxy trait selection developed by MAIZE will contribute and provide leadership to GGP partners. ***Receives***: As proposed, the GGP will develop a community of practice to ensure sharing of tools and expertise to MAIZE's benefit. GGP investment in "generic" data tools and software should reduce the need for MAIZE to invest in some of these.	***Provides***: Breeding programs that validate and deploy the novel methodologies and tools developed through the genetic gains platform for increasing genetic gains and breeding efficiency; global partnerships with public and private sector institutions engaged in maize breeding; experience in training and capacity building of public (NARS) and private sector (SMEs) breeding programs in SSA, Asia and Latin America. ***Receives***: Low-cost and effective genotyping systems and services (for both high-density marker platform for marker discovery as well as high-throughput marker platform for forward breeding); breeding information system and bioinformatics capacity.		
Big Data platform	***Provides***: Biophysical and socioeconomic data; GIS and RS data sets ***Receives***: Unified approaches among CRPs to the collection, management, access and analysis of big data (biophysical and socioeconomic)	***Provides***: Big data for use in validation of tools. Experience, expertise and tools for managing and using big data. ***Receives***: Support for generic needs, including: (1) access to data storage and back-up; (2) guidelines for data quality control; (3) guidelines for implementing open access; (4) partnerships with advanced institutes experienced in working with big data; and (5) exchange of best practices.	***Provides***: MAIZE generates large volumes of genotypic and multi-location phenotypic data on thousands of breeding materials annually. ***Receives***: Same as in FP2.	***Provides***: Geospatial data and their management/use in projects (e.g., TAMASA, MasAgro, CSISA). Expertise and data from on-going research in precision agriculture. Clear research challenges to frame multi-source data in response to systems research questions. ***Receives***: Know-how on collecting, curating, storing, using, gaining and providing access to large, complex, heterogeneous data sets. Community of practice to share knowledge, experience, approaches and tools.	

1.8 Partnerships and comparative advantage

MAIZE draws on a strong partnership network with diverse contributions from partners for discovery/ innovation, validation/proof-of-concept, and deployment/scale-out, and in addition provides feedback loops at various levels for defining R4D priorities (see **Table 1.5** below and Annex 3.2). The range of MAIZE partnerships covers: (1) CGIAR Centers that implement various CRPs (WHEAT, RICE, PIM, CCAFS, A4NH, DCL AFS, RTB) and collaborate on cropping systems and value chain work in MAIZE target geographies; (2) advanced research institutes (ARIs) and universities on discovery research; (3) NARS partners and governments in the target countries in SSA, Asia and LA, on implementation, and to ensure sustainability of the work and impact; and (4) an array of development partners, especially private sector, regional and sub-regional organizations, extension agencies, NGOs, CBOs, farmers and farmer organizations that validate, adopt, scale-up and scale-out the improved tools/ technologies/practices.

Table 1.5: Some of the strategic and inclusive partnerships of MAIZE under various Flagship Projects.

FP1	**FP2**
• PIM and the University of Minnesota on foresight work • Wageningen UR and the former Humid Tropics CRP on systems characterization and systems trajectories, synergies and trade-off analysis • KIT on gender and development work • Oak Ridge National Laboratory (ORNL) and the University of Minnesota on Big Data Note: While these partnerships may not directly lead to delivery and impact, collaboration with the best and most innovative foresight, systems and gender specialists available ensures that interventions are designed and targeted in such a way as to maximize maize-based systems outcomes and impacts.	• Genetic Gains Platform • Cornell University on high-density genotyping-by-sequencing (GBS), and genomic selection • US and UK-based universities (e.g., Minnesota, Purdue, Alabama, Wisconsin) on genomic selection • University of Hohenheim on R4D on haploid inducers and DH technology • IBP, DArT and JHI on database management, medium-density GBS, and breeding informatics • The University of Barcelona and the private sector on field-based phenotyping • Multinational companies (Monsanto, Pioneer) and partners in SSA (e.g., KALRO, ARC and NARO) on maize transgenic testing under CFTs and stewardship implementation • KALRO and the private sector on the MLN trait pipeline Note: These partnerships effectively help develop novel tools, explore new diversity to enrich the breeding pipeline, and derive decision-support tools that together with other tools increase genetic gains and breeding efficiency.
FP3	**FP4**
• A wide array of NARES, seed companies and NGOs are partners in germplasm development and multi-location testing in SSA, LA and Asia. Introgression of other institutional germplasm and technologies (e.g., Monsanto under WEMA; Pioneer under IMAS) • Some NARES partners (e.g., KALRO and ARC) contribute elite germplasm for product development • USDA-ARS provides maize germplasm for developing MLN resistant and aflatoxin resistant germplasm • Purdue University provides diverse yellow/orange maize germplasm for provitamin A enrichment	• Public sector–NARES in Mexico; Guatemala, Haiti, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Rwanda, Zambia, Zimbabwe; Bangladesh, India and Nepal for adaptive research • Private sector (machinery manufacturers, input suppliers, etc.) for co-invention of technologies • ARIs (KIT, WOCAN, Univ. Illinois, Univ. Sheffield) for household and farm systems analyses • Wageningen UR, Oak Ridge National Laboratory, CIAT, CIRAD, SAIL Earth Institute-Colombia University and ITC for systems frameworks and quantitative analysis at

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- Close to 200 seed company partners and community-based seed suppliers across SSA, Asia and LA, for scaling-up and delivering improved maize seed generated through MAIZE

Note: These collaborations help MAIZE leverage the best germplasm from both public and private sector sources and, through extensive regional testing networks, ensure that the right germplasm is selected for use by smallholders in target countries
</td><td>

landscape scale, and other institutions

- Humid Tropics for cropping systems research and systems modeling
- Water, land and ecosystems CRP for efficient water, nutrient and soils management and reducing the environmental footprint of MAIZE
- Scaling-out of sustainable intensification innovations through public sector (NARES), private sector (machine manufacturers, input suppliers etc.), financial institutions, NGOs (SFSA, Total Land Care, One Acre Fund, etc.)
</td></tr>
<tr><td colspan="2">FP5</td></tr>
<tr><td colspan="2">

- Wageningen UR; Purdue University; EMBRAPA
- PIM, A4NH, DCL AFS and Livestock CRPs
- NARES
- Private sector partners
- Technical Centre for Agricultural and Rural Cooperation (CTA) and KIT for value chain facilitation and gender transformative interventions

Note: Nutrition is a multi-level, multi-cultural and multi-sectorial challenge. Docking FP5 activities with A4NH and PIM is important for effectively addressing the challenge. FP5 will also develop stronger collaboration with ARIs, NARES and private sector partners in maize and maize-livestock value chains to enable adoption and dissemination of the developed products, and advocacy for better integration of value chain work, especially in SSA and LA. FP5 will also collaborate with CRP PIM on the development of tools and methods for assessing postharvest losses.
</td></tr>
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MAIZE Comparative Advantage

The CGIAR Independent Evaluation Arrangement (IEA) team stated in its report on MAIZE (April 2015; [FINAL REPORT: Evaluation of CRP on MAIZE]): *"MAIZE has a clear comparative advantage in supplying improved germplasm at different stages of advancement for the needs of smallholder farmers both in stress-prone and in market-oriented environments. MAIZE also leads in long-term field experimentation, evaluating conservation agriculture, and in organizing regional breeding networks, and it has unique experience in agro-ecological zones that are of high priority for the CGIAR. Furthermore, MAIZE benefits from and contributes to the global reputation and strong credibility of the CGIAR among policy makers and the scientific community. The ability of MAIZE to mobilize efforts for strategic research, technology design and mechanisms for delivery of outputs further adds to the strength and comparative advantage of MAIZE*."

MAIZE partners thus have a proven track record, strong partnerships, and demonstrated outcomes and impacts through development and deployment of improved maize varieties and sustainable intensification options in the maize agri-food systems of SSA, Asia and LA (see **Table 1.6** below).

Table 1.6: Comparative advantage of MAIZE

Area/Theme	Comparative Advantage
Germplasm distribution	Institutions in more than 100 countries, mostly in tropical and subtropical regions, annually request and receive stress tolerant and nutritionally-enriched elite MAIZE germplasm developed by CIMMYT and IITA, as international public goods. This germplasm, with diverse trait combinations, coupled with adaptation to various agro-ecologies, is the key driver behind commercial products developed by NARES and small- and medium-size seed companies in SSA, LA and Asia. MAIZE is also the largest provider worldwide of improved germplasm with abiotic stress tolerance (drought, heat, waterlogging, NUE), resistance to *Striga* and Maize Lethal Necrosis (MLN), as well as Quality Protein Maize (QPM) and provitamin A-enriched maize. The strong pipeline of improved maize germplasm is the result of more than five decades of breeding history, intensive efforts of a dedicated team, and establishment of the largest managed-stress phenotypic network for maize in the public system for a range of traits relevant to smallholders in the tropics.
Sustainable intensification	MAIZE conducts extensive sustainable intensification work, co-designing and implementing sustainable intensification solutions in real conditions with farmers, NARES and other partners in an array of agro-ecologies and under diverse socioeconomic environments. MAIZE undertakes multidisciplinary R4D approaches in partnership with the world's leading research institutions, to increase adoption of sustainable intensification practices and, ultimately, impact.
Rapid response to new biotic threats	MAIZE is at the forefront in tackling emerging threats to smallholders' food security. MAIZE's rapid response to the MLN epidemic in the last four years was a clear demonstration of the capacity of the CGIAR and its public and private partners in eastern Africa to act quickly and effectively, and to galvanize and organize an effective multi-institutional response. This was recognized as a major achievement of MAIZE Phase I by the IEA Report [FINAL REPORT: Evaluation of CRP on MAIZE].
Genebank	MAIZE uses its germplasm bank to characterize and exploit genetic resources to improve crop resistance and adaptability and, in doing so, widens the genetic diversity utilized and breeding gains achieved for traits or genetic variation that are missing in improved germplasm. Access to, and use of, this diversity and ensuing germplasm is unique to MAIZE, and is a core comparative advantage that is made available to the international community.
Expertise	CGIAR partners co-leading MAIZE have highly experienced scientific staff based in SSA, LA and Asia, recognized internationally for their contributions to maize R4D. These teams have strong linkages with public and private sector partners in target countries/regions, besides intensive engagement with farming communities, including women, youth and the socially disadvantaged in maize agrifood systems. MAIZE scientists and managers are widely acknowledged as "honest brokers" of knowledge and innovative technologies. A strong legal team has negotiated access to a substantial number of IPR-protected technologies for use by NARES and SMEs.
Capacity Building	MAIZE provides one of the largest platforms for training and capacity building of students, scientists, technicians and professionals from NARES and SME seed companies on maize R&D, with over 50,000 training days annually, and close to 100 graduate students finishing their degree training every year.
Knowledge Management	MAIZE shares its knowledge and data with the world to enable spillover benefits and to maximize the return on research investment. MAIZE researchers published over 250 articles in academic journals from 2011 till July 2015, with an increasing focus on publishing open-access articles (~30%). Large data sets are also shared with the public, including results from over 17,600 multi-location maize trials (in SSA, Asia and LA) that can be downloaded for use with the MaizeFinder software.

1.9 Evidence of demand and stakeholder commitment

The MAIZE R4D portfolio is continuously being shaped by the demands and priorities expressed by farmers, public and private R4D partners, high-level experts, and donors. Annually, more than 10,000 farmers, seed companies, extension agents, NGOs and NARES partners provide crucial feedback through more than 3000 maize field days and on-farm demonstrations. At least 800-900 of these clients attend one or more of the 30 annual project workshops/review meetings.

During the past four years, MAIZE has organized e-consultations and phone interviews with dozens of high-level experts and donors. For example, 350 MAIZE partners provided crucial advice during the launch meeting of MAIZE Phase-I in January 2012. In 2014, 2015 and 2016, MAIZE received crucial prioritization advice annually from at least 60 partners. Overwhelming support has also been received for the MAIZE-AFS Phase-II preproposal and full proposal.

Representation of MAIZE is sought for international/regional conferences, with participation of policy makers, government representatives, regional and sub-regional organizations, farmers' organizations, farmers, and donors. MAIZE will once again hear the voices of our partners through their strong representation at the GCARD3 event (April 2016), just as it did during GCARD1 and GCARD2.

In Africa, maize is acknowledged as one of the four strategic commodities. MAIZE was strongly represented at the 2012 Dublin II meeting on the CGIAR and CAADP. MAIZE is a key partner of FARA, NEPAD, ASARECA, CORAF, and SADAC. MAIZE responds quickly and actively when national governments request R4D support. For example, MAIZE provided key technical and coordination support for tackling the challenge of MLN in eastern Africa. In West Africa, MAIZE plays a key role in the Nigerian Government's Agricultural Transformation Programme. MAIZE has extensive partnerships and feedback loops with more than 200 private seed companies engaged in scaling-up and commercializing maize seed in SSA, Asia and Latin America. Besides receiving improved maize germplasm (under SMTA) for breeding programs, at least 100 seed companies in the target geographies annually request and receive improved MAIZE pre-commercial hybrids. MAIZE also actively partners with at least 50 seed companies in Africa, besides NARES, in a collaborative testing network of improved hybrids through regional on-station trials.

In Asia, MAIZE, together with APAARI, ICAR, NAAS and BISA, organized a stakeholder consultation of 100 participants in New Delhi, India, in May 2015, on alleviating malnutrition through nutritious maize. In 2014, APAARI, brought together nearly 300 participants from 19 Asian, and 11 non-Asian countries. All of its 15 major recommendations (Paroda et al., 2015) have been addressed in the MAIZE Phase II preproposal. The Government of India's support for MAIZE is unparalleled in Asia through its co-investment in the Borlaug Institute for Sustainable Agriculture (BISA) platform. Private and public sector partners are increasingly joining the International Maize Improvement Consortium (IMIC-Asia) to benefit from improved MAIZE germplasm and capacity development. IMIC-Asia currently has more than 50 seed company members.

In Latin America, MAIZE's partnership with the Mexican Government has become a model for the CGIAR. In this symbiotic relationship, both MAIZE and the Mexican Government developed and operationalized a partnership with MAIZE to address the issues of food security and poverty alleviation in Mexico through the sustainable intensification of maize-based systems. IMIC-Latin America currently has 45 public and private sector members that annually release 14 new MAIZE-derived varieties. Yearly hub meetings and fora are organized where the local representatives of the over 150 public and private collaborators come together and discuss the strategy and work plans.

1.10 Capacity development

<table>
<tr><th colspan="4">1. Capacity Development role in impact pathway</th></tr>
<tr><td colspan="4">Maize seeks to ensure that technologies and approaches for sustainable and profitable intensification of maize-based framing systems are targeted towards smallholders and adopted by them. The MAIZE CRP Capacity Development strategy comprises four objectives for: (i) Enhancing MAIZE science capacity through the development of highly competent maize research workforce. This will be implemented mainly through a graduate and short-term skills and competencies development program. This will involve training courses in key areas in collaboration with leading universities, NARES, private sector, and advanced research institutes, and internships, etc. Capacity will be strengthened in understanding impacts of maize innovations through foresight, targeting, adoption and impact pathways; (ii) Enhancing gender in research design and impact pathways. In particular, the capacity of young women and men to participate in decision-making and to facilitating their access to markets and value chain opportunities and job opportunities; (iii) Improving research-based management, governance, learning and knowledge sharing to increase organizational and institutional capacity through the establishment of a sustainable culture of learning and collaboration by primarily focusing on people, partners and processes. Capacity will be enhanced to use action learning to solve organizational problems and spread innovation through improving the harvesting of research findings, best practices and insightful lessons from seminars, learning events and research projects into knowledge and learning resources and to make these accessible via the MAIZE platform and other delivery modes. Capability will also be enhanced in data and information management, learning and knowledge sharing in all research areas in order to accelerate research feedback, and to comply with CGIAR policies on open- data access, as well as in the development of tools, protocols and support materials to support the development of competency based approaches and collaboration; and (iv) Strengthening capacity in technology dissemination and upscaling of technologies to support sustainable intensification through the establishment and strengthening of innovation platforms, support of extension services, private sector, famer organizations and NGOs.</td></tr>
<tr><th colspan="3">2. Strategic CapDev actions (see CapDev Framework)</th><th rowspan="2">3 Please indicate any Indicators- from CapDev Indicators document or other - that could be used to track progress and contribution to CapDev Sub-IDOs</th></tr>
<tr><th colspan="2"><u>Intensity</u> 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</th><th>Give an indication of <u>how</u> chosen elements will be implemented (Note: more space available for full plan in Annex)</th></tr>
<tr><td>1. Capacity needs assessment and intervention strategy design</td><td>Medium</td><td>This is coordinated at project level and in conjunction with other CRPs and national partners in country coordination/site integration countries.</td><td>• Number of target partners in CRP’s impact pathway with whom capacity needs assessments are carried out</td></tr>
<tr><td>2. Design and delivery of innovative learning materials and approaches</td><td>High</td><td>MAIZE recognizes that tools and guidance can make a significant contribution in building the capacity of AR4D practitioners. Therefore, a set of tools, protocols and support materials will be developed to support the development of competency-based approaches and collaboration. Capability in data and information management should also be enhanced, in compliance</td><td>▪ Number of participants from NARS and research partner organizations attending
▪ Number of knowledge products generated using innovative research approaches and research process management tools and practices</td></tr>
</table>

		with CGIAR policies on open-data access. This activity should take root and become an integral part of maize improvement programs and contribute to the sub-IDOs: enhanced genetic gains through tools and methods; efficient management of databases and informatics tools that enhance accessibility of genotypic and phenotypic data; and enhanced use of genetic resources.	
3. Develop CRPs and Centers' partnering capacities	Low	MAIZE is co-leading efforts to: a) develop a standard approach to monitoring, evaluation and learning across the CRPs, and; b) co-leads GENOVATE collaboration on gender norms. MAIZE also seeks to further strengthen existing and emerging partnering capacities through evolving country coordination plans.	• No. of collaboration vehicles (communities of practice or platforms) managed • Number of joint publications accepted to peer-reviewed journals • Number of technologies/tools adopted across partnering organizations
4. Developing future research leaders through fellowships	Low	Hosting of visiting fellows, post-docs and graduate students; targeted training courses. Different types of short-term training will be used to develop and maintain up-to-date knowledge and skills, including coaching and mentoring, workshops and short-term courses.	▪ Amount of funding for fellowship programs ▪ Number of fellowships provided (disaggregated by level, gender, department)
5. Gender-sensitive approaches throughout capacity development	High	CapDev activities will aim at increasing the capacity to analyze the implications of gender for technology adoption and ensuring feedback from analysis to research, conducting strategic gender research for better research prioritization, and developing quality standards for gender analysis, mainstreaming of strategic thinking, theories of change and gender sensitive approaches, mentoring and coaching female scientists, gender-sensitive extension, breeding objectives more responsive to the preferences of women and men. In particular, they will increase the capacity of young women and men to participate in decision-making and facilitate their access to markets,	• Funding made available for design/review of gender-sensitive approaches in partner projects /programs/policies (disaggregated by type of organization) • Number of new policies that support gender-transformative measures (disaggregated by country) • Number of CapDev activities in gender approaches/toolkits initiated (disaggregated by type) • % of women and youth participating in training courses, extension and

		value chain opportunities and job opportunities.	value chain opportunities • % of women in graduate training
6. Institutional strengthening	High	• MAIZE will target institutional strengthening in public and private sector partners who play a pivotal role in the theory of change along the MAIZE impact pathways. • Communication and advocacy materials for government, regulatory agencies, FOs, youth and women organizations • Investment in facilities, equipment and access to information • Partnership and collaborative research programs	• Number of early career scientists from partner organizations participating in CRP research • Increase in the number of peer-reviewed publications led by NARS students and faculty • Availability of funding from CRPs for institutional strengthening • Number of collaborations (e.g., joint research, training/workshops conducted jointly, shared funding arrangements, common membership in multi stakeholder platforms) with partner organizations
7. Monitoring and evaluation (M&E) of capacity development	Medium	MAIZE will establish a CapDev function to coordinate, monitor and evaluate activities within the overall framework of MAIZE M&E; and adjust the plan as necessary to achieve results.	• Number of internal/external evaluations of capacity strengthening activities undertaken
8. Organizational development	Medium	• MAIZE's investment in organizational development is focused on national agricultural research organizations. • Use of research facilities and knowledge sharing mechanism • Training and action learning with farmers, processors, private sector, women and youth on varietal selection, agricultural practices, postharvest, seed production, entrepreneurship • Training of partners in advanced breeding and other technologies	• Number of workshops or trainings provided on research management, advanced breeding • Number of NARS participating in different training courses • Number of NARS using postharvest technologies, processing, marketing • Increase in funded research projects led by NARS and research partners
9. Research on capacity	Low	MAIZE will target work with	• Number of planning

development		national partners to identify the capacity building needs of boundary partners who play a pivotal role in the theory of change along the MAIZE impact pathways.	meetings with partners on capacity development initiatives • Increase in engagement activities between NARS and brokers and end users of research (identifying research needs and subjects; sharing research results)
10. Capacity to innovate	High	Much of the CapDev in this area will be through "learning-by-doing" in the innovation platforms for upscaling, as well as through the exchange and sharing of practical experiences at different learning workshops and other experience sharing fora. Syntheses of successful approaches with illustrative case studies and other insights drawn from the action research projects and other sources will provide complementary learning materials to be shared through platforms and other channels.	• Number of groups and multi-stakeholder (innovation) platforms facilitated by CRP (disaggregated by gender, socioeconomic status, organizational affiliation) • Adaptation, adoption and spread of innovations associated with participating groups, platforms, households, etc. • Number of NARES-researched and field-tested technologies, patents or practices in valorization (through commercialization or public programs) • Number of technologies/tools adopted across partner organizations

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 (2017, $M)	**(14% of total budget)**					
Budget for Flagships (2017, $M)	**FP1** **23%** **US$ 1,313,914**	**FP2** **15%** **US$ 1,273,844**	**FP3** **7%** **US$ 2,373,224**	**FP4** **0%** **US$ 0**	**FP5** **15%** **US$ 380,471**	**PMU** **10%** **US$ 26,919**

Note: Although FP4 does not reflect the budget for CapDev in the above table, due to the theory of change, in reality FP4 does allocate at least 10% of resources to CapDev activities.

1.11 Program management and governance

Oversight and management of MAIZE is based on the management principles defined in the CGIAR SRF and the standard performance contract of the CGIAR Consortium. The lead center is CIMMYT. It uses institutional capacities and networks, as they are deployed across the globe, and largely focuses on the pragmatic implementation of an R4D agenda, driven by stakeholders' priorities. MAIZE is overseen by an

Independent Steering Committee (ISC) with nine members who combine disciplinary expertise (germplasm, agronomy, socioeconomics, gender, value chains) with regional (Africa, Asia, LA) and CGIAR/public/private sector/farmer organization representation. The Committee is chaired by a non-CGIAR Chair and has been fully operational since 2013. It oversees the MAIZE Director and Management Committee as per CGIAR guidelines.

The **MAIZE Management Committee (MMC),** chaired by the CRP Director, comprises representatives of CIMMYT, IITA, and three non-CGIAR partners as Tier-1 partners: Kenya Agriculture and Livestock Research Organization (KALRO); Instituto Nacional de Investigaciones Forestales y Agropecuaria (INIFAP); and Syngenta Foundation for Sustainable Agriculture (SFSA). INIFAP (Mexico) and KALRO (Kenya) are the largest current research partners in MAIZE, while the SFSA, a non-profit organization, links MAIZE with research capacities in the multinational private sector. Responsibilities for various Flagship Projects are allocated to distinct MMC members. The MMC provides oversight and guidance to FP leaders, discusses and endorses strategies, work plans, partner grants and budgets as an entity. The MMC also oversees and promotes adoption of best practices in data management, and data sharing policies across the Flagships. All MMC decisions are made by consensus or by quorum (2/3 majority and at least 3 institutions represented.

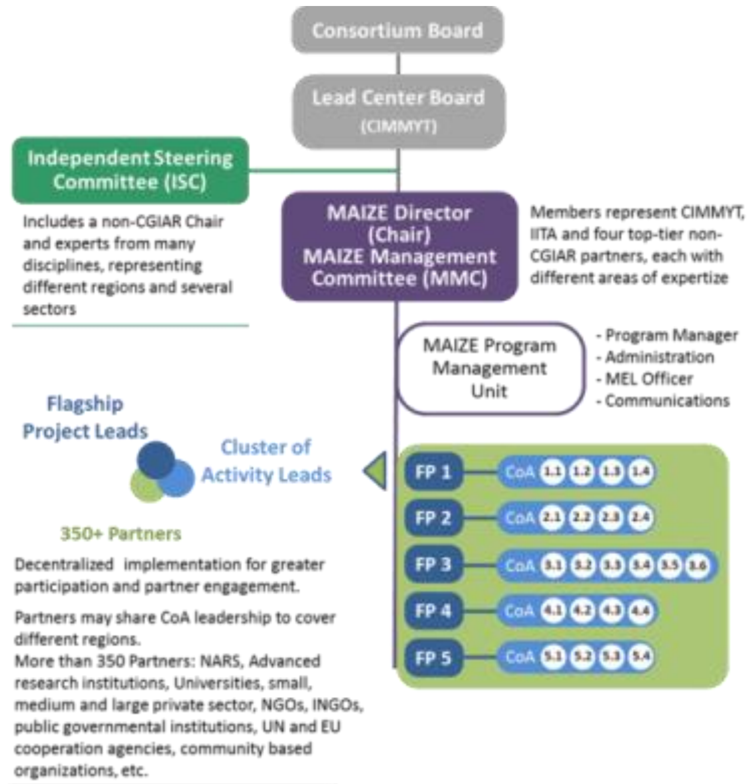


Figure 1.7: MAIZE management and governance structure

Flagship and Cluster of Activity leaders: Flagship and Cluster of Activity leaders will provide the scientific direction to the FP/CoA, contribute to the development of the annual MAIZE Plan of Work and Budget (POWB), guide the execution of POWBs, ensure high quality work, and galvanize contributions to the MAIZE annual report. FP and CoA leaders will actively contribute to resource mobilization and partnership development. MAIZE FP and CoA are world-renowned experts in their respective fields (see Annex 3.8 for details). The professional experience and expertise of the MAIZE Director, Flagship and CoA leaders, and key external partners are reflected in **Annex 3.8**.

Program Management Unit: MAIZE operates a highly cost effective Program Management Unit. Dedicated staff provides core coordination and support to MAIZE in a range of key areas, such as program coordination, administration and finance, monitoring, evaluation and learning, communications and knowledge management.

In response to lessons learned in Phase I and the Independent Evaluation Arrangement's (IEA) external evaluation, MAIZE has already taken key actions and will strive to further improve its governance and management.

- Under the CRP, CIMMYT and IITA created one maize improvement program. This was noted as "highly commendable" by the (IEA's) external evaluation of MAIZE.
- On the 1st of June, 2015, MAIZE appointed a director. The IEA's 2015 Evaluation Report stated that the appointment of a director "is likely to enhance the efficiency and effectiveness of MAIZE leadership and coordination."
- In 2016, MAIZE will take on board a senior expert on scaling and development funded through the German Government's CIM Program and supported by GIZ.

Overall, MAIZE is implemented in a highly decentralized manner to ensure participatory decision-making and effective engagement of regional and local partners for targeted outcomes. Due to the strong regional nature of operations, thematic MAIZE Flagship and Cluster of Activity (CoA) leadership is shared between organizations to cover the global portfolio. Performance of such shared leadership is managed through the accountability matrix for distinct work-packages included, discussed and agreed to by the MMC for the annual work plan. MAIZE implementation is based on partnership approaches with NARES and the local private sector that emphasize: (a) regional priority-setting among and within various Flagships; (b) collaborative planning, execution and assessment towards impact; and (c) needs-driven capacity building. Currently, over 75% of partner funds are managed through participatory approaches at the regional level, and only 25% at the global level.

1.12 Intellectual asset management

MAIZE is committed to the effective and efficient management of intellectual assets at every stage of the CRP life cycle, in order to effectively disseminate research outputs and maximize impact. MAIZE research outputs will be managed in line with CGIAR Principles on the Management of Intellectual Assets and their Implementation Guidelines in a manner that fosters less rural poverty, enhances food security, provides for better nutrition and health, and increases sustainably managed natural resources.

Key issues during CRP implementation and anticipated challenges from an Intellectual Assets (IA) management perspective include:

1. incorporating IA management into the project life cycle;
2. aligning CGIAR IA Principles' requirements with private sector partner interests, as well as with local legislation and local markets/practices;
3. ensuring available funding and human resources for proper implementation; and
4. exercising due diligence in dissemination of CRP outputs.

Item 1 will be addressed through three main activities: (i) participation in the project management life cycle; (ii) implementation of IA principles by the Lead Center, Participating Center and other partners; and (iii) capacity building of partners, subject to available budget.

Key dissemination pathways for maximizing global impact include: open-access repositories, information channels adapted to specific target groups, partnership approaches and capacity development, management as international public goods, partnerships (with NARs, PPPs, etc.), scaling-up/-out, networks, on-farm management and participatory research.

Operations envisioned include incorporating IA management into project cycles; IA tracking; drafting of partner agreements; compliance with CBD and ITPGR and national regulations on genetic resources;

ethics in research and privacy protection; and CGIAR and Center policy development updates. Coordination and decision-making will be handled through the MAIZE-MC (see **Annex 3.10** for details).

1.13 Open access management

MAIZE seeks to ensure that all research data and other information products produced or supported by the CRP are effectively managed to enable further research, development and innovation, leading to the best possible impact on target beneficiaries in accordance with the CGIAR SRF goals. MAIZE fully supports the rollout of the CGIAR Open Access and Data Management Policy, which is a critical component for providing international public goods, safeguarding and utilizing genetic resources, and strengthening research capacity (see MAIZE comparative advantage, **Section 1.8**). CIMMYT and IITA both have Open Access and Data Management Policies that adhere to these principles and are in the process of finalizing data management plans guided by the CGIAR implementation plan guidelines. MAIZE will encourage all non-CGIAR collaborators/partners, irrespective of the funding sources, to abide by CGIAR Open-access/Open-data (OA/OD) principles and to coordinate their open-access efforts with the Lead or Participating Center.

Lead and Participating Center Management will support the early inclusion of open-access planning in the project management lifecycle for new projects. It plans to initiate activities that induce behavioral change in scientists to embrace open-access practices, both within and outside the CGIAR. An overview of CIMMYT and IITA repositories can be found in table 3.9-1 “technical considerations.”

MAIZE will continue to (co)-fund and, through its researchers, participate in further development of OA/OD-related standards, methods and tools (e.g., CGIAR Open Access & Open Data Support Pack), not only within the CGIAR (including in collaboration with the two Platforms) but also focusing on international efforts related to interoperability, dissemination pathways and other topics aimed at increased uptake of CRP data and information products.

1.14 Communication strategy

The communications team at CIMMYT and IITA will provide expertise and strategic guidance to management, researchers and partners, enhancing the effectiveness and impact of MAIZE work, public image and donor support, through these priority activities, in collaboration with R4D partners' communicators and service providers:

- Communicating about the program, the science, the results, and progress towards achievement of the SRF 2022 targets throughout the CRP life cycle. This includes:
    - Document the successes of key projects, partnerships (MasAgro, CSISA, SIMLESA, AIP-Pakistan, SARD-SC, etc.), and competitive grantees, and share the information with relevant audiences through diverse outputs and media.
    - Assisting partners and donor agencies to document successes.
- Promoting learning and sharing of information to improve communications and collaboration with CRP oversight, CGIAR, partners, and within and across CRPs:
    - Maintaining and promoting use of platforms (web sites, social media) with pertinent CRP documentation and tools.

    - Promoting the development and effective use of relevant apps (Slate, infographics, maps, among others).
    - Sharing information about progress and impacts (reporting, studies, and newsletters).
- Engaging with actors on the ground to scale out technologies and practices:
    - Media and marketing campaigns to generate technology awareness, local engagement.
    - Developing outreach material (print, video, other).
    - Catalyzing and other support for extension, including strategic guidance and building local capacity.
    - Working with local NGOs and other CRPs (CCAFs, Climate Smart Villages in India; A4NH) to document farm-level success and learning.
    - Engaging in and providing support for policy dialogue and events (FARA-2013, CGIAR Development Dialogues, Mexico Forum with State Ministers of Agriculture) attended by policy makers, opinion leaders, and other key stakeholders.

1.15 Risk management

In 2014, the MAIZE Management Committee developed and operationalized a risk management matrix. Its purpose is to regularly assess and manage CRP-specific risks, which are mainly driven by the rights and obligations of the Performance Implementation Agreement signed between the Consortium and the Lead Center CIMMYT, as well as CGIAR regulations referenced therein. The matrix identifies a number of risks related to asset management, compliance, general management, change management, finance and technology. Based on the risk assessment, the MAIZE Management Committee agrees on specific mitigation measures. This complements (and does not duplicate) the risk management performed by CIMMYT and IITA Center Management. The top risk in the past and going forward is the in-financial year W1&2 budget changes and delayed transfer of W1&2 funds, which directly affects CRP research and development operations. Up to now, the MAIZE Management Committee has agreed to prioritize CGIAR-led research over partner and management budgets, to maintain the MAIZE partner budget as the most flexible component of the budget and commit a reserve. MAIZE continues to sign only one-year partner sub-grant contracts, in order to manage partner expectations and minimize any delays of payments to them. Given MAIZE experience in Phase I, "non-fulfilled obligations by the partners for commissioned and competitive grants" is considered a low-likelihood and low-impact risk, but remains monitored on a quarterly basis. To date, only a handful of competitive grants have been terminated due to under-performance.

MAIZE continues to proactively monitor maize-based agri-food systems globally through its partner network and on-going research activities. Emerging threats, including severe biotic and/or abiotic stresses, are identified and acted upon rapidly and as appropriate. For instance, during MAIZE Phase-I, maize lethal necrosis (MLN) suddenly emerged in eastern Africa. MAIZE launched an intensive and a rapid response, facilitated by its network of public and private sector partners using W1&2 resources; this led to the mobilization of additional W3/bilateral resources for continued follow-up and comprehensive action. Similarly, El Niño is a recurring weather phenomenon that had particularly damaging effects in eastern and southern Africa in 2015-2016. MAIZE is not only following-up on this proactively but also mobilizing efforts, both short-term and medium-term, in the affected regions through its network of national, regional and international partners.

1.16 Budget summary

MAIZE's budget has been administratively capped by the CO both in Phase-I and in the call for full proposals for Phase-II. This pre-amble is to flag that MAIZE could productively and strategically use significantly more resources – but the below budget request adheres to the caps imposed both on the core and uplift budget. The core budget is based on the pre-proposal budget less 30% (see **Tables 1.8** and **1.9**). The largest Flagship Projects are FP3 and FP4; utilizing approaximatlely 41% and 35% of the total CRP budget respectively (see **Table 1.9**). These FPs are the two foundation stones of the CRP and are the major engines through which the CRP outcome targets will be met. These flagships comprise a high percentage of bilateral and Window 3 funding (89% in both cases) and have a strong national, sub-regional and regional focus (see **Table 1.8**). The two next largest flagships are Flagship 1 and Flagship 2; utilize approximately 7% and 11% of the total CRP budget respectively (see **Table 1.9**). These flagships also comprise a high percentage of bilateral and Window 3 funding (63% and 69% respectively), see **Table 1.8**. Flagship Project 1 focuses at a range of geographical scales from global, regional, sub-regional, national and sub-national. This FP is essential for both prioritizing MAIZE-AFS investments and analyzing the outcomes to which FP3, FP4 and FP5 contribute. Flagship Project 2 has a strong global focus; producing outputs (germplasm, tools, databases) that underpin breeding investments in FP3 and those of national partners in target countries. Flagship Project 5 utilizes approximately 3% of the total CRP budget; management costs are approximately 2% of the total CRP budget (see **Table 1.9**). Flagship Project 5 comprises a balance between bilateral and Window 3 funding (54%) and windows 1&2 funding (56%) and has a strong national, sub-regional and regional focus (see **Table 1.8**). **Table 1.8** and **Table 1.9** illustrates W1&2 base budgets broken down by Program Management, CIMMYT, IITA and partners and W3 and bilateral contribution by CIMMYT and IITA.

Table 1.8: MAIZE Base Budget by Flagship, 2017

	$ Total	Management	$ FLAGSHIP 1	$ FLAGSHIP 2	$ FLAGSHIP 3	$ FLAGSHIP 4	$ FLAGSHIP 5
Base W1&W2 Management	1,622,318	1,622,318					
Base W1&W2 CIMMYT	6,650,941		1,144,720	1,683,078	2,435,179	1,187,964	200,000
Base W1&W2 IITA	2,278,000		300,000	334,000	420,000	849,000	375,000
Base W1&W2 Partners	1,948,741		422,535	268,000	268,000	526,421	463,785
Base CIMMYT W3&Bilateral	41,468,501		2,570,572	4,669,803	23,395,684	10,193,302	639,140
Base IITA W3&Bilateral	14,031,499		601,352	536,223	1,393,616	10,940,791	559,518
Base Total	**68,000,000**	**1,622,318**	**5,039,179**	**7,491,104**	**27,912,479**	**23,697,478**	**2,237,442**

Table 1.9: MAIZE Base Budget by Flagship for Phase-II

	2017	2018	2019	2020	2021	2022	Total (FP)
FP1	5,039,179	5,291,138	5,555,695	5,833,415	6,125,137	6,431,459	34,276,022
FP2	7,491,104	7,865,659	8,258,942	8,671,771	9,105,454	9,560,844	50,953,774
FP3	27,912,479	29,308,103	30,773,508	32,311,683	33,927,668	35,624,551	189,857,993
FP4	23,697,478	24,882,352	26,126,470	27,432,401	28,804,335	30,244,944	161,187,980
FP5	2,237,442	2,349,314	2,466,780	2,590,081	2,719,615	2,855,634	15,218,865
CRP Mgmt.	1,622,318	1,703,434	1,788,606	1,878,014	1,971,932	2,070,551	11,034,854
Total	**$68,002,017**	**$71,402,018**	**$74,972,019**	**$78,719,385**	**$82,656,162**	**$86,790,005**	**$462,541,605**

Table 1.10 and **Table 1.11** illustrate uplift budgets by management, CIMMYT, IITA and partners and W3 and bilateral contribution by CIMMYT and IITA. **Table 1.12** illustrates uplift budgets by FP and funding source.

Table 1.10: MAIZE Uplift Budget by Flagship, 2017

	$ Total	Management	$ FLAGSHIP 1	$ FLAGSHIP 2	$ FLAGSHIP 3	$ FLAGSHIP 4	$ FLAGSHIP 5
Uplift W1&W2 Management	2,374,000	2,374,000					
Uplift W1&W2 CIMMYT	9,976,412		1,717,080	2,524,616	3,652,769	1,781,947	300,000
Uplift W1&W2 IITA	3,417,000		450,000	501,000	630,000	1,273,500	562,500
Uplift W1&W2 Partners	2,982,906		633,802	402,000	402,000	789,631	755,472
Uplift CIMMYT W3&Bilateral	62,202,434		4,153,958	5,381,813	34,092,225	17,625,285	949,153
Uplift IITA W3&Bilateral	21,047,248		902,027	804,334	2,090,424	16,411,186	839,276
Base Total	**102,000,000**	**2,374,000**	**7,856,868**	**9,613,763**	**40,867,418**	**37,881,550**	**3,406,402**

Table 1.11: MAIZE Uplift Budget by Flagship for Phase-II

	2017	2018	2019	2020	2021	2022	Total (FP)
FP1	7,856,868	8,249,711	8,662,197	9,095,307	9,550,072	10,027,576	53,441,730
FP2	9,613,763	10,094,451	10,599,174	11,129,132	11,685,589	12,269,868	65,391,978
FP3	40,867,418	42,910,789	45,056,328	47,309,145	49,674,602	52,158,332	277,976,613
FP4	37,881,550	39,775,627	41,764,409	43,852,629	46,045,260	48,347,523	257,666,998
FP5	3,406,402	3,576,722	3,755,558	3,943,336	4,140,502	4,347,528	23,170,047
CRP Mgmt.	2,374,000	2,492,700	2,617,335	2,748,202	2,885,612	3,029,892	16,147,741
Total	**$ 102,002,017**	**$ 107,102,018**	**$ 112,457,019**	**$ 118,079,770**	**$ 123,983,659**	**$ 130,182,741**	**$ 693,807,224**

Table 1.12: MAIZE Uplift Budget for Phase-II by Funding Source

	Amount Needed	W1+W2 (%)	W3 (%)	Bilateral (%)	Other (%)
FP1	53,441,730	36%	31%	33%	0
FP2	65,391,978	36%	50%	14%	0
FP3	277,976,613	11%	56%	33%	0
FP4	257,666,998	10%	37%	53%	0
FP5	23,170,047	47%	17%	36%	0
Mgt	16,147,741	100%	0%	0%	0

Section 2: Flagship Projects

FP1: Enhancing MAIZE's R4D Strategy for Impact

2.1 Rationale, scope

Maize is one of the three leading global cereals that feed the world (Shiferaw et al., 2011) and a staple food for hundreds of millions of people in the developing world. However, it also has multiple other uses, providing feed to billions of livestock (especially poultry) and increasing industrial and biofuel uses. This makes maize the world's most multi-purpose crop. It also makes maize agri-food systems inherently complex, diverse and dynamic.

An agri-food system (AFS) considers both the agricultural and agro-industrial sectors and how both "interact closely with other production and service sectors. This broadens the vision of agriculture and recognizes the importance of economic and production activities that take place outside the primary production process, as well as highlighting the impact of the political, environmental and social environment on these activities" (Santacoloma et al., 2009). MAIZE Flagship Project 1 (FP1) provides a coherent horizontal guiding platform to help MAIZE embrace an integrated AFS approach in general, and grasp the implications for its international research-for-development (R4D) in particular.

Realizing the potential of agricultural development for poverty alleviation and food security is challenging (IBRD, 2007; Christiansen et al., 2011). An AFS approach broadens the perspective beyond the traditional and narrow focus on the farm and the farmer, including the enabling environment and the forward and backward linkages along the value chain, all the way from input supply through processing and value-addition to the final consumer. At the same time, the maize AFS provides valuable focus and an entry point for R4D.

AFS inherently emphasizes on the supply-demand nexus. Subsistence autarkic maize-based systems that produce maize solely/primarily for household self-sufficiency in isolation are increasingly scarce. They also provide limited prospects for economic development and poverty alleviation. Instead, the burgeoning and diverse maize demand still offers huge developmental dividends for smallholder producers able to produce surplus maize across the developing world. Maize may be generically categorized as a staple food crop – but for millions of resource poor farmers it is seen as a cash crop, inherently scalable, accessible and viable. Indeed, agricultural development of maize producers hinges on market access for both innovation supply/access and as economically viable outlets for surplus production (Frelat et al., 2016). Economic viability hinges on producing maize that meets the demand for maize in terms of maize products (food, feed, fuel) at a competitive price and quality.

MAIZE has a large area of influence. Maize is the major cereal crop in SSA and LA, where many countries still have land available for some degree of area expansion, i.e., land extensification along with sustainable intensification (see FP 4). Maize continues to rapidly expand in importance in Asia. A relatively recent FAO study (Alexandratos and Bruinsma, 2012) foresees growth in global maize production to 2050 of 1.43% p.a. (including 0.83% yield improvement and 0.59% land expansion), driven mostly by the increasing need for animal products and the evolving food and feed industries in Africa and Asia. Maize is also well placed to help feed Africa, the only continent that has seen an increase in the number of undernourished people over the last decades and that will have an additional billion mouths to feed by 2050 – double the current population.

MAIZE has a diverse area of influence. The scope for further maize AFS development in the developing world remains great, but implications differ given maize AFS specifics (different uses, different dynamics, different stakeholders and different public-private complementarities). AFS actors operate in diverse contexts shaped by agro-ecological circumstances, market access and development, population pressure and institutional arrangement and governance structures. This calls for a better understanding of the supply-demand nexus of maize AFS and associated agricultural innovations, and its temporal, spatial and social dimensions. In other words, further research and understanding of the R4D implications and nuances of maize AFS are needed, as well as close integration and strategic alignment with national and regional priorities and complementarities with the private and public sectors based on comparative advantage.

The context in which MAIZE operates is evolving. Both future needs of our beneficiaries as well as the context in which they will operate are shaped by a number of factors: megatrends (global drivers of change), pressures and events that are forcing women and men of different age groups, civil societies and countries to reassess priorities and interventions. Drivers of change include changes in agro-ecological production potential and the comparative advantage of different crops in different locations; changes in diets; changes in the socioeconomic and political/institutional environment that influence innovation, research supply (private sector, ARIs, NARS) and social inclusiveness (women, youth); and changes in maize as an input into the bio-based economy (biofuels, biochemicals). The evolving context therefore calls for systematically re-assessing R4D priorities and implications, including market opportunities and comparative advantages within maize AFS.

Maize AFS and many of the grand challenges are directly interlinked. FP1 enhances MAIZE R4D strategy for impact by enhancing our understanding and thus directly assesses the implications of various Grand Challenges (see **Table FP5.1:** below).

Table FP1.1: MAIZE FP1 and the societal grand challenges

Grand challenge[1]	**MAIZE FP1 contributions**
GC1 - Competition for land from multiple sources	Maize plays a pivotal role as a multipurpose crop and crop with great intensification potential. FP1 helps understand the R4D and targeting implications. Integral to the foresight work are migration and urbanization and how they transform agriculture and rural landscapes.
GC2 - Soil degradation	Understanding barriers to and enabling conditions for adoption of sustainable intensification (SI) practices and communicating these with relevant stakeholders will enhance adoption and help to curb land degradation. Targeting work addresses spatial dimensions of soil and water degradation in maize AFS.
GC5 - Climate change and agriculture	Assessing how climate change could transform maize AFS. Assessing SI practices, improved maize germplasm (drought, heat and waterlogging tolerant), hermetic storage and other climate-smart agricultural practices will reduce production risk; sharing such results with decision makers and

	development partners will create awareness about climate change adaptation prospects in maize AFS.
GC7 - Nutritious and diverse agri-food systems and diets	CoA 1.2 provides empirical evidence of the role of SI practices, germplasm, biofortification and improved storage in enhancing farmers' nutrition and health security and diet diversity, which encourages farmers to adopt SI practices and policymakers and development partners to promote them.
GC8 - Postharvest losses	Identifying working and cost-effective pre- and postharvest technologies, understanding enabling conditions and showing impact of these technologies will enable policymakers and development partners to promote such technologies to reduce production losses. Value chain work identifies options to address postharvest losses and enhance food safety.
GC9 - Employment and income opportunities created for men, women and youth	Value chain work identifies new entrepreneurial and job opportunities. Increased socially-inclusive adoption facilitated through understanding of major barriers. Enabling factors will increase demand for technologies and increase surpluses; this in turn increases employment and income opportunities in maize AFS, including for input supply, production and processing.

[1] Summary title of grand challenges listed in CGIAR Strategy & Results Framework 2016–30 (SRF, 2015).

2.2 Objectives and targets

MAIZE is a strategic, international approach that includes a public-private partnership for maize research-for-development (R4D) to sustainably strengthen resource-poor women and men farmers of different age groups and poor consumers in maize AFS. MAIZE's strategy for impact should be based on a solid understanding of its potential impact and comparative advantage and consequent priorities in the target areas. Ex-ante analysis should make future potential impacts explicit and help in thinking through the implications and impact pathways. Ex-post analysis should make actual achieved impacts explicit – including unintended consequences. Both ex-ante and ex-post analysis will help illustrate MAIZE's value for money to the international community, refine priorities, and guide the learning agenda and future interventions. Its strategy for impact should be cognizant of social inclusiveness throughout by thinking through the implications to ensure intended resource-poor beneficiaries of different age groups are reached and documenting and learning from its achievements in the context of social inclusiveness. Its strategy for impact should assess changes in context to identify new opportunities and changes in comparative advantage and refine priorities accordingly. MAIZE's strategy for impact should hinge on its comparative advantage with strategic consideration of the dynamics of the demand and use of maize products (food, feed, fuel) and research supply (private sector, ARIs, NARS) to establish and refine priorities in its target areas.

MAIZE Flagship Project 1 (FP1) strategizes MAIZE's R4D to enhance impact in maize AFS. FP1 aims to do this by better understanding the supply-demand nexus of agricultural innovations in maize AFS within its temporal, spatial and social dimensions. FP1 inherently recognizes and researches the complexity of maize AFS, their interconnections with environmental, institutional and socioeconomic factors and the consequences of globalization. FP1 will enhance MAIZE's understanding of the big picture and household-level implications in maize AFS, while keeping an eye on strategic priorities of the AFS to avoid mission drift, in accordance with regional and national priorities.

FP1 enhances MAIZE's R4D across all the Flagships, informing strategies for impact through foresight and targeting, learning from adoption and impacts, strategic and transformative gender research, and identifying value chain opportunities. This FP will utilize and expand MAIZE's rich understanding of livelihoods, AFS, markets, agro-ecology, nutrition, social inclusiveness, institutional and other socioeconomic phenomena to help MAIZE prioritize and adjust based on the new evidence. FP1 revolves around multi-disciplinary research to prioritize, target, understand and enhance maize interventions for greatest impact within an AFS perspective. It thereby integrates socioeconomic research with germplasm improvement, system intensification, agronomy and value addition. This Flagship links analyses of completed technology diffusion with current technology pipelines at all development stages and informs the technology development process of its key findings to enhance impact.

FP1 maximizes the value-for-money for MAIZE as a whole by providing horizontal guidance to MAIZE and supporting the internal coherence of all FPs through four specific objectives, each of which is the basis for a Cluster of Activities (CoAs):

1. To inform MAIZE's R4D strategy through foresight and targeting.
2. To learn from MAIZE's interventions through their adoption and impacts.
3. To enhance MAIZE's gender and social inclusiveness.
4. To identify maize value chain opportunities for enhanced livelihoods.

The investment made in FP1 will generate multiple outcomes and contributions to sub-IDOs. By providing horizontal guidance to MAIZE and its outcomes-to-impact, FP1 also contributes to the full range of MAIZE outcomes generated by the other FPs. FP1 documents and enhances MAIZE's contributions to CGIAR 2022 (and 2030) targets as specified in the CGIAR SRF, through ex-ante and ex-post impact assessment activities, with particular focus on: (i) number of farm households adopting improved maize varieties and/or improved crop management practices; (ii) number of people assisted to exit poverty (by gender); (iii) the rate of yield increase for maize; (iv) number of seed companies distributing MAIZE cultivars (e.g., hybrids with one or more inbred parents from MAIZE or containing a significant proportion of MAIZE germplasm); (v) number of people who meet minimum dietary energy requirements (by gender); (vi) the increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse; and (vii) the forest area saved from deforestation.

FP1 plays a critical cross-cutting role in reinforcing many of the SRF guiding principles in MAIZE, including, inter alia, representing and demonstrating its value for money, increasing its operational efficiency, generating public goods with multiple benefits, providing attractive investment opportunities and accelerating impact at scale with a particular focus on women and youth. Its support will improve the use of scarce research resources, accelerate the uptake of innovations and enhance benefits and social inclusiveness for resource-poor producers and consumers in maize AFS in Africa, Asia and Latin America. The geographic focus of FP1 follows MAIZE's target geographies with a prevalence of maize AFS and international development potential (focal countries include Ethiopia, Kenya, Malawi, Nigeria, Tanzania, Uganda, Zambia, Zimbabwe, India, Bangladesh, Pakistan, Nepal and Mexico).

2.3 Impact pathway and theory of change

The FP1 theory of change was developed during a workshop with the Flagship Program team. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. Workshop participants increased their understanding of the CGIAR SRF and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning on a variety of topics.

Using the CGIAR SRF's sub-intermediate development outcomes (sub-IDOs), the team agreed to focus on all sub-IDOs and cross-cutting sub-IDOs chosen by MAIZE's other FPs, given that FP1 supports and contributes to all of them. These include the following eleven sub-IDOs and six cross-cutting sub-IDOs:

- 1.1.2 Reduced production risk;
- 1.3.1 Diversified enterprise opportunities;
- 1.3.2 Increased livelihood opportunities;
- 1.3.3 Increased value capture by producers;
- 1.3.4 More efficient use of inputs;
- 1.4.1 Reduced pre- and postharvest losses, including those caused by climate change;
- 1.4.2 Closed yield gaps;
- 1.4.3 Enhanced genetic gain;
- 1.4.4 Increased conservation and use of genetic resources;
- 2.1.1 Increased availability of diverse nutrient-rich foods;
- 3.2.2 Agricultural systems diversified and intensified in ways that protect soil and water;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated;
- B.1.3 Improved decision-making capacity of women and young people;
- C.1.1 increased capacity of beneficiaries to adopt research outputs;
- D.1.1. Enhanced institutional capacity of partner research organizations; and
- D.1.3 Increased capacity for innovation in partner research organizations.

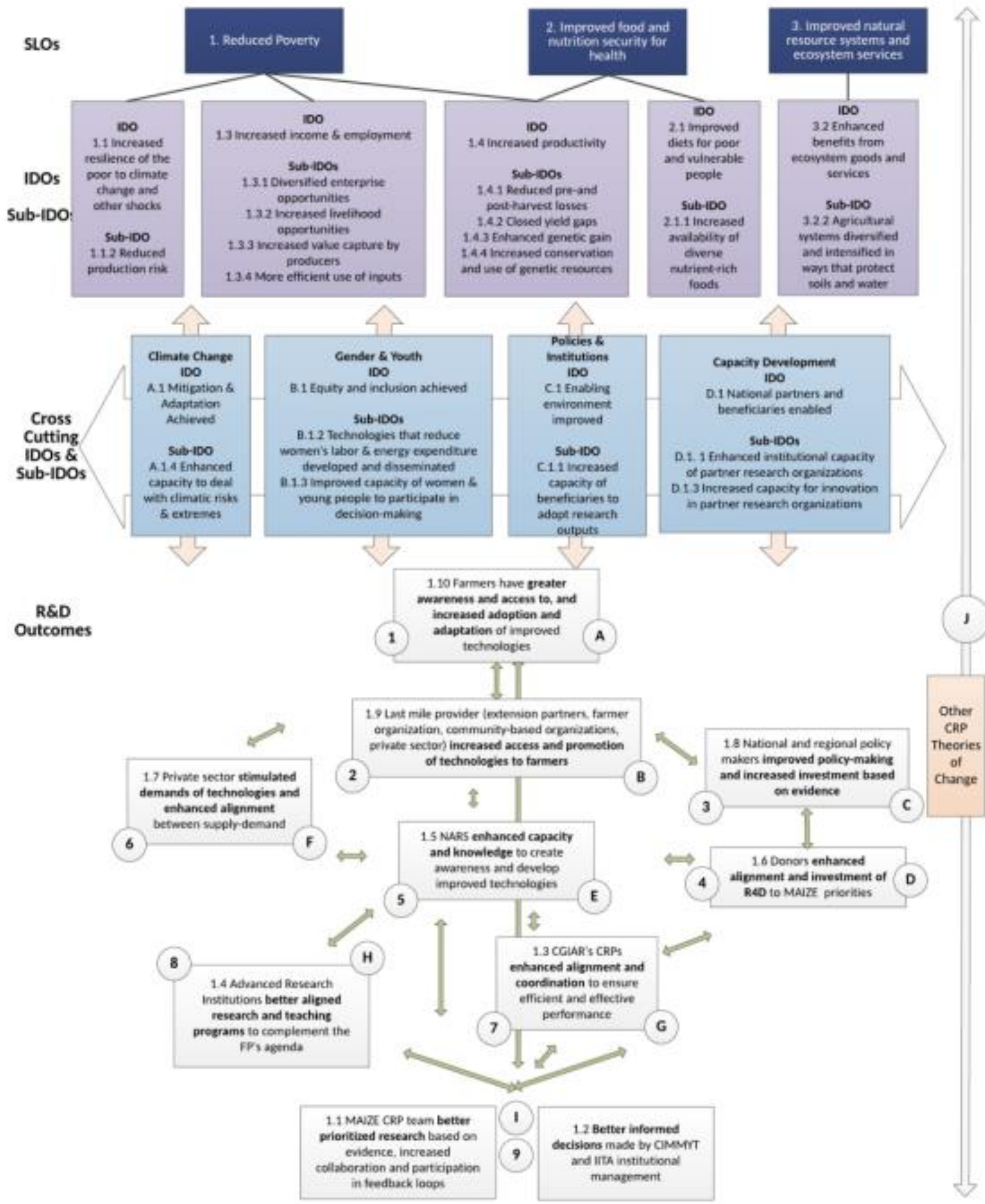
The four sub-IDOs at the core of the FP are: (a) increased value capture by producers; (b) increased capacity of partner organizations; (c) improved capacity of women and young people to participate in decision-making; and (d) increased capacity of beneficiaries to adopt research outputs. Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs. Based on these areas of focus, the team agreed that this Flagship Program contributes to reducing poverty (SLO 1), improving food and nutrition security for health (SLO 2), and improving natural resource systems and ecosystem services (SLO 3) by increasing resilience of the poor to climate change and other shocks (IDO 1.1), increasing income and employment (IDO 1.3), increasing productivity (IDO 1.4), improving diets for poor and vulnerable people (IDO 2.1), enhancing benefits from ecosystem goods and services (IDO 3.2), and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C) and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. The theory of change identified the CRP team and management, NARS researchers, policymakers, donors, private sector and other last mile providers (e.g., extension agents, rural development NGOs, traders) as first users. The ultimate beneficiaries are resource-poor producers and consumers, with a strong focus on finding avenues that ensure majority benefits to women and youth. Current and proposed interventions and associated outputs to support the achievement of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory, as well as the risks that may have the potential to undermine success, were documented.

The theory of change identified 10 interlinked R&D outcomes for FP1. Central to the FP1 mandate, a first outcome would be a MAIZE CRP team that better prioritizes research based on evidence and increases collaboration and participation in feedback loops. This would foster better informed decisions by the institutional management of the lead centers. In addition, FP1 would help to enhance the alignment and coordination of the CGIAR CRP portfolio to ensure efficient and effective performance, including docking with integrating CRPs and complementarities with other AFS CRPs. Research and teaching programs of advanced research institutions would also be better aligned to complement the FP's agenda. Taken together, the foregoing outcomes would enhance NARS capacity and knowledge to create awareness and develop improved technologies. The private sector would also stimulate technology demand and enhance alignment between supply and demand. On the other hand, FP1 is expected to enhance donor alignment with MAIZE priorities and R4D investments. This in turn would result in improved national and regional policy-making and increased investment based on evidence. Taken together, the preceding outcomes would increase the access and promotion of technologies to farmers through last-mile providers and, as a final outcome, farmers would have greater awareness of and access to improved technologies, and would increasingly adopt and adapt them.

This theory of change will be the foundation of the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of data collection and analysis based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the Flagship Program as well as reflecting on lessons and program improvements. Finally, the impact pathways are an integral part of MAIZE's impact assessment strategy, which sets clear priorities for focusing such assessments (in CoA 1.2), provides an analytical framework and elaborates on their use in planning and documenting scaling up of results and impact.

Figure 2.1: Theory of Change for MAIZE FP1: Enhancing MAIZE's R4D Impacts



Assumptions and Risks	Interventions and Outputs

A
• Farmers are aware of and have access to improved technologies
• Farmers see value in improved technologies
• Improved technologies are relevant, affordable, profitable and suitable to farmer needs
 	
B
• Partners have capacity, infrastructure and are willing to scale out technologies
• Risks:
    ○ Lack of an enabling environment for scaling out
    ○ Lack of and changes in funding and political support
 	
C
• Existence of enabling policy environment and government support to make policies based on evidence
• Policymakers are receptive to research information and use it
• Risk: Frequent conflicting and competing priorities
 	
D
• Donors share our priorities and vision, and are willing to collaborate and share knowledge
• Donors have the capacity to collaborate
• Benefits of collaboration outweigh transaction costs
• Risks:
    ○ Priority changes away from agricultural research for development
    ○ CGIAR and CRP mission drifts away from mission, values, capacity, priorities
 	
E
• Partners see value and are willing to collaborate
	1
	• Within the CRP, identify and share adoption constraints and incentives, and perform costs-benefit analysis of technologies
	    ○ Outputs: Constraints, incentives and cost-benefit information and associated data; dissemination documentation
	• Evaluate different approaches for awareness creation and dissemination and share best practices within the CRP
	    ○ Outputs: Best practices; dissemination documentation
	
	2
	• Conduct formalized needs and capacity assessments of partnering last-mile providers, identify gaps and best fits and share findings within the CRP
	    ○ Outputs: Needs and capacity of last-mile providers, gaps and best fit organizations; dissemination documentation
	• Develop and provide targeting information, targeting capacity building and extension material packages
	    ○ Outputs: Information and associated data; training and associated materials; dissemination documentation
	• Conduct research on scaling-out pathways to enhance dissemination of adoption
	    ○ Outputs: Research information and associated data; dissemination documentation
	
	3
	• Identify opportunities for CRP to influence policy-making and share within CRP
	    ○ Outputs: Opportunities

Assumptions and Risks	Interventions and Outputs

• Existence of an enabling environment and government support
• Risks:
  ○ NARS lack financial and human capacity
  ○ Conflict of interests
  ○ Over-commitment or lack of commitment
  ○ Staff turnover
	documented; dissemination documentation
	• Develop and provide policy advice to multiple audiences (CRPs, multilateral organizations, donors, local and regional governments) to influence policy-making
	  ○ Outputs: Policy briefs; advice; dissemination documentation

F • Existence of an enabling environment for private sector involvement
• Private sector is willing to collaborate and share knowledge
• Private sector has the capacity to collaborate
• Benefits of collaboration outweigh transaction costs
• Risks:
  ○ Fails to see opportunities for diverse groups / interests
  ○ Potential for emergence of ethical issues
	4 • Collect, document and share donor intelligence (e.g., motivation, mission, priorities, indicators) within the CRP
	  ○ Outputs: donor intelligence; dissemination documentation
	• Prepare marketing / communication products on research findings and benefits of MAIZE products and share with donors
	  ○ Outputs: Policy briefs; marketing / communication products; dissemination documentation

G • CPRs are willing to collaborate and share knowledge
• CRPs have the capacity to collaborate
• Benefits of collaboration outweigh transaction costs
• Risks:
  ○ CGIAR and CRP mission drifts away from mission, values, capacity, priorities
  ○ Limited investment to develop capacity and collaborate
	5 • Conduct formalized needs and capacity assessment of partnering NARS and identify gaps
	  ○ Outputs: Identified needs and capacity, and gaps
	• Develop and provide training, services and mentoring
	  ○ Outputs: Training and associated materials; services documentation; dissemination documentation

H • ARIs are willing to collaborate and share knowledge • ARIs have the capacity to collaborate • Benefits of collaboration outweigh transaction costs	**6** • Develop and provide strategic advice to CRP on best practices when collaborating with the private sector ○ Outputs: Advice; products; data; dissemination documentation • Develop and provide information on emerging marketing opportunities and on CRP products and services to the private sector

Assumptions and Risks	Interventions and Outputs

I
• Existence of an enabling environment for collaborating, networking, communicating, knowledge-sharing, innovation, critical thinking, taking risks and learning from failures where:
  ○ Feedback and constructive criticism are encouraged and operationalized across the institutions
  ○ Time, resources and incentives are available
  ○ Management provides active and continuous support, guidance and direction
  ○ Benefits of collaboration outweigh transaction costs
• Existence of an effective communication approach
• Risks:
  ○ Lack of ability to retain talent and hire the right people
  ○ Lack of effective tools for collaboration
  ○ Internal performance evaluation processes are not adaptable to support collaboration
 	
J
• Risks:
  ○ New emerging pests and diseases
  ○ Financial, social and political instability
  ○ Climate change
	○ Outputs: Policy briefs; information and associated data; dissemination documentation
	
	7
	• Identify cost-effective opportunities for enhancing collaboration and complementarity with other CRPs and share within CRP, preferably via integration site plans
	  ○ Outputs: Opportunities documented; dissemination documentation
	• Share research findings with other CRPs
	  ○ Outputs: Research information and associated data; products; dissemination documentation
	• Contribute to joint initiative, preferably via integration site plans
	  ○ Outputs: Knowledge; products; data; dissemination documentation
	
	8
	• Define and regularly revise a collaborative research agenda
	  ○ Outputs: Collaborative research agenda (e.g., areas for research, associated institutions)
	
	9
	• Comprehensive and regularly updated foresight and targeting approach (i.e., analysis) based on CRP needs
	  ○ Outputs: Approach; regularly updated data; FP needs
	• Foresight and targeting information provided to the CRP
	  ○ Outputs: Foresight and targeting information and associated data; dissemination documentation
	• Conduct and share cost-benefit analysis of interventions with the CRP
	  ○ Outputs: Cost-benefit information and associated data;

Assumptions and Risks	Interventions and Outputs

	dissemination documentation
	• Conduct analysis of research prioritization and share advice and recommendations with the CRP
	  ○ Outputs: Prioritization information and associated data; dissemination documentation
	• Provision of technical support
	  ○ Outputs: Technical materials; training and associated materials
	• Provide internal and external capacity building on integrating gender and youth
	  ○ Outputs: Training and associated materials

2.4 Science quality

FP1 enhances MAIZE's R4D strategy for impact and is duly cognizant of the need for scientific rigor to ensure the robustness of its scenarios, assessments and products and achieve the intended outcomes. Evidence will be a lynchpin in adjusting internal and external priorities and perceptions. FP1 strives for excellence in science and to maintain science quality. Scopus-recognized peer-reviewed journals remain the preferred publication outlet for its international public knowledge goods.

FP1 encompasses a multidisciplinary team of pragmatic system thinkers and R4D professionals in maize AFS with a high contribution from the social sciences (foresight, impact assessment, gender, value chain/business development), as well as such disciplines as social anthropology, geography, geo-spatial sciences and modeling (crop, bio-economic).

FP1's science occupies a unique niche: it is grounded in reality, multidisciplinary and has a clear international R4D focus on maize AFS. As such it contrasts and complements academia and integrating CRPs such as PIM. The diverse publication outlets reflect FP1's niche while maintaining scientific quality. In a recent external review commissioned by the CGIAR, the MAIZE lead center was recognized for having the highest field-weighted citation impact in the social sciences (2.36), the highest share of the top 10% highly cited social science papers (41%), and the highest number of publications in agricultural and biological sciences (Elsevier, 2014). This is matched by choosing partnerships with outstanding universities and research think-tanks – both within and outside the target geographies. Still, science quality in many of the target geographies is uneven and can imply significant investments in capacity development.

Within the confines of FP1's unique niche, we continue to use proven scientific methods and adapt them to the needs and resources available without compromising scientific quality. Given the multidisciplinary team, many scientific methods cut across disciplinary divides, including the complementary use of quantitative-qualitative approaches. Given the R4D focus and niche, much of the scientific novelty is the application and adaptation of approaches. In collaboration with partners, we are exploring some of the latest methodological advances, including randomized-control trials (e.g., ongoing work on drought tolerant germplasm and weather index-based insurance with UC Davis) and DNA fingerprinting for varietal tracking in impact assessment (for other examples, see **Table FP5.3:**). The increasing availability of data sets also opens up opportunities for repurposing data. Building on MAIZE-1 and other available data sets, we are merging and analyzing complex data sets ("big data"), particularly in relation to foresight and targeting, impact assessment (e.g., Frelat et al., 2016) and gender.

FP1 builds on a body of previous Phase-I and transition work:

- **Foresight and targeting:** Ex-ante work on germplasm improvement thus far has primarily revolved around economic impact assessment of high priority abiotic (Kostandini et al., 2013; in press) and biotic (e.g., maize lethal necrosis: de Groote et al., 2016a; *Striga:* Mignouna et al., 2011.) stresses, and the potential role of biofortification for feed value (Krishna et al., 2014). Targeting work informs the scaling projects (FP3-4), both in relation to germplasm (Hyman et al., 2013; Notenbaert et al., 2013; Homann-Kee Tui et al., 2013) and sustainable intensification (Tesfaye et al., 2015a). Climate change is an integral dimension, particularly in its implications for maize production in target geographies (Cairns et al., 2013; Neufeldt et al., 2013; Shiferaw et al., 2014; Stirling et al., 2014; Tambo and Abdoulaye, 2012, 2013; Tesfaye et al., 2015b) and spill-overs (Chung et al., 2014; Gbegbelegbe et al., 2014).

- **Adoption and impact:** International agricultural research has helped shape the current global maize outlook (Shiferaw et al., 2011). Previous work in SSA has shown good adoption and impact of improved CGIAR maize (Alene et al., 2009, 2015; de Groote et al., 2015). Ethiopia is a central success story (Abate et al., 2015) in ongoing impact assessment work, both in terms of traditional varietal studies using representative panel data (Zeng et al., 2015) and recent explorations into the use of DNA fingerprinting for unambiguous varietal identification (ongoing, to be published in MAIZE-2). Recently published MAIZE adoption/impact work from CIMMYT and IITA includes selected germplasm studies (Beyene and Kassie, 2015; Bezu et al., 2014; Fisher and Snapp, 2014; Fisher et al., 2015; Hellin et al., 2014; Kassie et al., 2014b; Kathage et al., in press; Lunduka et al., 2012; Manda et al., in press; Snapp and Fisher, 2015; Tambo and Abdoulaye, 2012, 2013; Raghu et al., 2015) and sustainable intensification practices (Amare et al., 2012; Kassie et al., 2013, 2015a,c; Manda et al., 2016; Marenya et al., 2014; Micheni et al., 2016; Ngwira et al., 2014; Teklewold et al., 2013a,b), including postharvest storage (de Groote et al., 2013; Gitonga et al., 2013). Another body of published work looks at tradeoffs and gradients associated with adoption of maize innovations, particularly sustainable intensification (Erenstein et al., 2012, 2015 special issue, multiple articles; Jaleta et al., 2013; Valbuena et al., 2012).

- **Gender and social inclusiveness**: Recently published MAIZE work from CIMMYT and IITA includes studies looking primarily at gender and germplasm (Fisher and Kandiwa 2014; Lunduka et al., 2013), sustainable intensification practices (e.g. Farnworth et al., 2015; Marenya et al., 2015; Ndiritu et al., 2014; Teklewold et al., 2013a,b; Gitonga et al., 2013; Manda et al. 2016), climate change (Beuchelt and Badstue, 2013) and livelihoods and food security (Kassie et al., 2014a, 2015b; Mutenje et al. 2016).

- **Value chain opportunities**: Recently published MAIZE work from CIMMYT and IITA includes linkages to farmers' livelihood security (Hellin et al., 2012; Frelat et al., 2016); consumer preference studies on maize (De Groote et al., 2014a,b, 2016b; De Groote and Kimenju, 2012; Gunaratna et al., in press); assessments of alternative maize markets (Hellin et al., 2013; Keleman et al., 2013) and maize uses – e.g., the potential demand for dual-purpose food-feed maize varieties (Grings et al., 2013 special issue, multiple articles); opportunities related to seed supply (Kassie et al., 2013; Kumar et al., 2012; Smale et al., 2015); opportunities related to sustainable intensification (Baudron et al., 2015); and institutional innovations that interact with MAIZE innovations (Donnet et al., 2012; Fisher and Kandiwa, 2014; Fisher and Lewin, 2013; Hellin, 2012; Holden and Lunduka, 2014; Holden and Fisher, 2015; Lunduka et al., 2013; Ndegwa et al., 2015; Shiferaw et al., 2015; Tadesse et al., 2015).

2.5 Lessons learnt and unintended consequences

FP1 helps MAIZE achieve its impacts and contribution to SRF targets and also contributes to shift from a commodity focus in Phase-I to an AFS focus in Phase-II. It has therefore been reorganized to reflect organizational learning and a more strategic focus as compared to Phase-I. Foresight and targeting are significantly strengthened to help foster a more proactive research portfolio and more rigorous prioritization in and across MAIZE FPs systematically. The foresight and targeting draws in part on the close collaboration with PIM, but includes strengthening both internal capacity and other strategic partnerships to provide timely responses and a broader suite of approaches. Climate change is a clear driver taken into account, both in relation to a close collaboration with CCAFS and as cross-cutting in MAIZE Phase-II. Phase-I demonstrates the importance of having an ear to the ground through the presence of staff across the main target regions and an active network of NARES partners. Through its traditional collaboration and strategic partnerships, FP1 aims to better understand and document incremental changes over time that shape a crisis before it unfolds, with the necessary evidence base to help reshape priorities and investment needs, including the changing R&D landscape, public-private complementarities and the public good niches that provide the highest value for money.

The adoption and impact CoA was refocused and aligned with the MAIZE impact assessment strategy, including a clearer focus on learning and feedback loops to enhance impact. This CoA also looks into any unintended consequences of maize innovations and corresponding R&D implications for MAIZE AFS. Being an integral part of the CRP provides the necessary inside views while adhering to objectiveness and scientific quality. The significance of gender (women and youth) for successful delivery will be increasingly mainstreamed into the scaling work in FP3 and FP4. The MAIZE gender team was constrained and stretched in Phase-I, but we were able to strengthen it during the transition phase with new bilateral resources. Youth was implicitly considered as part of gender in MAIZE Phase-I, but received additional impetus in the pre-proposal call and is now being strengthened to become an integral part of MAIZE Phase-II. This builds on lessons from the Phase-I Humid-Tropics CRP and strategic partners. The transition phase postharvest CoA has evolved into identifying value chain opportunities to enhance smallholder livelihoods, while farm-to-fork R4D is moved to FP5.

FP1 also drew more generic lessons from the Phase-I and transition implementation, with the CRP portfolio more clearly showing the complementarities between the CRPs. FP1 similarly complements the other MAIZE FPs. FP1 primarily comprises social sciences, but is not a disciplinary silo. There are clear cross-linkages with other FPs, with some social scientists embedded in other FPs where the level of analysis and emphasis differ, but with clear complementary roles. A surprising lesson was perhaps the continuously evolving funding portfolio and uncertainty. W1/2 still provides essential coherence to the FP1 portfolio, but its strategic use is somewhat curtailed by the annual uncertainty.

2.6 Clusters of activity (CoA)

CoA 1.1: Informing R4D strategies through foresight and targeting

Foresight analysis provides an important instrument to monitor and enhance the understanding of the evolving context in which MAIZE operates. Given the research-to-adoption lag, future beneficiary needs should inform our current priorities. Furthermore, we must take into account the plausible and probable biophysical, socioeconomic and political/institutional context at the time when technologies, including varietal improvement, come to fruition. Both the future needs of our beneficiaries as well as the context in which they will operate are shaped by a number of factors, i.e., global drivers of change, pressures and events. At the same time, MAIZE's diverse portfolio of innovation pipelines at different developmental stages (discovery, validation and scale-out) requires us to make projections of their likely future impact and inform associated tradeoff decisions, e.g., future impacts for poor producers versus benefits for poor consumers. A better understanding of future needs and ex-ante assessments of innovations can help to position and prioritize research investments. In addition to the dynamic context of maize AFS, there is the spatial context calling for identifying spatially diverse needs and opportunities and associated implications for recommendation domains and innovation targeting.

This CoA uses and develops appropriate foresight, targeting and modeling tools by drawing on increasing amounts of georeferenced data and modeling capacities and building on Phase-I achievements (see FP1 quality of science section). Global drivers of change require the use of global analysis tools but the effects of the drivers, pressures and events have varying regional, national and sub-national repercussions. This implies that different sets of tools are also used to analyze the effects at different levels of aggregation. We recognize at least four levels of aggregation where analysis is needed for better predictions and informed research priority setting. The first is the aforementioned global level, the second is the meso-regional/national level, the third is the community/landscape level and the fourth is the household/individual level (both resource-poor producers and consumers). Each level requires different tools, techniques and methodologies, both quantitative and qualitative, in order to assess the future for R&D.

Ex-ante impact assessment is focused on the potential contributions to CGIAR 2022 (and 2030) targets. For all major MAIZE innovation pipelines (FP2-5), product development and placement/targeting are to be based on systematic and forward-looking analyses by 2022, and assessments are to be updated and refined as innovations pass from discovery through validation and scaling-out. This CoA envisages an initial foresight exercise and subsequent updates and refinements so as to: (i) identify potential opportunities/threats and game changers for maize AFS; (ii) assess how major drivers such as climate change and rural transformation will alter maize AFS in the developing world; and (iii) assess the future needs of maize producers and consumers and their implications for maize innovations.

The analysis conducted in CoA 1.1 is closely linked to MAIZE's other FPs. Foresight sheds light on the traits that need to be taken into account in the breeding process to meet future demands (FP2-3) and both foresight and ex-ante impact assessment are crucial for informing innovation pipelines for sustainable intensification and scaling (FP4) of nutritional, postharvest and processing technologies (FP5). There is close collaboration with other CoAs, which includes sharing tools, techniques and methodologies and drawing on the current and historic findings related to changing AFS circumstances regarding value chains, technology adoption and social inclusiveness. The gender-youth nexus, which in the past has tended to be less prominent in global and meso-level models, will receive full attention. Insights into future dietary changes will also better align MAIZE's economic value with nutritional value and dietary diversity (considering that private actors implement many food system actions) and will link back into the breeding and agronomic technology development process through research priority setting.

CoA 1.2: Learning from M&E, Adoption and Impacts

International agricultural research contributes to agricultural growth in developing countries and the achievement of SLOs (e.g., reduction in poverty and food insecurity), although the extent of the contribution remains an empirical question and may result in unintended consequences. MAIZE therefore needs to rigorously document its value for money. CoA 1.2 will undertake adoption and impact studies to evaluate the merits and consequences of new MAIZE innovations in AFS, including impacts on individuals (farmers, consumers, and processors), their communities and national economies and the associated learning in terms of R&D implications.

The impact assessment envisages a two-tier assessment of MAIZE innovations. The macro level will focus on MAIZE germplasm use across the developing world, with systematic stock-taking of varietal releases, MAIZE attribution and estimated adoption. This builds on earlier and recently re-initiated global efforts (Morris et al., 2003; Morris, 2002), supplemented by regional studies, e.g., DIIVA-SSA (Alene et al., 2015; de Groote et al., 2015) and SIAC-Asia. At the micro-level, systematic impact studies will be conducted in selected target countries by building up, to the extent possible, from (nationally) representative and panel data aligned with site integration and existing data sets (e.g., LSMS), and providing regional coverage. Micro-level studies will include MAIZE germplasm and sustainable intensification in maize AFS. Results from the micro-studies will be aggregated to determine the contribution of MAIZE innovations to national agricultural growth and poverty reduction.

Phase-I and ongoing adoption/impact work in MAIZE by CIMMYT, IITA and partners will form a starting point for this CoA. This includes a substantial body of MAIZE studies focusing on the adoption and impacts of MAIZE germplasm and sustainable intensification practices, particularly in Africa and Asia (see FP1 quality of science section). Past studies primarily focus on the farm household level and in the Phase-II, we foresee extending them to maize AFS. Relevant ongoing projects include components in several germplasm projects in SSA and Asia (DTMASS, including an RCT, NuME, HTMA, STMA), integrated sustainable intensification projects (SARD-SC, SIMLESA) and purposive impact assessment projects (e.g., Adoption Pathways, with a large collection of panel data sets).

Adoption studies will complement ex-post impact studies, allowing for earlier learning from processes. CoA1.2 will actively strengthen the necessary feedback loop between research, the agricultural development community and farmers. In the past, communication and transmission of information and technology from researchers to farmers tended to be linear, with limited input from farmers or decision makers. Part of CoA1.2 research will therefore use action and participatory research approaches to inform the adaptation of maize innovations at the initial stages of their development, scaling and adoption in direct collaboration with FP3 and FP4. The MEIA strategy in CoA1.2 will be guided both by pathways that lead to adoption as the (intermediate) outcome and the adoption-to-impact pathways. Therefore future studies are proposed to address behavioral factors underlying adoption and dis-adoption, what farmers are willing to pay, or how they manage risk, as well as the larger-scale questions of impacts on agricultural productivity, income, food security, nutrition, poverty and environmental sustainability.

CoA 1.3: Enhancing gender and social inclusiveness

The CoA provides overall strategic leadership for gender research and guidance in order to systematically integrate gender and social inclusion across all MAIZE FPs. It addresses overarching research questions (**Table FP5.4**) using mixed and complementary methods (quantitative and qualitative) in MAIZE gender and socioeconomic research. It envisages that, by 2022, gender/social inclusion lenses will be routinely applied to MAIZE innovation pipelines and assessments. Differentiated recommendations on choice of intervention and scale-out strategies will systematically support social inclusion of women and youth in maize AFS by 2022.

Ongoing work includes the GENNOVATE initiative to document and analyze how gender norms and agency influence the ability of men, women and youth to learn about, try out, adopt and adapt new agricultural technologies. This is a collaborative, comparative, qualitative cross-CRP research initiative at scale that represents a methodological innovation in the area of social science in the CGIAR in general and in MAIZE in particular. Other recent work that helps to inform Phase II includes strategic and integrative gender research on small-scale mechanization (Eerdewijk and Danielsen, 2015), improved postharvest storage technologies, conservation agriculture, participatory varietal selection (PVS) and seed sector development. Similar progress has been achieved in relation to documenting gender aspects of technology adoption and impact assessment (see FP1 quality of science above). Selected ongoing projects (e.g., SIMLESA, STMA, IMAS, FACASI, WEMA, CSISA) include integrative gender research, e.g., gender responsive technology development and testing in SSA; gender integration in value-chains; R4D and capacity building; service provision and information diffusion in South Asia; assessing the life histories of women's and men's cultivated plots and how they have evolved over time in SSA; and action-oriented pilot projects in SSA to motivate and engage young adults in a range of improved crops, postharvest processing and agribusiness opportunities, and to take agriculture as a viable business.

To facilitate and encourage integration of gender, youth and social inclusion in maize R4D, investments are made to strengthen gender in MAIZE frameworks and procedures, e.g., project cycle, operational policies and M&E, as well as to strengthen overall capacity to identify and address gender issues in maize AFS research in collaboration with partners (e.g., development of a gender competency framework and modular capacity building program, led by Cultural Practice LLC; and gender equality and professional capacity enhancement, led by KIT).

MAIZE I achieved a strong momentum focusing on establishing gender and social inclusion as a prioritized research area for the CRP. In Phase II, the focus will be on consolidating the systematic and rigorous application of established quantitative and qualitative gender and social research methods in the context of maize AFS research, including: (a) strategic gender research that aims specifically to understand the implications of gender dynamics for maize AFS development; and (b) further increasing the integration of gender analysis and targeting in technical R4D projects with a biophysical or socioeconomic focus. As part of this, the concept of sex-disaggregation, understood as going beyond the level of household leadership, will be systematically applied in all people-level data collection and analysis.

CoA 1.4: Identifying value chain opportunities to enhance smallholder livelihoods

Market and value chain analysis provides an important instrument for identifying opportunities to enhance livelihoods in maize AFS and associated R4D implications. AFS evolve in response to demand and supply and are transformed by the consequences of globalization, urbanization, rural transformation and changing preferences, including reduced direct human consumption (in urban centers), changing maize products and processing (CoA 5.2) and increased demand for maize as animal feed (CoA 5.3) in response to rising incomes. Such an analysis goes beyond treating maize as a simple standard commodity and considers maize as a differentiated product with diverse market opportunities. These include specialty maize markets (particularly in Latin America, linked to CoA 3.3), but also Quality Protein Maize (QPM) for human and animal nutrition, vegetable maize, white maize for food and yellow maize for the animal feed industry. As a result, MAIZE's R4D agenda needs to be informed and adapted to major potential market opportunities and game-changers. The growth of the poultry industry in India is one such example (Hellin et al., 2015) that has implications for the quantity and type of maize demanded. Adoption of maize AFS innovations hinges on the incentives stakeholders have in their local context, and can thus be either catapulted or thwarted by input and output value chain opportunities and constraints, along with the presence or absence of supporting financial and business development service providers. Ensuring parallel deployment of new technologies and the evolution of value chains and market opportunities is key for resource-poor stakeholders in maize AFS to capture a substantial portion of the value. This raises issues not just of the types of maize grown but also the interventions that are needed to make these value chains more effective, efficient, equitable and socially inclusive.

This CoA intends to systematically assess maize value chain opportunities in the target geographies and interlinkages with global markets and developments by building on previous and ongoing work (see FP1 quality of science section). A special focus is to assess the potential opportunities and game changing nature of maize utilization. This calls for strong value-chain-driven, farm-to-fork evidence to assist smallholder involvement in maize as a cash crop in Asia. During the previous Phase, partners undertook regional assessments in Asia, SSA and LA and took stock of the value chain opportunities and implications for MAIZE R4D. Other recent value chain work includes consumer preference studies on maize and assessments of alternative maize uses. This CoA draws on the internal capacity at CIMMYT and IITA, while expanding partnerships including with PIM. New collaborative work with CCAFS in East and West Africa (Nigeria) explores weather index-based insurance to reduce the risk faced by farmers and enhance farmer technology uptake and intensification in maize AFS, including as a complement to drought tolerant germplasm.

The main outcome of this work is to provide MAIZE development partners with evidence-based information that could be used to develop interventions along the value chain for the improvement of livelihoods in maize AFS. Also, knowledge generated by this work could help target breeding programs better (by incorporating preferred traits by men and women farmers, processors, feed millers, agro-processors and consumers). This CoA therefore complements targeted R4D by addressing value chain opportunities in FP5. Similarly, this CoA identifies and assesses input value chain opportunities, which then dovetails into work related to developing seed markets and seed market segmentation under FP3, as well as non-seed input value chain development work, such as mechanization and associated business model development under FP4.

2.7 Partnerships

FP1 aligns with the CRP MAIZE partnership strategy. FP1 occupies a unique niche to generate international public goods to enhance MAIZE's R4D strategy for impact. Being led by scientists from the two leading maize centers in the CGIAR gives it a distinct comparative advantage by providing a unique AFS focus and R4D perspective, and an objective and neutral partnership platform to link with strategic partners across the globe. FP1 hinges on multi-disciplinary collaborative research across programs and institutions, as well as on multi-faceted, inclusive and strategic partnerships within the confines of a unique AFS perspective, i.e., the "maize focus" and its theory of change.

Internal to the CRP and central to its mandate, FP1 provides horizontal guidance to MAIZE and supports and contributes to all the other FPs. Although FP1 is inherently multidisciplinary, it has a high contribution from the social sciences, which partner with other disciplines to address strategic R4D issues in maize AFS. These internal partnerships vary by CoA. FP1's foresight and targeting work has clear linkages with the discovery and upstream work in FP2, FP3 and FP5; as well as with the system dynamics in FP4. FP1's adoption, learning and impact work increases in relevance from the proof-of-concept level to downstream scaling out levels in FP3, FP4 and FP5. Gender and youth are most obvious in the downstream levels of the latter three FPs, but need due attention at the higher levels.

External to the CRP, FP1's most direct partners include the CGIAR, advanced research institutes (ARIs) and national agricultural research systems (NARS) (**Table FP5.3:** and **Annex 3.2**). Within the CGIAR, MAIZE aligns with AFS CRPs (e.g., WHEAT, RICE, DCL) and docks with integrative CRPs (e.g., PIM, CCAFS and A4NH), both in terms of specific collaborative projects, site integration and to ensure synergies. The docking of foresight work with PIM has a particularly strong foundation in bioeconomic modeling that will be pursued. PIM focuses foresight at the higher multi-commodity level, whereas MAIZE brings the more granular and focused AFS level. MAIZE provides useful refinement and disaggregation of R&D implications for technologies and innovations; of the major drivers as they apply to maize AFS; and of ground-level realities and agro-ecologies. New opportunities to strengthen docking with PIM beyond foresight are being pursued. Similarly, there are ongoing discussions to explore new opportunities with CCAFS in relation to joint resource mobilization and with A4NH in relation to food system innovations and understanding of changing diets.

Non-CGIAR partners include an array of ARIs and NARS in target geographies. There is a long tradition of partnerships with NARS across the target geographies that is particularly strong where the CRP lead centers have staff on the ground but spilling over into neighboring geographies, particularly in SSA. Some of these partnerships are directly embedded in larger bilateral regional projects led by other FPs but offering active partnership networks that facilitate wide consultation and follow-up, including through annual project stakeholder meetings, and linkages to policy and decision makers (e.g., NARS directors). Regional partner consultation also occurs through commissioned studies (e.g., the ongoing maize markets foresight study through the ReNAPRI network in eastern and southern Africa; regional assessments in Asia, SSA and LA in Phase-I), conferences/regional meetings (e.g., the 2014 Asian Maize Conference) and through regional organizations (e.g., ASARECA; CCARDESA; CORAF; APAARI). Partnerships with ARIs in particular have evolved and been strengthened during the transition phase. Guiding the partnerships is the added value of partners in terms of scientific contribution, which enhances the probability of impact, associated complementarities and synergies with in-house capacity and needs.

Table FP1.2: MAIZE FP1 partners, by CoA

CoA	Type	Partner name	Key contributions
1.1	CGIAR	PIM/IFPRI	Foresight and bioeconomic modeling (Global Futures; PIM 1.1)
		CCAFS	Bioeconomic modeling
	ARI	Wageningen UR (van Ittersum et al.) Univ. Nebraska (Cassman et al.)	Yield gap analysis; poverty, food security and nutrition linkages; geo-spatial framework for upscaling and impact assessment
		Univ. Minnesota (Pardey et al.)	Impact and foresight of MAIZE
		Univ. Georgia (Kostandini et al.)	Ex-ante impact assessment; valuation reduced risk
		Michigan State Univ. (Crawford et al.)	Modeling drought tolerant maize
		Univ. Florida (Boote et al.)	Crop modeling
		Partnership for Economic Policy (Shiferaw et al.)	Economy wide modeling
		Oak Ridge National Laboratory (Jahn et al.)	Data analysis and integration
	NARS	Key countries in South Asia, SSA and LA (see 1.2 below)	Research implementation, including context-specific knowledge, expertise and policy linkages
1.2	CGIAR	PIM/IFPRI	Impact assessment community of practice (PIM 1.2)
	ARI	Univ. California, Davis (Carter/Lybbert)	Impact assessment (drought tolerant maize and weather index insurance randomized-control trials)
	ARI	Gottingen Univ. (Qaim et al.)	Nutritional impacts
	ARI	Harvard Univ. (Gunaratna et al.)	Nutritional impacts
	ARI	Virginia Tech (Alwang et al.)	Impact assessment
	ARI	Wageningen UR (Bulte et al.)	Impact assessment
	ARI	DArT Australia	DNA fingerprinting
	NARS/SRO	Key countries in SSA, including Ethiopia (EIAR); Kenya (Tegemeo; KALRO); Zimbabwe (Uni Zimbabwe); Nigeria	Research implementation, including context-specific knowledge, expertise and policy linkages
		Key countries in Asia, including India (ICAR-NCAP); Pakistan (PARC, NARC); Bangladesh (BARI)	
		Mexico (INIFAP, CP); LAC (IICA)	
		SROs (ASARECA; CCARDESA; CORAF; APAARI)	
1.3	CGIAR	PIM/IFPRI	Gender tools, collaboration, community of practice
	ARI	Royal Tropical Institute (KIT)	Gender integration, equality and professional capacity enhancement
	ARI	Institute of Development	Youth

		Studies (IDS, Sumberg et al.)	
	ARI &	Universities of Glasgow Caledonian; Wageningen UR; Brighton; East Anglia; Cornell	Research collaboration, dissemination of and peer-feedback on research findings and approaches, comparative advantage with regards to specific knowledge and skills, networking, brokering
	NARS	Key countries (S Asia; SSA; LA - see 1.2 above)	
	Develop-ment, extension, NGOs	WOCAN; Total Landcare; Fondo para la Paz	Research implementation, context-specific knowledge and expertise, subject matter expertise, research-into-use collaboration
1.4	CGIAR	PIM/IFPRI	Value chain analysis tools (PIM 3)
		A4NH	Food systems
	CGIAR/-ARI	CCAFS/Columbia Univ (Hansen et al.)	Weather index-based insurance
	ARI	KIT (Hoogendoorn et al.)	Seed value chains; mechanization
		Michigan State Uni (Jayne et al.); Uni Pretoria; ReNAPRI network	Maize markets foresight in eastern and southern Africa
		Wageningen UR (Almekinders et al; Bulte et al.)	Seed value chains; assessing risk management tools
	NARS	Key countries in Asia, SSA and LA (see 1.2 above)	Research implementation, including context-specific knowledge, expertise and policy linkages

2.8 Climate change

Climate change is one of the societal grand challenges and a cross-cutting theme for the CRP MAIZE overall. FP1 enhances MAIZE’s R4D strategy for impact and as such takes due cognizance of climate change and its implications, particularly for adaptation. FP1 helps assess how climate change could transform maize AFS and associated food security and resilience. Most obvious perhaps is climate change as part of foresight analysis (CoA 1.1) – an integral driver of the evolution and stability of maize production over the coming decades. Climate change also increases weather variability and the incidence of stresses and, thereby, the riskiness and potential returns to maize production and innovations. FP1 assesses the adoption and impacts of various climate-smart agricultural practices generated by MAIZE, including improved maize germplasm (drought, heat and waterlogging tolerant), sustainable intensification and hermetic storage. FP1 also takes due cognizance of interactions between climate change and social equity, including implications for gender, social inclusion and youth in terms of differential location, asset base and/or roles in maize AFS. Finally, climate change affects maize value chains, be it in terms of the geography of production, processing and consumption or driving the demand and market for associated innovations (e.g., weather index-based insurance; agri-business models for seed and service providers). Some of the work will be pursued in collaboration with CCAFS, while other work will be an integral part of MAIZE. FP1 will share its results with decision makers and development partners and create awareness about climate change adaptation prospects in MAIZE AFS.

2.9 Gender

FP1 will align with the CRP MAIZE gender strategy, given that it is the institutional home for both the MAIZE gender team and gender strategy. It is also home to a dedicated CoA, 1.3, which focuses on strengthening the integration of gender, youth and social inclusion into maize AFS research and is guided by overarching research questions (**Table FP5.4)**. The approach combines strategic gender research and integration of gender into technical maize research across all FPs, including the other CoAs in FP1. To support and facilitate this process, a special component of the CoA is dedicated to strengthening capacity for gender responsive approaches and mainstreaming of gender into operational frameworks and procedures.

In order to strengthen the evidence base for gender analysis, FP1 has standardized sex-disaggregation in all its people-level data collection and analysis, including in relation to ex-ante and ex-post impact assessments. The findings of gender research in FP1 (both strategic and integrative) feed into and inform research priority setting and targeting across MAIZE.

Overall, FP1 contributes to gender equality and social inclusion in maize AFS R4D by strengthening the evidence base through gender research, foresight analysis, adoption studies, impact assessment and value-chain development; as well as through evidence-based policy recommendations and research targeting and priority setting. In addition to housing the MAIZE core gender team, FP1's other social scientists are active gender and youth ambassadors to ensure the social inclusiveness of MAIZE, as evidenced by a number of recent publications (see FP1 quality of science section).

Table FP1.3: Overarching gender research questions for MAIZE FP1.

FP1: Enhancing MAIZE's R4D strategy for impact
• How do the roles, resources, constraints and priorities of women and men of different age groups differ in maize AFS? What are the implications of this, e.g., for technology development and diffusion? • How do gender relations and access to resources influence adoption of new maize technologies by women and men of different age groups? And how does introduction of new technologies influence gender relations? • How to ensure that introduction of improved maize technologies benefits both men and women of different age groups? • What is the capacity for gender responsive technology generation and dissemination of R&D partners, including advisory services, input and service providers, and seed enterprises? • What are the gendered impacts of maize R4D, who benefits, and how?

2.10 Capacity development

FP1 will align with the MAIZE overall CapDev plan and CGIAR CapDev Framework. Capacity development will revolve around increasing the capability of partner organizations and beneficiaries to innovate, learn and adapt with a focus on mainstreaming strategic thinking, theories of change and gender-sensitive approaches. Other key elements include increasing organizational and institutional capacity to more fully understand the impacts of maize innovations.

Capacity will also be enhanced through sharing findings within the CRP, the provision of targeting information and extension material packages and other innovative training and learning. In conducting a collaborative research agenda and research on scaling out pathways to enhance dissemination of adoption, partners' capacity will be improved through exchange of information, lessons and insights and outputs. The dissemination of research information and associated data, marketing and communication products on research findings and benefits, policy briefs will also contribute to partners' capacity development as well as the provision of policy advice to multiple audiences (CRPs, multilateral organizations, donors, local and regional governments) to influence policy-making.

FP1 uses on-the-job collaboration, fellowships and exchange workshops, knowledge-sharing methods and tools with a focus on mainstreaming strategic thinking, theories of change, a gender lens, multi-disciplinary approaches and analytical rigor. In particular, the FP1 will contribute to develop capacity in equity and inclusion by improving the capacity of young women and men to participate in decision-making and to facilitate their access to markets and value chain opportunities and job opportunities. FP1 also actively pursues opportunities to integrate students (preferably Ph.D.) in the CoAs by welcoming internships and, particularly, thesis research.

2.11 Intellectual asset and open access management

FP1 will align with CRP MAIZE intellectual asset and open-access management, and adhere to associated CGIAR and institutional principles. FP1 generates international public goods to enhance MAIZE's R4D strategy for impact and the underlying principle is to make these easily and widely available. Under FP1, scientists develop tools for data management, stewardship and analysis, in order to improve modeling and make better use of empirical data. These tools will be designed with OA/OD in mind (e.g., provide access). Researchers will make their well-documented yet adequately anonymous and non-confidential raw data (e.g., household surveys) available to other scientists through Dataverse. Prior to uploading to Dataverse, data may be shared on a case-by-case basis through a data-sharing agreement. Although the focus is on international public goods, any underlying confidential data - including sensitive private sector perspectives and trade data - will be respected and treated as such and associated publications will be adequately synthetic and anonymous. Publications are a major FP1 output and will be easily accessible. To maintain science quality, Scopus-recognized journals remain the preferred outlet, and to the extent possible papers will be published as open access therein. When resources limit the possibility of open access, efforts will be made to facilitate access to the underlying research through pre-prints and individual requests within the allowed space. To facilitate access, main findings will also be shared through other communication media, including policy briefs with adequate cross-referencing to the underlying detailed studies.

2.12 FP management

FP1 is managed jointly by the two lead centers, with both joint FP coordination and co-CoA leaders (**Table FP5.5**). Co-leadership allows both centers to have a clear co-leading role and provides clear focal points within each organization for each CoA and the FP as a whole. Co-leadership is further warranted by the geographic complementarities between the two lead centers. Co-leadership also eases integration with MAIZE's other FPs, which is critical for FP1 to provide horizontal guidance.

Table FP1.4: MAIZE FP1 management

FP/CoA Structure	FP1 Coordinators and CoA leaders	
	CIMMYT	IITA
FP1 Enhancing MAIZE's R4D Strategy for Impact	Olaf Erenstein	Tahirou Abdoulaye
1.1 Informing R4D strategies through foresight and targeting	Gideon Kruseman	Sika Gbegbelegbe
1.2 Adoption, impact and learning	Paswel Marenya	Shiferaw Feleke
1.3 Gender and social inclusiveness	Lone Badstue	Amare Tegbaru
1.4 Value chain analysis	Jon Hellin	Tahirou Abdoulaye

2.13 Budget summary

Details of FP1 projected base and uplift budgets for Phase-II, including analysis by funding sources, are provided in **Annex 3.19**. Flagship 1 relies on a strategic combination of a limited W1/2 base to complement the W3/bilateral components. Within the overall FP1 strategic priorities and funding availability, the scope and geographies of W3/bilateral funding will influence how we strategically (re-)prioritize and (re-)allocate W1/2 in Phase-II. The ability to mobilize W3/bilateral resources for strategic core FP1 areas potentially "frees-up" W1/2 to be reallocated to other strategic FP1 areas. Most W3/bilateral resources mapped to FP1 are by definition relevant to FP1 but also reflect donor and partner interests, and may thereby only partially overlap with the strategic core FP1 areas. W1/2 will be used to secure the core base and continuity in each of the four CoAs, but the overall uses may vary over the duration of the MAIZE Phase-II based on our ability to secure strategically relevant W3/bilateral in each CoA and the FP. We envisage each CoA to have at least one substantially active W3/bilateral project closely aligned with the CoA priorities as well as a having an embedded contribution from/to a larger portfolio of W3/bilateral projects where the CoA itself is not the core focus of the project. W1/2 will add strategic value by integrating, strategic complementation, and synthesizing the portfolio of W3/bilateral investments to enhance MAIZE's R4D strategy for impact, and maximize its value for money.

Aligned with the above overarching strategy, **W1/2 resources (under the base budget scenario) will be primarily used for implementing strategic components of the flagship, and addressing the following priorities**:

- Building and maintaining the critical capacity and scope for MAIZE foresight and targeting with a focus across the main target geographies and across the MAIZE product portfolio, including ex ante assessments of core innovation pipelines, improved linkages and synergies with the Big Data initiatives, and expanding the MAIZE focus and relevance in collaborative foresight studies.

- Implementing the core of the MAIZE impact assessment strategy by maintaining a critical MAIZE impact assessment capacity, and ensuring a combination of both strategic country case studies and a regular updating of the revitalized global MAIZE impact studies.
- Implementing the core of the MAIZE gender and youth strategies by strengthening and maintaining a critical MAIZE gender and youth analytical capacity, and ensuring a combination of a strategic research portfolio and mainstreaming to ensure and enhance MAIZE's social inclusion.
- Building and maintaining the critical capacity and scope for MAIZE value chain and market analysis across maize uses, market developments and interactions in the main target areas with a focus of deriving R4D implications, including a combination of global, regional and strategic country case studies.

Uplift W1/2 budget for FP1, if received, will be used to:

- Further strengthen foresight and targeting work (including maize crop and bio-economic modelling capacity and scope) and associated strategic partnerships.
- A harmonized and stronger impact assessment and M&E&L framework that strengthen programmatic learning and support focused investments and increased scope of impact assessments (including more strategic country case impact studies and panel data).
- Stronger support to gender research to provide new opportunities for women across target regions – and build competence, capacity and partner networks related to youth in agriculture R4D and MAIZE AFS.
- Comprehensive farm-to-fork value chain analysis to support maize seed systems innovation and business models through strategic MAIZE AFS case studies.

FP2: Novel Diversity and Tools for Increasing Genetic Gains

2.1 Rationale, scope

FP2 harnesses advances in science and new technologies to develop and validate maize-specific tools and to provide novel raw materials that are mainstreamed in FP3 to enhance breeding efficiency and germplasm enhancement. Such novel tools and methods, including: (i) the discovery and deployment of allelic diversity and molecular markers for key traits; (ii) the development of more accurate, high-throughput phenotyping protocols; (iii) the development and mainstreaming of new data analysis methods; (iv) the development and optimization of breeding methods (e.g., genomic selection and doubled haploids); and (v) tools that simplify storage and use of more comprehensive data sets will accelerate the rates of genetic gain in FP3 breeding activities. As a result, FP2 is an essential "tool discovery, validation and deployment" step in the impact pathway of MAIZE, linking priority setting (FP1) to developing germplasm with a broad genetic base and scaling out products to farmers (FP3), using such diverse germplasm within the sustainable intensification of maize-based systems (FP4) and value addition (FP5) activities.

Significant progress in tool development and mainstreaming has been achieved during MAIZE Phase-I and through the following projects:

1. MasAgro Bioversidad (Seeds of Discovery), resulting in genotyping-by-sequencing of 90% of CGIAR maize landrace accessions, plus phenotypic information for core sets.
2. Drought Tolerant Maize for Africa (DTMA) and Water Efficient Maize for Africa (WEMA), using and learning from marker-assisted recurrent selection for drought tolerance in maize as well as using association analyses of drought tolerant germplasm from diverse sources to promote access to novel alleles for accelerated genetic gain.
3. Genomics and Open-source Breeding and Informatics Initiative (GOBII), pioneering the use of high-density genomics information in mainstream breeding in the public sector.
4. The Integrated Breeding Platform (IBP), allowing the implementation of breeding applications in the public sector, including NARS and companies in low- and middle-income countries.
5. Maize Doubled Haploids – Africa, making maize doubled haploid technology accessible to NARS and seed companies in Africa.
6. See **Table FP2.1** for FP2 contributions to the CGIAR Grand Challenges.

Table FP2.1: FP2 Contributions to CGIAR Grand Challenges.

Grand Challenge	MAIZE FP2 Contributions
GC1: Competition for land from multiple sources: food and feed crops, livestock, biofuels and biomaterials, forest products, conservation, urban expansion, and a host of other ecosystem services.	• Improving input use efficiency of maize means increasing yield with current input levels, including land use. • Increased yield and stability means more food produced on less land, using fewer inputs.

GC5: Climate change threatens agriculture, while at the same time agriculture is a substantial producer of greenhouse gases.	• Bringing together multiple types of data (e.g., genotypic, phenotypic, interaction with soil microbes, changing CO_2 levels, etc.) to better understand GxExM interactions could lead to the identification of new genes useful for tolerating climate change or of germplasm adapted to negative conditions caused by climate change (in 2.3). These data could also be used to deliver better genotype- and environment-specific recommendations for field management (in 4.2 and 6.2). Similar measures aimed at developing varieties that use less N fertilizer could also promote climate-smart agriculture (given that N fertilizer produces substantial greenhouse gases). • Identification of broad reserves of genetic variation and provision of knowledge to enable adoption of that variation will contribute to the development of more durable climate resilient varieties.
GC6: Diminishing genetic resources. Between 7 and 25% of vascular plant species are under threat of extinction by 2050.	• CIMMYT is the guardian of over 25,000 maize accessions in its genebank. A systematic effort to explore genetic variation through pre-breeding and make the diversity usable in breeding is currently underway.
GC7: Nutritious and diverse agri-food systems and diets are becoming more important. Increased consumption of animal products, fruits and vegetables alongside traditional cereal staples offers scope to improve nutritional and health outcomes among the under-nourished.	• Identification of broad reserves of genetic variation and associated knowledge enables adoption of such variation in developing maize varieties with enhanced nutritional quality and productivity.
GC8: Postharvest losses of crop, livestock, fish and tree products to pests, spoilage and spillage are estimated at 30% to 50% globally. Reducing these losses offers considerable opportunities to improve food availability and affordability.	• Bringing together multiple types of data (e.g., genotypic, phenotypic, access to and adoption of adequate storage technologies) (through connections to 5.3) could lead to the identification of new genes useful for resisting postharvest pests or germplasm adapted to postharvest pests (in 2.3). These data could also be used to enable better foresight, targeting and policy recommendations (in 1.1 and PIM).

2.2 Objectives and targets

The theory of change (ToC) underlying FP2 (**Figure 2.2**) shows how FP2 outputs contribute to specific sub-IDOs, especially: (a) enhanced genetic gains (through tools and methods that enable more efficient management of breeding programs, new/additional genetic variation and its use, increased selection intensity, and decreased cycle time in breeding programs);(b) increased conservation and use of genetic resources (databases and informatics tools that enhance accessibility of genotypic, phenotypic and other data, facilitating enhanced use of genetic resources, including those held in germplasm banks); (c) enhanced capacity to deal with climatic risks and extremes (through FP3); (d) enhanced institutional capacity of partner research organizations (open access tools, e.g., for electronic data capture or for data analysis and decision support; methods for enhancing efficiency in breeding; tools and methods for diversity assessment and identification and use of beneficial alleles; and (e) enhanced collaboration with partner organizations to develop research outputs (through capacity building courses, workshops, graduate student mentorship, visiting scientists, etc.).

Key performance indicators for FP2 include:

- Number of breeder-ready markers/high-value haplotypes for prioritized traits identified and validated (under FP2) and deployed in breeding programs (FP3)
- Reduction in cost of DH development process based on research undertaken in FP2
- New tropicalized haploid inducer lines developed, disseminated and used by MAIZE partners
- Decision-support tools developed, disseminated and used by MAIZE partners
- New source germplasm developed and used in breeding programs
- Number of public/private institutions trained on enabling tools for increasing genetic gains
- Number of public/private institutions implementing novel breeding strategies developed under FP2

Target Countries/Geographies and First Users

The scope of FP2 is global. The first users of the outputs of FP2 will be MAIZE FP3 breeders, including CIMMYT, IITA, NARES and private sector partners across SSA, Asia and LA.

2.3 Impact pathway and theory of change

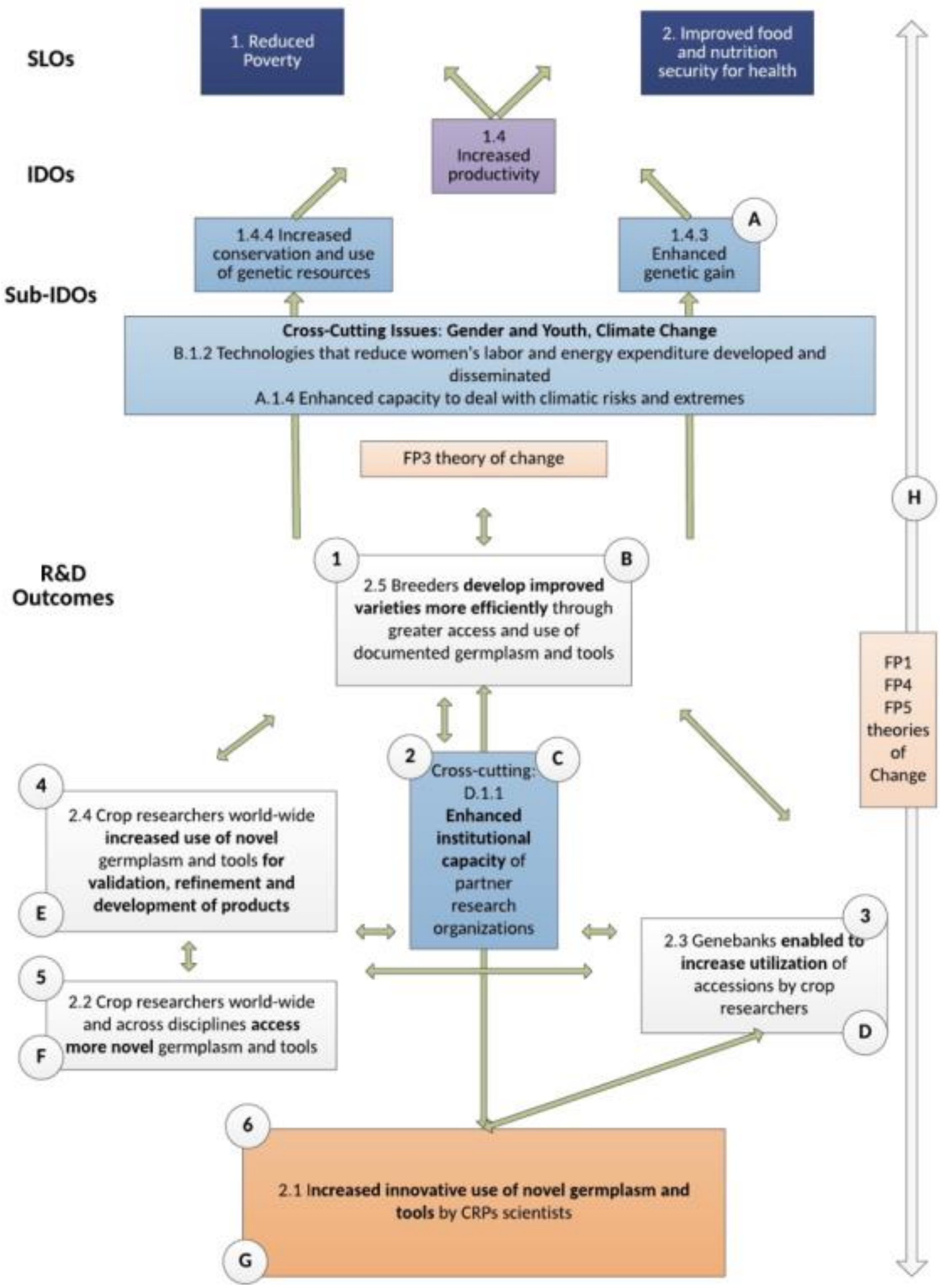
The FP2 theory of change was developed during a joint workshop that encouraged sharing and learning across Flagship Program teams from both MAIZE and WHEAT CRPs. Using the CGIAR Results Framework, the team agreed that the primary focus of FP2 is on two sub-IDOs and three cross-cutting sub-IDOs:

- 1.4.3 Enhanced genetic gain;
- 1.4.4 Increase conservation and use of genetic resources;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated; and
- D.1.1. Enhanced institutional capacity of partner research organizations.

Sub-IDO 1.4.3, related to enhanced genetic gain, encompasses all elements of gain sought by the CRP, including yield, abiotic, biotic and quality traits.

Based on these areas of focus, FP2 contributes to reducing poverty (SLO 1) and improving food and nutrition security for health (SLO 2) by increasing productivity (IDO 1.4) and enhancing the cross-cutting issues of climate change (A), gender and youth (B) and capacity development (D). The pathway of change illustrates the causal relationship between research and development outcomes and sub-IDOs. Partners involved in the pathway of change are identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes are mapped. Finally, assumptions describing the contextual underpinnings of the theory as well as the risks that have the potential to undermine success are documented. This theory of change will be the foundation of the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of data collection and analysis based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the Flagship Program as well as reflecting on lessons and program improvements.

Figure 2.2: Theory of Change for MAIZE FP2:
Novel Diversity and Tools for Increasing Genetic Gains



Assumptions and Risks	Interventions and Outputs
(A) • Enhanced genetic gain encompasses all elements of gain sought by the CRP (e.g., yield, abiotic, biotic and quality traits) (B) • Breeders are adequately funded and willing to adopt and adapt documented germplasm and tools • Risks: ○ Relevant climate predictions are not precise ○ Unanticipated combinations of abiotic stresses occur ○ Unanticipated pests and/or diseases appear (biotic) requiring new research in germplasm and tools (C) • Conducive environment for capacity building • Existence of effective communication and dissemination capacity and systems • Effective assessment of the needs and capacity of partners (internal and external) • Risk: Staff turnover reduces capacity building efforts (D) • There will be continuous demand for documented germplasm and tools • Technologies are cost-efficient (E) • Crop researchers are adequately funded and willing to use documented germplasm and tools • Feedback loops exist to ensure effective communication between CRPs scientists, crop researchers, breeders and genebanks • Strong collaboration exists between CRPs scientists, crop researchers, breeders and genebanks • Risks: Lack of uptake due to the existence of disincentives	(1) • Develop and provide training to breeders in new methods ○ Outputs: training and associated materials • Disseminate new documented germplasm by demonstrating yield gain potential via open-access channels ○ Outputs: documented germplasm, data, dissemination documentation • Develop marketing approaches, methods and skills to share tools and documented germplasm developed by FP2 ○ Outputs: marketing approaches, methods, and associated dissemination documentation; training and associated materials • Identify and implement institutional incentives for knowledge-sharing (e.g., data-sharing measures) and incentivize via employee performance review, including support for publication ○ Outputs: measures for knowledge-sharing, knowledge, dissemination documentation, employee performance review (2) • Develop and implement a capacity building strategy and plan ○ Outputs: Capacity building strategy and work plan, associated capacity building documentation • Provide appropriate infrastructure support ○ Outputs: technical advice, infrastructure (e.g., hand-held data logger, labs) • Provide research support services ○ Outputs: documentation associated with services (e.g., double haploids, markers, phenotyping) • Technical backstopping ○ Outputs: documentation associated with backstopping (e.g., training, IT tools, biometrics)

Assumptions and Risks	Interventions and Outputs

F
• CGIAR has the lobbying power – and uses it - to influence increased international exchange of germplasm
• Target partner countries have/move towards international germplasm exchange policies and practices
• Availability of resources and existence of capacity for dissemination, training and backstopping
 	
G
• Funders acknowledge need for holistic solutions
• Scientists understand the needs of beneficiaries and the context in which they live
• Availability of resources and time to conduct needs and capacity assessments
• Risks:
    ○ Donor funding and accountability structure may inhibit innovation
    ○ Relevant intellectual property landscape may change
    ○ Intellectual property issues may constrain use and dissemination of germplasm and tools
 	
H
• Existence of an enabling environment allowing scientists to take risks, innovate and learn from failures
• Scientists have multidisciplinary curiosity
• Risks:
    ○ Financial, social and political instability
    ○ New emerging pests and diseases
    ○ Climate change
	3
	• Develop and use informatics tools for diversity analysis
	    ○ Outputs: diversity analysis data
	• Identify and improve accession and passport information
	    ○ Outputs: accession and passport data
	• Rationalize dynamic core sets
	    ○ Outputs: sets
	• Explore and complete global diversity in other collections
	    ○ Outputs: accession and passport data, dissemination documentation
	• Disseminate characterization of germplasm
	    ○ Outputs: characterized germplasm, dissemination documentation
	• Create databases and consolidate data to manage information
	    ○ Outputs: databases, data
	
	4
	• Develop and provide training and services (e.g., backstopping)
	    ○ Outputs: training and associated materials; services documentation
	• Support partners to properly plan for sustainably taking over complex tools (e.g., Green Global Foundation)
	    ○ Outputs: advice, tools, dissemination documentation
	• Develop and implement tool deployment strategies and specialists
	    ○ Outputs: deployment strategies, training and associated materials
	• Build customer satisfaction and feedback loop between partner researchers and CRP and between FPs
	    ○ Outputs: surveys or other customer satisfaction tools, and associated responses
	
	5
	• Conduct formalized needs and capacity assessment
	    ○ Outputs: Needs and capacity identified

<table>
<tr><th>Assumptions and Risks</th><th>Interventions and Outputs</th></tr>
<tr><td></td><td>

Develop and share value proposition/business models
Outputs: models and associated dissemination documentation
Develop and share an integrated holistic product and process description (e.g., protocol and documentation; training and application; documented germplasm, data and markers; accession and passport data) and incentivize via employee performance review
Prepare and share comprehensive germplasm development documentation as a service to next users (including meta data development for IWIN)
Outputs: protocols and associated dissemination documentation, training and associated materials, germplasm data and markers, accession and passport data
Develop communication channels and networks (internal and external) to share product description
Outputs: communication channels and materials; networking tools
Advocate (jointly with CRP FPs and other CRPs) for open access to data and documented germplasm
Outputs: advice, position papers

6

Develop/refine breeding approaches for targeted environments and beneficiaries (e.g., incorporate GS, DH, hybrids, gene editing)
Outputs: breeding approaches
Improve existing phenotyping tools and develop new ones (e.g., remote sensing, sensory, image-based non-invasive) and other tools as deemed appropriate
Outputs: phenotyping and other tools
Improve existing, develop and use genotyping tools (e.g., sequencing, GBS)
Outputs: genotyping tools

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Assumptions and Risks	Interventions and Outputs

	• Characterize breeding target environments (e.g., agro-ecological zone) and target beneficiaries
	  ○ Outputs: breeding target environments characterized, breeding target beneficiaries identified
	• Conduct high quality phenotyping in well managed field environment, including confined field trials
	  ○ Outputs: phenotyping trial data
	• Biotechnology to generate new diversity (e.g., genome modification, genome editing, mutation)
	  ○ Outputs: germplasm data
	• Perform pre-breeding (e.g., wide-crossing, targeted pre-breeding driven by trait discovery, use of different approaches, use of exotics)
	  ○ Outputs: pre-breeding germplasm data
	• Discover, document and share germplasm characterization driven by traits, biotic, abiotic factors, including quality and agronomic needs
	  ○ Outputs: germplasm data and associated dissemination documentation
	• Discover, document and share markers for unique alleles/haplotypes
	  ○ Outputs: marker data and associated dissemination documentation
	• Foster effective networking with other initiatives, especially upstream
	  ○ Outputs: Scientific information regularly shared and received
	• Develop and implement integrated germplasm information system (genealogy, phenotypic, genotypic, sensor, and environmental data)
	  ○ Outputs: Integrated germplasm information system

2.4 Science quality

Examples of novel and cutting-edge science in FP2 include:

- Establishment of multi-disciplinary teams to improve communication and collaboration through stages of the discovery-validation-deployment pipeline of new tools from FP1 to FP5 (across FP2).
- Pioneering work and collaboration with other AFS CRPs (DCL, RICE, WHEAT) and proposed platforms (Genetic Gains and Big Data) on informatics tools to integrate large complex data sets into decision support tools in the framework of the IBP (CoA 2.1).
- Development and validation of cutting-edge, novel biometrics analysis methods, especially in the area of genomic selection (CoA 2.1).
- Contribution to the development of the tropical maize reference genome (CoA 2.3).
- Utilization of improved DH inducer lines and optimized doubling protocols to reduce DH development cost (CoA 2.2).
- Implementation of peer-reviewed haplotype advancement strategy to ensure rigorous and unbiased scrutiny of scientific results supporting deployment decisions (CoA 2.2 and 2.3).
- Identification and use of molecular tools to modernize and accelerate resistance breeding programs (CoA 2.3).
- Implementing scale-appropriate state-of-the-art seed chipping technology through strategic partnership to enable significant reduction in tissue sample collection cost and turn-around time (CoA 2.2 and 2.3).
- Implementation and development of enabling tools to accelerate utilization of elite temperate germplasm and landrace accessions in elite tropical breeding pipelines (CoA 2.2, 2.3 and 2.4).
- Utilization of gene editing technology to create novel variation for breeding pipelines (CoA 2.3).
- Understanding mechanisms of polygenic resistance to the parasitic weed *Striga,* for pyramiding genes to achieve durable resistance through FP3 germplasm development efforts (CoA 2.3).

2.5 Lessons learnt and unintended consequences

Major lessons learned from previous research are: **(**a) research and resources must be invested to reduce the costs of doubled haploids and make the technology attractive to users and a sustainable, integrated component of the breeding pipeline; (b) significant improvements in database management coupled with efficient, user-friendly decision-support tools will be necessary to routinely use the high volumes of genotypic and phenotypic data collected by modern plant breeding programs; (c) genomic selection (GS) has not been consistently effective for very diverse and unrelated populations; GS implementation will therefore be slowed while careful coordination and planning with breeding teams develops, augments and updates appropriate training sets for accelerating breeding gains; and (d) significant reduction in the cost of DNA extraction and genotypic data generation will be required to enable large-scale and routine use of molecular tools within the breeding pipeline targeting low- and middle-income countries.

2.6 Clusters of activity (CoA)

FP2 is organized in four CoAs that define an impact pathway (**Figure 2.2**). The CoAs collaborate to provide breeding programs with tools and models to enhance breeding efficiency and the rate of genetic gains in support of MAIZE's mission to increase the profitability of resource-poor maize farming systems, reduce production risks and improve input use efficiency.

- **CoA 2.1: Informatics, database management and decision support tools**. Provides the lead for data management and stewardship. The ability to manage and apply novel tools to extract knowledge from individual and combinations of large and complex genomics and phenotyping data sets is key to the success of MAIZE.
- **CoA 2.2: Development of enabling tools for germplasm improvement**. High-throughput phenotyping methods, doubled haploids, and molecular and genome-based selection tools are designed, improved, validated and deployed for use in germplasm improvement.
- **CoA 2.3: Unlocking genetic diversity through trait exploration and gene discovery**. Working with the Genebank Platform and FP3, characterize the genomic diversity of maize to identify novel variants for use by breeding programs. The application of genetic engineering tools will be explored.
- **CoA 2.4: Pre-breeding: Development of germplasm resources.** Validate and apply tools developed by CoAs 2.1, 2.2 and 2.3 for pre-breeding to capture novel alleles and allelic combinations for key traits from unimproved genetic resources into elite genetic backgrounds to accelerate germplasm development in FP3.

CoA 2.1: Informatics, database management and decision support tools

CoA2.1 sources and adapts integrated systems and tools for storing and accessing data, as well as informatics tools for processing and analyzing data to support research and breeding. Increasingly, MAIZE pioneers large data volume applications, including sequencing of germplasm bank accessions. This CoA develops and deploys standards, tools and systems that integrate diverse and quickly evolving data types to help enhance genetic gain and increase the conservation and use of genetic resources. Together with the Genetic Gains Platform (GGP) and others, MAIZE will deploy tools developed by partners, for example, breeding program management software from the Integrated Breeding Platform and web-based visualization tools to interpret complex genomics and phenomics data developed by the James Hutton Institute. Interventions, issues and challenges are addressed through:

1. <u>Data management and interoperability to enable knowledge extraction:</u> The CGIAR is rapidly developing open-access "germplasm data banks" to complement its well established germplasm resources. Centralized and documented databases store the data generated through MAIZE diversity analysis and breeding research. Approaches are being developed to enhance data annotation and quality control processes using controlled vocabulary terminology and internationally recognized standards for phenotypic, genotypic, environmental, management and other key datatypes by implementing standards-compliant software, protocols and policies. The systems deployed, often selected and validated with the GGP, will be primary repositories for data collected and used across multiple FPs and CoAs. Diverse types of data, including genotypic, phenotypic, agronomic, weather and socioeconomic data, will be inter-connected to enable their use in biometric prediction algorithms, crop modeling and other analyses. Data-sharing tools will facilitate knowledge extraction and enable data publication via open-access repositories. Training in data standards, curation protocols, software systems and tools will be provided for CRP scientists, collaborators and partners.

2. <u>Informatics tools for making efficient decisions and accelerating genetic gains:</u> Given escalating data volumes, new tools will be adapted or developed that help breeders make quick selection decisions and allow mainstreaming of cutting-edge breeding applications. This includes

informatics tools for using diverse data from or for genomic selection (GS) and high-throughput phenotyping in the development of selection indices, three-way and multi-way interaction models, definition of heterotic patterns, and parent selection. Genetic gain is a function of several factors including the precision of data, which can be improved using existing and new methodologies that often are not employed due to lack of knowledge or lack of tools to facilitate their use. Analytical methods and tools will be acquired or developed for MAIZE research to fully benefit from emerging technologies. Capacity development activities will follow tool development. Statistical models and software that MAIZE plans to make available and provide training for include:

- New phenotyping methodologies, including experimental designs, high-throughput phenotyping methods and use of environmental variables.
- Predictive genomic models considering GWAS analysis and models for the integrated analysis of experimental data and interaction terms such as genotype × environment, genotype × management, and genotype × environment × management.
- New measurements of adaptability and stability.
- Tools for simulation, because when real data cannot be obtained, simulation is one of the best approaches that can be used to analyze the efficiency of different breeding programs.
- Statistical analyses to assist gene discovery in germplasm bank accessions and to promote basic trait exploration and gene discovery, allele mining, gene editing and use of genetic resources.

CoA 2.2: Development of enabling tools for germplasm improvement

CoA2.2 shortens breeding cycles and improves trait heritability in the breeding pipelines by making doubled haploid (DH) technology more affordable and developing publicly available tools to mainstream genomic and molecular approaches in breeding programs. Strategic interventions include:

1. Enhancing the efficiency of doubled haploid (DH) technology: MAIZE has made DH technology accessible to NARS, and small- and medium-sized breeding programs in low- and middle-income countries. Optimization of the DH process will target cost reduction of DH line development by more than 30% through haploid inducers with higher haploid induction rate, selection systems that reduce land and labor requirements for haploid identification, improvements in chromosome doubling efficiency, and reduction in haploid seedling mortality. The DH technology will be integrated with marker-assisted breeding and genomic prediction to increase population size and selection intensity, accelerate breeding and maximize genetic gain.

2. Enabling marker-assisted breeding for prioritized traits: With CoA2.3, FP3 and the A4NH CRP, enable marker-assisted breeding for resistance/tolerance to high priority biotic and abiotic stresses and nutritional quality traits. Globally prioritized traits include tolerance to drought and heat, and resistance to turcicum leaf blight, gray leaf spot, and Striga. Provitamin A is a priority for Central America and SSA (Semagn et al., 2015). Tar spot complex resistance is a priority in Latin America. Resistance to maize lethal necrosis (MLN) (Mahuku et al., 2015; Gowda et al., 2015), Striga, maize streak virus (Nair et al., 2015), and nitrogen use efficiency are priorities for SSA. Validating markers for MLN resistance, especially for maize chlorotic mottle virus (MCMV), is a high priority for eastern Africa. Resistance to banded leaf and sheath blight and downy mildew, and waterlogging tolerance are priorities for Asia (Prasanna et al., 2010, 2014). CoA2.2 continually prioritizes target traits with stakeholders and responds to emerging needs.

3. A comprehensive tropical maize trait pipeline for use in forward breeding applications will be established, encompassing: (a) maize genomics enabling tools; (b) structured discovery populations; (c) organization of trait-focused teams with peer-reviewed haplotype promotion criteria and strategies; (d) fine-mapping and tailoring approaches for haplotypes; (e) a communications strategy to enhance use of forward breeding; (f) development of high-throughput seed chipping capacity through partnerships; and (g) engagement with service providers and technology developers to lower genotyping costs.

4. Genomic knowledge to enhance breeding efficiency: Genetic relationships estimated from molecular markers will be combined into a Global Tropical Maize Germplasm Matrix to assist breeders in selecting parents for developing new breeding populations and hybrids. It will accelerate strategic use of temperate germplasm for tropical maize improvement. Haplotypes for validation and forward breeding will be prioritized using signature of selection evidence for regions originating from elite ex-PVP temperate germplasm. Similarly, important haplotypes from tropical breeding programs which demonstrate signatures of selection in stress tolerant populations will be prioritized as forward breeding targets in temperate x tropical populations.

5. Optimizing genomic selection approaches and their routine application in breeding programs: Coordination with FP3 will prioritize germplasm groups to target for GS and establish standards for phenotypic data collection of training set populations. Interactions with CoA2.1 and the Genetic Gains Platform will ensure that data management and GS prediction analysis pipelines result in useful and timely prediction reports to breeders. Genetic gain will be accelerated by enabling substitution of genomic predictions for phenotypic data during initial stages in the breeding pipeline, eliminating one or two seasons of testing. Genomic prediction will replace up to 50% of the stage 1 testing effort by 2021. Priority traits include yield under drought and optimal conditions, flowering time, harvest moisture content, plant and ear height and resistance to region-specific diseases. GS will support rapid cycling of elite multi-parental populations to maximize available genetic diversity.

CoA 2.3: Unlocking genetic diversity through trait exploration and gene discovery

CoA2.3 applies genotyping, phenotyping and informatics approaches to characterize and facilitate the use of maize genetic resources by researchers and breeders. Maize landrace accessions, populations and wild relatives held by the CGIAR and partners are explored to identify germplasm, haplotypes and alleles of potential value for breeding. The focus is on traits with limited genetic variation in elite breeding lines. Interventions include:

1. Assess maize genebank resources and adapted germplasm to identify valuable source germplasm: Evaluate landraces, populations and wild relatives using genotypic, phenotypic, GIS, passport and pedigree analysis to identify germplasm sources with valuable genetic variation for priority traits. Definition of dynamic trait- and diversity-based core sets and germplasm panels, selection-sweep analysis to identify common genomic signatures associated with desired characteristics, identification of underutilized genepools, and identification of germplasm complementary to existing elite materials. Phenotypic characterization of core sets of genebank accessions will identify high-value materials for germplasm development (CoA2.4) and novel sources of valuable genomic regions.

2. Identification of genomic regions of value from novel sources: Novel germplasm sources will be used to identify genomic regions associated with priority biotic and abiotic stresses and nutritional and

end-user quality traits. This is achieved through association and structured population mapping, and analysis of specific gene motifs associated with stress tolerance. Priority traits include resistance to MCMV and *Striga*, tolerance to heat and drought, nutrient use efficiency, kernel methionine and provitamin A stability. High-value haplotypes will be validated using haplotype-based selection, phenotypic evaluations, as well as transgenic and gene editing approaches.

3. <u>Tropical maize genomics resource development</u>: Filling gaps in the current maize reference genome and developing SNP markers with improved coverage of genetic variation are key research issues. The current maize reference genome was built upon temperate maize inbreds, including B73. An estimated 40% of tropical maize sequences cannot be mapped onto the current reference genome, which means that genotyping and MAS based on this reference genome are biased and less effective when used on tropical maize. CoA2.3 will contribute to the development of tropical maize genomes and will collaborate with partners to ensure that maize pan-genome and hapmap construction efforts adequately represent publicly available tropical maize variation.
4. <u>Genetic modification technologies to develop and validate novel genetic variants for target traits</u>: Genetic modification technologies will be used to validate function and assess the potential value of allelic variants identified through mapping or candidate gene analysis. Gene editing methods, mainly CRISPR-Cas9, will be employed to modify native genes to impact high-value traits, including disease resistance, nutrient use efficiency and tolerance to drought and heat. Opportunities to implement this technology in-house as well as in partnership with the industry will be pursued.
5. <u>Optimizing genomic selection approaches for application in pre-breeding programs:</u> CoA2.3 will work with CoAs 2.2 and 2.4 to optimize GS approaches to maximize the capture of useful novel genetic variation for complex traits in landraces and non-elite populations. Application of GS models in landrace populations offers specific challenges compared with elite germplasm-based GS. This work will rely largely on simulation validated through the use of existing data and targeted phenotyping and genotyping.

CoA 2.4: Pre-breeding: development of germplasm resources

Phenotyping of maize landraces in CoA2.3 has identified useful genetic variation in maize landraces for traits such as drought tolerance (Cooper et al., 2014; Cairns et al., 2013b), high anthocyanin content in grain, and resistance to MLN (Wangai et al., 2012; Mahuku et al., 2015) and tar spot disease complex. Selected landraces with desirable variation for target traits are currently being used as donors in developing lines with novel haplotypes that can be used by breeders in their elite line breeding programs. Additional priority traits that await investment include heat tolerance (Cairns et al., 2013a, b; Deryng et al., 2014; Lobell et al., 2011), Fusarium ear rot resistance (Munkvold et al., 1997; Hung and Holland, 2012), combined drought and heat stress tolerance (Cairns et al., 2013b) and banded leaf and sheath blight.

CoA 2.4 develops and deploys early generation and advanced inbred lines and backcross populations with novel haplotypes for priority traits, high yield potential and desirable agronomic characteristics. Methodologies for effective and efficient use of genetic resources in pre-breeding, including validation and implementation steps, are also developed. Genomic selection and other strategies to accelerate the movement of useful alleles from landrace germplasm while selecting against undesirable alleles will be explored. Early generation material, including fully tested BC1S2 lines with novel haplotypes for resistance to tar spot disease complex and drought tolerance, will be made available to breeders beginning in 2017. Considering the urgency of identifying novel alleles for MLN resistance, early generation breeding materials with putative resistance to the component viruses of MLN will be provided to breeders before being fully tested for yield potential and other agronomic characteristics. Annual releases will occur for the above mentioned traits and heat tolerance and high anthocyanin content. All lines and breeding materials will be accompanied by genotypic data characterizing the novel haplotypes.

2.7 Partnerships

Strategic partnerships, including docking with other CRPs

FP2 relies heavily on partnerships with advanced research institutions, leading service providers and the proposed Genetic Gains and Genebanks Platforms (see **Table 1.5** and **Annex 3.2**). Partnerships with advanced research institutions include the University of Hohenheim for continuous refinement of DH technology for the benefit of partners in low- and middle-income countries and Cornell University on the identification of novel high-value allelic variation in maize landraces and implementation in MAIZE of the GOBII project. CoA 2.1 partners with the Integrated Breeding Platform (IBP) and other CRPs on the specific tailoring and implementation of the Breeding Management System (BMS). MAIZE FP2 has established joint research and enabling technology platform development partnerships with other CRPs, especially WHEAT, RICE, and DCL AFS. The GOBII project, a proposed component of the Genetic Gains Platform, is a showcase example of cooperation among these CRPs, involving five major crops. It is already generating interest from alternate crops, and the pioneering work done within GOBII is expected to benefit other non-focus crops within a ten-year timeframe. Efforts are also underway with the same CRPs to develop a shared high-throughput low-plex genotyping facility which could support the mainstreaming of forward breeding strategies across crops and institutions, complementing current collaborations with the private sector, ARIs and CG-private partner high-density marker service providers (Diversity Arrays Technology, Cornell University, SAGA). The Seeds of Discovery Project (MasAgro Biodiversidad), jointly undertaken by MAIZE and WHEAT, shares the development of strategies, genotyping platform use, learning, bioinformatic approaches and visualization tools. MAIZE and WHEAT are also in the planning stages of collaborating with Monsanto to establish high-throughput automated seed chipping capacity under a humanitarian license.

2.8 Climate change

FP2 develops novel tools and traits to enhance the effectiveness of maize breeders in developing new cultivars that meet the needs and preferences of society. Climate change presents some of the biggest challenges to maize productivity and affects almost every goal and challenge of plant breeding. Tolerance to higher temperatures, particularly increased night temperatures, is the most obvious need and one of the greatest challenges to maintaining or increasing productivity in the coming decades; identifying useful genetic variability and developing tools that enhance breeding effectiveness for heat, drought and waterlogging tolerance is a priority for FP2. Changing climate has many more subtle effects on biological systems, from individual through ecosystem levels. With increased atmospheric CO_2 concentrations, for example, micronutrient concentrations in grain, and hence nutritional quality, tend to decrease. Similarly, with changing temperature and moisture regimes, cropping systems change, weed and pest species change and pathogens evolve, resulting in new pest and disease challenges to maize crops. New tools developed by FP2 will be crucial for enabling breeders to rapidly adjust phenotyping protocols, genomic selection models and breeding strategies to address the predicted and unpredictable challenges posed by climate change. FP2 also presents the last line of defense against new challenges, as genetic resources held in genebanks or novel diversity generated through gene editing may be required if and when elite breeding materials lack the genetic variation necessary for breeding progress. Genotypic and phenotypic biodiversity characterization efforts, informatics tools being developed, pre-breeding strategies being validated and FP2's capacity development efforts are building the genetic resources utilization platform that will be needed to overcome the impacts of climate change on maize production.

2.9 Gender

The focus of this Flagship appears far removed from the farmer-consumer interface. Although the relevance of the gender dimension will become clearer as we move downstream in the technology development process, the need to consider end-use quality and other preferred attributes will remain an important activity of FP2. When key decisions regarding overall research direction and priorities are made, these traits will be integrated into FP2 activities. Relevant research questions for FP2 include:

- How can downstream gender research and analysis of the technology development-deployment continuum guide upstream targeting and decision-making?
- How can gender-focused research on maize production leverage and add value to native trait variation analysis and trait pipeline development?
- How can we ensure that efforts to increase genetic gain benefit both men and women maize farmers and consumers in particular contexts?

FP2 will draw on results of research on traits and trait combination preferences of men and women maize farmers and consumers in particular contexts, generated in FPs 1 (De Groote et al., 2013), 3 and 5, to determine targeting and priority setting. Building on this and on progress achieved in Phase-I, in its portfolios FP2 will focus on trait combinations of particular interest to women farmers, including high beta-carotene, high lysine and specialty traits of particular value for the income generating opportunities of certain groups. This may also include research on novel trait variation and molecular pipelines that address nutritional quality, antioxidants and herbicide tolerance to reduce drudgery. In this regard, FP2 aligns closely with FP3, with inputs from FP1 on priority setting and trait targeting. Gender preferences and gender implications of target traits are carefully considered in conjunction with FP3 when deciding on appropriate traits to focus on.

2.10 Capacity development

FP2 capacity development will focus on increased breeding efficiency and effectiveness by integrating plant breeding and genomics-derived technologies. This activity will be coordinated with FP3 to improve the capabilities of future research leaders as well as upgrading and broadening the knowledge of current researchers through training on the latest advances in genetics, genomics, statistics, experimental design, data management and phenotyping methodologies to improve breeding efficiency. This will avoid duplication and maximize complementarities and synergies between FPs.

FP2 will build capacity in data management, sharing and analysis, as this has become an integral part of Phase-II that contributes to the sub-IDOs: enhanced genetic gains through the use of appropriate tools and methods; efficient management of databases and informatics tools that enhance genotypic and phenotypic data accessibility and the use of genetic resource and other data, in compliance with the CGIAR Open Access Policy.

Use of informatics and novel database management and decision support tools to extract knowledge from large and complex data sets will be a component of capacity building. Innovative training materials will be developed and made available to breeders to enhance data management. Sharing of germplasm with documented yield potential via open-access channels, marketing approaches, methods, and associated dissemination documentation will contribute to skills and competency development. Research support services and technical backstopping will also be provided to build research skills.

Hands-on training through coaching and mentoring, workshops, technical short-term courses and long-term postgraduate training, postdoctoral and visiting scientist schemes, knowledge-sharing tools and methods, design and delivery of innovative learning materials, guidelines, common tools and protocols will be used in collaboration with FP3 to update the knowledge and skills of staff.

2.11 Intellectual asset and open access management

FP2 will play a major role in selecting, deploying, and providing training in the use of software, tools, and standards that will facilitate compliance with CGIAR Intellectual Asset management and Open Access/Open Data policies for MAIZE scientists, especially in the area of breeding and germplasm research.

In addition, FP2, outputs including data, algorithms, software, methodologies, and germplasm will be managed according to CGIAR policies regarding Intellectual Assets and Open Access with due regard for Center, donor, collaborator, and host country policies and regulations. Projects established under FP2 will include written plans to ensure that all collaborators are aware of their Intellectual Asset ownership and stewardship duties as well as their rights and responsibilities regarding Open Access sharing of outputs.

Notably, efforts will be made to publish major research findings in peer-reviewed Open Access journals or to provide free access to non-OA publications through alternative legitimate means, e.g. pre-prints stored in an institutional repository such as DSpace. Curated data, software, and other information products derived through research in FP2 will also be made available to the public via Open Access repositories and/or databases and tagged with metadata and ontology terms that will encourage the discovery and reuse of FP2 information products as well as proper attribution. MAIZE germplasm developed in FP2 will be disseminated, based on international regulations, and Standard Material Transfer Agreement (SMTA). And, as permissible under CGIAR IA principles, discoveries with potential for licensing to commercial companies may be patented before being published, for example, novel sources of disease or pest resistance.

2.12 FP management

FP2 is managed jointly by the two lead centers, with joint FP coordination and co-CoA leaders. Co-leadership allows both centers to have a clear co-leading role and provides clear focal points within each organization. Co-leadership is further warranted by the geographic complementarities between the two lead centers. Co-leadership also facilitates integration with MAIZE's other FPs, which is critical for FP1 to provide horizontal guidance. **Table FP2.2** provides the names of the FP3 Coordinators and CoA management team

Table FP2.2. MAIZE FP2 and CoA management team

FP/CoA Structure	FP2 Coordinators and CoA leaders	
	CIMMYT	IITA
FP2 Novel Diversity and Tools for Increasing Genetic Gains	Kevin Pixley	Abebe Menkir
CoA 2.1 Informatics, database management and decision support tools	Kate Dreher	Trush Shan
CoA 2.2 Development of enabling tools for germplasm improvement	Mike Olsen	Melaku Gedil
CoA 2.3 Unlocking genetic diversity through trait exploration and gene discovery	Sarah Hearne	Melaku Gedil
CoA 2.4 Pre-breeding: development of germplasm resources	Terence Molnar	Abebe Menkir

2.13 Budget summary

Details of FP2 projected base and uplift budgets for Phase-II, including analysis by funding sources, are provided in **Annex 3.19**. FP2 receives an excess of two-thirds of its budget from W3/bilateral projects, such as MasAgro Biodiversidad, STMA, WEMA, GOBII and IMAS projects. These W3/bilateral projects have similar budgets mapped through 2017/2018. Beyond the 2-5 year lifespans of these existing bilateral projects, we can only estimate contributions; nonetheless, it is expected that resource mobilization activities during MAIZE Phase-II will lead to a continuity of current or even potential increase in funding in relative terms.

With the exception of one donor, W3/bilateral funding focuses strongly on discovery and development of new germplasm resources in existing breeding pools and the enhancement of data and knowledge management capacities around that area. Donor priorities are now shifting towards the "downstream" aspects of the maize breeding and seed systems, potentially limiting the continued provision of base genetic variation required for increasing genetic gains. Given these factors, W1/2 funding is critical to support the continuation of the trait delivery pipeline and in a more strategic manner to support the longer term discovery of novel genetic variation in exotic germplasm and facilitation of access to novel variation to maize breeders through pre-breeding. Following this, **FP2 basic W1/W2 resources will help address the following priorities**:

- Effectively maximize genetic gain from the phenotypic, genealogical and genotypic data generated by MAIZE and proprietary programs using breeding informatics and biometrics tools/approaches
- Facilitate the development, dissemination and deployment of enabling tools/technologies like doubled haploids, molecular markers/haplotypes and an efficient and effective trait discovery and mobilization pipeline to enhance genetic gains across MAIZE breeding programs.
- Secure the continual exploration for, identification of, and repackaging of novel genetic variation and high-value alleles for improving prioritized traits.
- Facilitate capacity enhancement in MAIZE and broader research community globally to effectively utilize tools, data, knowledge and germplasm products developed by FP2 to enhance genetic gains.

Uplift W1/2 budget (circa 962K per year), if received, will be particularly used to:

- Extend capacities to effectively capture and use climate data in phenotypic and genotypic selection of the best maize germplasm for line development (20%).
- Expand the work on novel diversity discovery and pre-breeding to include additional traits (e.g., resistance to ear rots) that are prioritized globally by MAIZE partners due to significant productivity and human health impacts, but with limited genetic variation in the extant breeding pools (80%).

If a further US$ 2 million per year is received either through W3/bilateral, W1/2, FP2 will implement a world-class gene editing laboratory, working in partnership with private sector partner(s) and serving as a capacity building platform for MAIZE partners, applying gene editing techniques to develop, validate and deploy novel variation for priority traits including resistance to MLN and other major diseases, herbicide tolerance, enhanced nutritional quality, etc.

Scope and geographies of future W3/bilateral funding and emergence of new biotic threats to regional or global maize production will also influence how we strategically prioritize and allocate W1/2 resources in Phase-II.

FP3: Stress Tolerant and Nutritious Maize

2.1 Rationale, scope

Maize is the major source of food security and economic development in sub-Saharan Africa (SSA) and Latin America and the Caribbean (LA), and is among the top three crops in Asia. Average annual growth rate of the harvested maize area from 1993 to 2013 was 2.7% in Africa, 3.1% in Asia, and 4.6% in LA (FAOSTAT 2016). Even though the growth in area was accompanied by 2.4 to 5.6% increases in production, grain yields in these regions are still low with high year-to-year variability because of the adverse effects of drought, sub-optimal soil nitrogen, waterlogging, and heat and soil acidity/aluminum toxicity, besides high incidence of diseases, insect pests and parasitic plants. Increases in temperature and decreases in precipitation due to climate change are projected to have the greatest effect in SSA, Asia, and LA, with SSA and South Asia being the most vulnerable (Smale et al., 2011; Zaidi et al., 2014). The predicted changes in temperature and precipitation, especially in SSA and Asia, will further accentuate the intensity and frequency of drought, increasing vulnerability of smallholder farmers to high risks associated with farming under rainfed conditions (Cairns et al., 2012, 2013; Masih et al., 2014; Shiferaw et al., 2014; Shi and Tao, 2014).

The diversity of production environments, biotic and abiotic constraints, consumer preferences for grain color and texture, farming systems, and socioeconomic circumstances in Africa, Asia, and Latin America presents significant challenges for maize breeding in the tropics, and highlights the need for appropriate targeting of maize germplasm. Maize breeders at CIMMYT and IITA initially created germplasm pools, populations and composites from diverse source germplasm and improved them through many cycles of recurrent selection for adaptation to diverse production environments in the developing world. These germplasm pools formed the genetic base from which open-pollinated varieties (OPVs) with high yield potential and tolerance to specific stresses were developed and released (Vasal et al., 1997; IITA 1992). To achieve these breeding goals, research activities were carried out at experiment stations in the major regions/agro-ecologies where specific stresses are endemic, and breeding could thus be done effectively. Over the last 20 years, more emphasis has been placed on the development of maize hybrids because of increasing areas planted to these hybrids (Aquino et al., 2000) and the emergence of numerous national seed companies in developing countries, including in Africa. The improved broad-based maize populations and pools have therefore been sources of inbred lines with considerable genetic diversity (Menkir et al., 2005, 2010; Warburton et al., 2008; Semagn et al., 2012) that have been made accessible to public and private sector breeders for inbred line improvement and hybrid development.

MAIZE in Phase-I has been successful in developing and deploying an array of climate-resilient and nutritionally enriched maize hybrids/synthetics in SSA, Asia and LA, through various projects, including Drought Tolerant Maize for Africa (DTMA), Improved Maize for African Soils (IMAS), Water Efficient Maize for Africa (WEMA), Heat Tolerant Maize for Asia (HTMA), Abiotic stress Tolerant Maize for Asia (ATMA), Affordable, Accessible, Abiotic stress tolerant maize for Asia (AAA), MasAgro-Maize and Maize HarvestPlus (in collaboration with A4NH). Through the DTMA project alone, more than 200 distinct drought tolerant maize varieties have been released across SSA, with significant adoption (Fisher et al., 2015). In 2014, over 52,000 metric tons of certified seed of diverse drought tolerant (DT) maize hybrids and improved OPVs were produced and made available to farmers by seed companies and community-based seed producers. In recognition of such successes, the CGIAR IEA Team Report (April 2015) on MAIZE noted that the "*Research design and approaches are innovative and sometimes state-of-the-art. Processes and partnerships are designed to ensure that latest scientific thinking is reflected in methodology and analysis. Outputs, people and processes of RS2 (Stress resilient and nutritious maize) are of exceptionally high quality compared with any public breeding effort for maize. Internal processes to assure science quality appear to be robust.*"

MAIZE FP3 in Phase-II will build on the successes and lessons learned during Phase-I, and will implement a cohesive breeding and seed systems strategy with defined target trait and product profiles for SSA, Asia and LA (**Annex 3.11**, **3.12** and **3.13**). FP3 is designed around six specific CoAs: 3.1: Climate-resilient maize with abiotic and biotic stress tolerance; 3.2: Tackling emerging trans-boundary disease/pest challenges (e.g., MLN); 3.3: Nutritional quality and end-user traits in elite tropical maize genetic backgrounds; 3.4: Precision phenotyping and mechanization of breeding operations; 3.5: Seed production research and recommendation domains; 3.6: Stronger maize seed systems. The **grand challenges addressed by FP3** through these six CoAs are indicated in **Table FP3.1**.

Table FP3.1: Grand Challenges addressed by MAIZE FP3

Grand Challenge	MAIZE FP3 Contributions
GC1: Competition for land from multiple sources: food and feed crops, livestock, biofuels and biomaterials, forest products, conservation, urban expansion, and a host of other ecosystem services.	• Climate change brings land displaced by some crops under maize cultivation. This will also bring new challenges of pests, diseases and mycotoxin contamination. Developing climate resilient maize is therefore most important for tackling these challenges. • Development of climate-resilient and nutrient use efficient varieties will increase yield per unit area, thereby reducing deforestation for expanding the maize area. • Stress resilient hybrids tolerant to high plant population density are highly suitable for inter-cropping with other complementary crops such as legumes. • Promoting maize varieties with high digestibility and nutritive value for use in animal feed could potentially reduce land degradation from animal grazing. • Scaling out high-yielding and stress resilient hybrids, along with sustainable intensification options, will contribute to improved productivity and make feed and food available without expanding maize to marginal or fragile areas.
GC3: Overdrawn and polluted water supplies threatening social breakdown and rising levels of conflict.	• Extensive and non-judicious use of agrochemicals is one of the major causes of water pollution. Varieties with resistance to major diseases and insect pests lessen the need to use agrochemicals.

GC5: Climate change threatening agriculture, while at the same time agriculture is a substantial producer of greenhouse gases.	• As a result of increasing temperature and more erratic rainfall, yields and genetic gains on farm are expected to decline. Climate resilient germplasm will help minimize climatic risks and extremes and allow for sustained genetic gains on farm. Increased ability to produce stable yields under biotic and abiotic stresses will be key to adapting to changes in climate. • MLN disease in eastern Africa has significantly affected the stakeholders, including farmers and seed companies. Introgressing MLN resistance into climate resilient maize varieties will protect the investments made so far in varietal development and deployment. • By expanding the adoption of climate-resilient varieties, both food supplies and incomes will be more resilient to climate change. In addition, the use of more productive varieties would help reduce the need for expanding into new areas, thus contributing to minimizing production of greenhouse gases.
GC6: Diminishing genetic resources. Between 7 and 25% of vascular plant species are under threat of extinction by 2050.	• CIMMYT is the guardian of over 25,000 maize accessions in its genebank. A systematic effort to explore genetic variation through pre-breeding and make the diversity usable in breeding is currently underway. FP3 focuses on utilizing this diversity, as well as the diversity of publicly available temperate and tropical germplasm and those of willing private partners through systematic introgression, product development, testing and distribution. • Enhanced adoption and use of new, diverse and stress-resilient maize cultivars by farmers is important for reducing the potential impact of biotic and abiotic stresses on maize production.

2.2 Objectives and targets

Strategic Relevance

Maize is predominantly (about 80%) grown as a rainfed crop in SSA, Asia and LA, and is particularly vulnerable to an array of abiotic and biotic stresses; consequently, yields are usually less than half of those under irrigated systems that are targeted production areas for private sector investment (Shiferaw et al., 2011; Zaidi et al., 2014). In Asia, the rainfed maize area is projected to increase at a rate of 1.8% per year, six times the projected rate of increase of irrigated areas.

Climate change is expected to further increase the frequency and severity not only of abiotic stresses, but also pest and disease outbreaks, such as maize lethal necrosis (MLN) in eastern Africa (Mahuku et al., 2015; Prasanna 2015), as well as expand the geographical distribution of invasive and parasitic weeds (**Annex 3.11**). Pre-emptive strategies that focus on assembling and utilizing diverse sources of tolerance to multiple stresses for broadening and diversifying the genetic base of adapted germplasm will be pursued in MAIZE Phase-II to enhance and sustain maize yields and income in the face of dynamic changes in abiotic and biotic stresses and associated shifts in the economic reality of the maize supply chain. Integration of high-throughput and novel phenotyping tools, DH technology, breeder-ready molecular markers for key traits, mechanization at key breeding sites, and rapid-cycle genomic selection will form the core components in FP3 to accelerate genetic gains and the competitiveness of MAIZE products in the target regions.

Expected Contributions to CGIAR SRF

FP3 primary outcomes include five specific sub-IDOs: 1.1.2. Reduced production risk; 1.3.3. Increased value capture by producers; 1.3.4. More efficient use of inputs; 1.4.1. Reduced pre- and postharvest losses, including those caused by climate change; and 2.1.1. Increased availability of diverse nutrient-rich foods. FP3 also contributes to four cross-cutting sub-IDOs, namely A.1.4. Enhanced capacity to deal with climatic risks and extremes; B.1.3. Improved decision-making capacity of women and young people; C.1.1. Increased capacity of beneficiaries to adopt research outputs; D.1.1. Enhanced institutional capacity of partner research organizations. Progress toward the above-menioned sub-IDOs will be measured and documented through relevant indicators and metrics, as indicated in **Table FP3.2**.

Table FP3.2: MAIZE FP3 contributions (with indicators and targets) to specific sub-IDOs.

Target Sub-IDOs	Nature of FP3 contributions	Indicators and targets
1.1.2 Reduced production risk	• Improved multiple stress-tolerant maize varieties with better yield and stability adopted by smallholder farmers in stress-prone rainfed environments. • New MLN resistant maize hybrids developed and deployed in SSA.	• Kg/ha/year improvement in mean yield of improved MAIZE hybrids relative to baseline checks in optimum and stress-prone environments of the tropics. • Number of MAIZE varieties released by seed enterprises and national programs. • Reduced impact of MLN on the commercial maize seed sector.
1.3.3 Increased value capture by producers	• Improved varieties suit the needs of the processing industry. • Through hybrid deployment in targeted areas, opportunities provided for more farmers to become improved seed producers.	• Number of varieties released / commercialized for niche markets of the processing industry. • Increase in the income of maize seed growers.
1.3.4 More efficient use of inputs	• Water and nutrient use efficient improved maize hybrids developed and deployed in target geographies.	• Number of drought-tolerant and N use efficient maize cultivars released and adopted by farmers. • Increase in rate of genetic gain for drought tolerance and NUE in tropical agro-ecologies.
1.4.1 Reduced pre- and postharvest losses, including those caused by climate change	• Multiple pre- and postharvest stress-tolerant improved maize varieties adapted to SSA, Asia and LA.	• Number of pre- and postharvest stress resistant maize cultivars released, and adopted by farmers in target geographies.
2.1.1 Increased availability of diverse nutrient-rich foods	• Nutritious maize hybrids/varieties with superior agronomic performance and desirable gender-informed traits (processing properties, palatability and storability) developed and deployed in SSA, Asia and LA. • Availability of improved maize varieties with specific end-use traits	• Number of nutrient-rich maize varieties developed and deployed with potential nutritional impact. • Number of seed companies producing and delivering nutritious maize varieties.

	(e.g., dual-purpose maize with stover/fodder quality; high kernel methionine, high oil, high carotenoids for poultry sector; specialty maize; blue maize) to the private sector for maize processing and derivation of nutrient-rich foods.	
A.1.4 Enhanced capacity to deal with climatic risks and extremes	• Replacement of climate-vulnerable and obsolete maize varieties with climate-resilient improved varieties. • An effective maize disease/pest surveillance, monitoring and diagnostic system, coupled with a community of practice among NPPOs, private seed companies and national/regional seed trade organizations.	• Increased percentage of climate-vulnerable obsolete varieties replaced with new MAIZE varieties, especially in SSA. • A functional phystosanitary CoP in SSA with shared expertise and learning across borders to deal with emerging/future threats such as MLN.
B.1.3 Improved decision-making capacity of women and young people	• Proactively embedding gender and youth lens in breeding and seed system partnerships. • Inclusive business models in maize-based seed systems.	• Number and proportion of partner institutions and seed companies applying gender-responsive business practices.
C.1.1. Increased capacity of beneficiaries to adopt research outputs	• MAIZE seed system specialists work closely with NARS and seed company partners in target geographies to catalyze uptake of improved maize germplasm and varieties.	• Number of improved MAIZE hybrids released by NARS and seed company partners in target geographies. • Number of maize seed shipments from CIMMYT/IITA to NARS and seed companies in SSA, Asia and LA. • Number of training courses organized in SSA, Asia and LA for improving partner SME seed companys' capacity to produce and effectively commercialize improved MAIZE varieties.
D.1.1 Enhanced institutional capacity of partner research organizations	• Co-designing and testing of improved maize varieties with a range of stakeholders. • Well-targeted short- and long-term training of NARS scientists.	• Number of scientists, especially women and young scientists, hosted and trained on maize breeding and seed systems. • Number of public/private institutions implementing novel breeding strategies developed under MAIZE.

2.3 Impact pathway and theory of change

The MAIZE FP3 theory of change was developed during a workshop with the MAIZE Flagship Program team. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. Workshop participants enhanced their understanding of the CGIAR Strategy and

Results Framework and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning on a variety of topics.

Using the CGIAR Results Framework's sub-intermediate development outcomes (IDOs), the team agreed to focus on five sub-IDOs and four cross-cutting sub-IDOs:

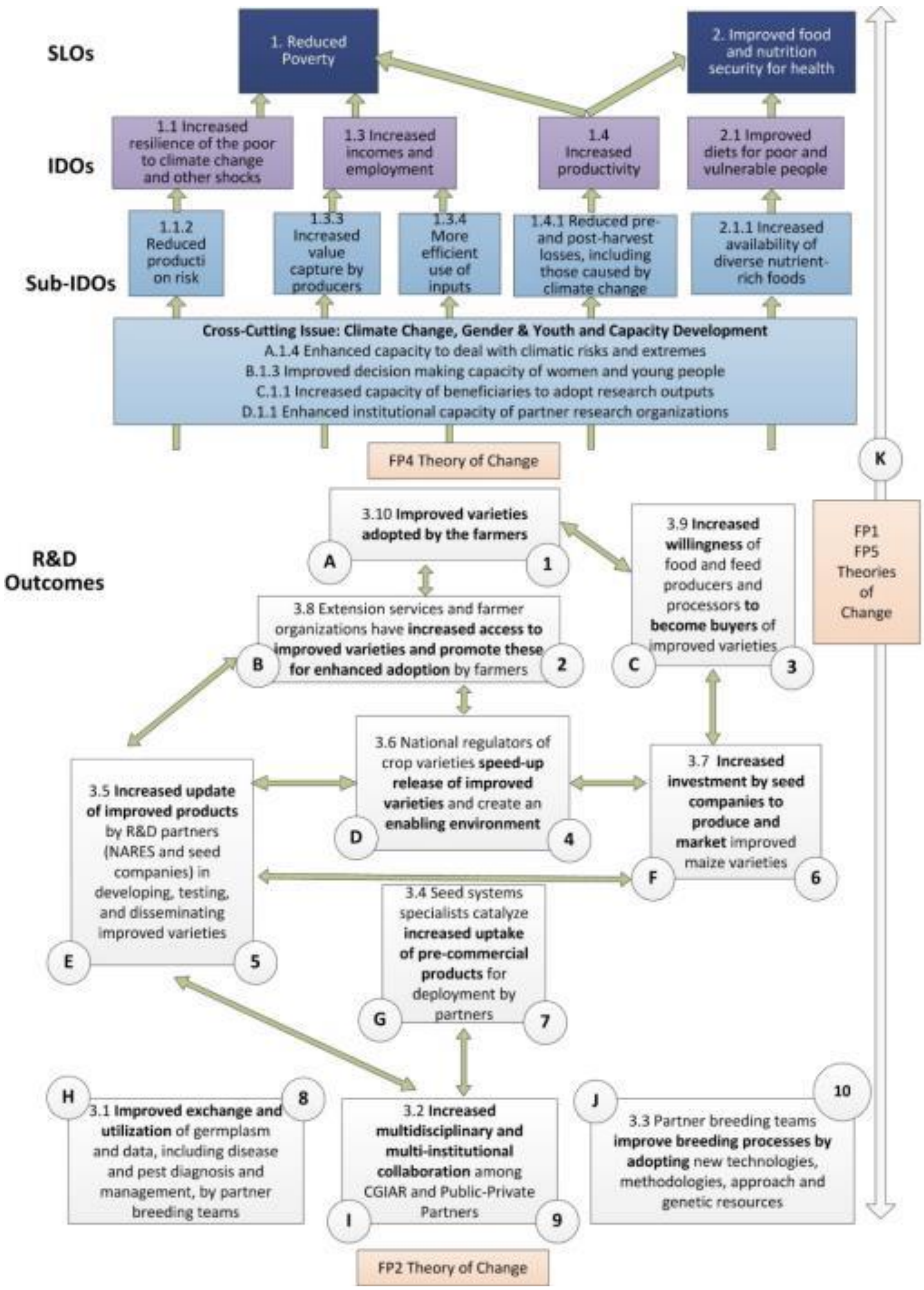
- 1.1.2 Reduced production risk;
- 1.3.3 increased value capture by producers;
- 1.3.4 More efficient use of inputs;
- 1.4.1 Reduced pre- and postharvest losses, including those caused by climate change;
- 2.1.1 Increased availability of diverse nutrient-rich foods;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.3 Improved decision-making capacity of women and young people
- C.1.1 Increased capacity of beneficiaries to adopt research outputs; and
- D.1.1 Enhanced institutional capacity of partner research organizations.

Other sub-IDOs were noted by the team as important to FP3, given that they overlap with the above sub-IDOs of focus. Based on the areas of focus, the FP3 team agreed that this Flagship Program contributes to reducing poverty (SLO 1) and improving food and nutrition security for health (SLO 2) by increasing resilience of the poor to climate change and other shocks (IDO 1.1), increasing incomes and employment (IDO 1.3), increasing productivity (IDO 1.4), improving diets for poor and vulnerable people (IDO 2.1), and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C), and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created to demonstrate the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory, as well as the risks that may undermine success, were documented.

This theory of change will be the foundation of the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of data collection and analysis based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the FP as well as reflecting on lessons and program improvements.

Figure 2.3: Theory of Change for MAIZE FP3: Stress Tolerant and Nutritious Maize



Assumptions and Risks	Interventions and Outputs
A • Farmers see value in and have access to improved traits and products • Other inputs and optional crop management practices are available and applied • Existence of a feedback loop regarding farmers' needs • Existence of an enabling policy environment and government support • Risk: Variability of local prices and instability of global prices **B** • FP3 products better than what is available on the target markets • Partners see value and are willing to promote new products • Existence of an enabling policy environment • MAIZE guidelines are synchronized with partner requirements • Risks: o Slow variety replacement by partners o Marketing strategy overshadows and slows new product adoption **C** • Quality and availability of improved MAIZE varieties are attractive to buyers and producers • Risks: o Changes in consumer preferences o End users do not see value in improved traits o Variability of local prices and instability of global prices **D** • Existence of enabling policy environment and government support to speed up improved variety release • CGIAR influences national decision-makers • Risk: Seed regulators lack financial and human capacity **E** • Partners see value and are willing to attend training provided by MAIZE and apply the acquired knowledge • Existence of enabling environment (e.g., regulatory framework) for germplasm movement	**1** • Communicate with farmers in target areas to obtain feedback on product needs o Outputs: Communication materials, documented needs • Promote improved seeds using on-farm demos and field days to increase farmers' awareness, organized around innovative plots and involving both women and youth o Outputs: Dissemination and marketing information; training documentation; training sessions • Seed company and farmer evaluations (feedback survey) and research on cost-benefits of tools and approaches o Outputs: evaluation results; cost-benefit data of tools and approaches **2** • Provide improved products and relevant information to seed systems team o Outputs: products, dissemination documentation • Formalize and implement an inclusive pipeline advancement process o Outputs: documented process, data on products needed • Apply the guidelines for product allocation o Outputs: documented guidelines, data on prioritized products **3** • Provide product profiles o Outputs: product profiles • Seek feedback from NARS and seed companies on their needs o Outputs: Survey results and information needs • Demonstrate MAIZE products o Outputs: Dissemination and product marketing information **4** • Provide capacity development to seed regulators on QC/QA, value addition, timelines and research and development o Outputs: policy briefs, technical advice, dissemination information

- Partners have human and financial capacity and the willingness to host trials
- Existence and availability of information regarding target environments and associated superior varieties
- Risks:
    - Poor data recovery and quality
    - Staff turnover
    - Restricted and slow germplasm movement
    - Ineffective training and backstopping

F

- Existence of viable seed companies
- Continued demand for improved seed
- Seed companies see value and are willing to adopt new maize technologies
- Existence of an enabling policy environment for seed production
- Risks:
    - Existence of fake or counterfeit seed on the market
    - Poor production methods lead to low seed quality on the market

G

- Existence and availability of improved technologies with good production characteristics
- Seed system specialists have the human and financial capacity and necessary infrastructure (e.g., storage) to adopt improved varieties
- Risk: Lack of market for end users

H

- Partners have the human and financial capacity and necessary infrastructure to exchange and use germplasm
- Germplasm and data are relevant and suitable to user needs
- Existence of appropriate tools, infrastructure and enabling environment (e.g., regulatory framework) to allow for germplasm exchange and utilization
- Risk: National regulators increase import and export fees

I

- Existence of conducive policy environment, especially with regards to the SMTA, to collaborate effectively with seed companies
- Existence of enabling regulatory frameworks within

- Advocate for domestication and harmonization of legislative systems across regions
    - Outputs: policy briefs, technical advice, dissemination information

5

- Provide training and backstopping
    - Outputs: Training and backstopping materials
- Provide data and germplasm exchange services (e.g., double haploid)
    - Outputs: data and germplasm exchange services
- Conduct joint evaluation of hybrids and varieties and share results
    - Output: hybrid and variety evaluation documentation, dissemination documentation
- Develop and share guidelines for advanced trials
    - Outputs: Guidelines, dissemination documentation
- Develop and share improved hybrids and varieties for target environment
    - Outputs: Data, improved varieties, dissemination documentation

6

- Exchange of breeding product data and information
    - Outputs: Data and information, dissemination documentation
- Provide capacity development and infrastructure
    - Outputs: Training materials, training sessions, dissemination documentation, infrastructure information and services
- Supply improved germplasm and initial breeder seed
    - Outputs: germplasm and associated data, breeder seed and associated data
- Provide support for variety release, registration and commercialization, and production of pre-basic and basic seed

target countries

- Technologies will remain of interest for public-private partnerships
- Strong collaboration within the CGIAR, CRP and FPs to exchange and use the knowledge generated
- Risk: Limited investment to develop capacity and collaboration

J

- Existence of conducive policy environment, especially in regards to the SMTA and Nagoya Protocol, for free seed movement and use
- New technologies can be easily applied within breeding
- Tools are user-friendly and support is available
- Partner breeding teams see value and are willing to adopt new technologies, methodologies, approaches and genetic resources
- Partners have the human and financial capacity and necessary infrastructure to adopt
- Risk: Policy and existing legal frameworks impede seed movement and use and render partnership breeding impossible

K

- Products are effective under sustainable intensification practices
- Risks:
    - Financial, social and political instability
    - New emerging pests and diseases
    - Climate change

    - Outputs: data, information, dissemination and marketing documentation

7

- Provide seed system specialists with elite seed materials and supporting data
    - Outputs: Elite seed materials and data, dissemination documentation
- Joint decision-making meetings
    - Outputs: Meeting minutes and record of decisions
- Product advancement
    - Outputs: Products data and information, dissemination, marketing documentation, data allowing breeders to make informed parental decisions for subsequent breeding cycles with increased genetic gain

8

- Create forums for data/information exchanges and decision-making
    - Outputs: Data/information exchange forums
- Provide support to improve breeding processes and utilization of new tools/technologies that increase genetic gain
    - Outputs: Training, guidance, processes
- Disseminate summarized data
    - Outputs: Data, dissemination documentation

9

- Collaborative partnerships to create an enabling environment for research
    - Outputs: Data and information about partnerships, dissemination documentation
- Provide capacity development
    - Outputs: Training materials, training sessions
- Establish and share standards and options
    - Outputs: Standards and options, dissemination documentation

	(10) • Incorporate new breeding technologies and tools (physiological, statistical, molecular, data management) to increase genetic gains and breeding efficiency
	    o Outputs: New technologies and tools
	• Provide feedback on utility and functionality of tools to FP2
	    o Outputs: Survey results (use and functionality), feedback documented and shared
	• Incorporate novel genetic resources into breeding program
	    o Outputs: New breeding products

2.4 Science quality

The FP3 team will continue to impose high standards on its R4D in Phase-II through improved breeding information/data management, precision phenotyping, mechanization/automation of breeding operations, crop modeling, remote sensing and multidisciplinary synergies. Some of the major areas of focus in different CoAs are indicated below:

CoA 3.1:

- Targeted introgression of novel alleles and allelic combinations for broadening and diversifying the genetic base of elite maize germplasm adapted to different mega-environments.
- Identifying target markets/geographies with comparative advantage of MAIZE varieties, and addressing client needs through strategic introgression of essential traits in adapted backgrounds (strategic positioning/targeting of MAIZE germplasm).
- Characterizing and using diverse sources of resistance to MLN-causing viruses, including CIMMYT and IITA germplasm accessions, exotic germplasm from USA and Thailand, temperate-tropical introgression lines and inbreeding strategies.
- Realignment of breeding program for future use of GIS tools to characterize future maize mega-environments and identify suitable screening sites (using climate analogues) for MAIZE partners.
- Routine incorporation of breeder-ready markers for key maize diseases to increase the size of the (phenotypically) untested layer of the breeding pipeline, allowing faster genetic gains.
- Continuous evaluation of genetic gains integrated into the breeding pipeline to monitor the efficiency of the pipeline, providing quantitative feedback on the impact of new technologies integrated into the pipeline.
- Rapid cycling of bi-and multi-parent populations through marker-assisted recurrent selection (MARS) and genomic selection (GS) to accumulate desirable alleles influencing complex traits.
- New statistical predictive models that increase precision of genomic selection for stress tolerance and help to gain a better understanding of genotype x environment x management (G x E x M) interaction.
- Judicious use of the transgenic approach for improving specific biotic and abiotic stress tolerance traits in close partnership with humanitarian license providers, NARS and regional organizations.

CoA 3.2:

- An effective maize pest/pathogen/parasitic weed surveillance and monitoring system established in SSA.
- A Community of Practice (CoP) among relevant phytosanitary agencies in SSA and LA, implementing harmonized protocols for effectively detecting and prevent trans-boundary movement of maize pathogens (e.g., MCMV) through commercial seed lots.
- Reliable and cost-effective diagnostic protocols for curbing the spread of pathogens (e.g., MCMV) through seed, implemented by NPPOs and commercial seed companies.
- A dedicated MAIZE pathogen/pest/parasitic weed web portal (linked to other knowledge hubs of regional organizations) and data management system (toolbox) with core databases, established under MAIZE Atlas.

CoA 3.3:

- Robust, high-throughput tools/techniques for assessing different nutritional (protein, oil, starch, lysine, tryptophan, etc.) and end-use quality traits (kernel hardness, kernel size, color, neutral detergent fiber, acid detergent fiber, etc.) to speed up the varietal development process.

CoA 3.4:

- Precision phenotyping sites, including well-equipped benchmark phenotyping sites and complementary satellite phenotyping sites, in partnership with public and private sector partners.
- Digital platform (proximal and remote) on unmanned aerial vehicles (UAVs) equipped with various high-resolution cameras (hyper-spectral, multi-spectral, thermal, RGB etc., depending on targeted traits) in support of high-throughput phenotyping and real-time data capture.
- Dissecting stress tolerance using new phenotyping tools/methods for informed selection decisions and for constituting new breeding populations for marker discovery.
- New high-throughput phenotyping tools for breeder preferred traits (including plant height, phenology, stand count and yield components) developed and disseminated.
- Increased signal-to-noise ratio through the use of UAV-based platforms to rapidly identify field variation which will be incorporated into trial designs.
- Incorporation of near-real time phenotyping data submission for better data return and remote monitoring of trials.

CoA 3.5:

- Inclusion of gender and socioeconomic considerations when designing crosses for developing products and seed production research and determining recommendation domains.
- Information database on seed producibility/yield of MAIZE-derived hybrids, web-based dissemination of potential seed technology practices and recommendation domains, and a targeted approach to product development intrinsically linked to deployment.
- Research into the economics of seed production of single-cross, three-way and double-cross hybrids.

CoA 3.6:

- Enhancing the impact of MAIZE products/germplasm through new partnership models, including MAIZE x private sector combinations in commercial hybrids, for breeding new germplasm.
- Deployment of new seed system management software in regional hubs, linked to institutional phenotypic and genotypic databases, to streamline inventory management, routine QC/QA operations, phytosanitary regulation compliance and shipment tracking.

Cross-cutting:

- Using GIS, remote sensing, and high-resolution digital tools for characterizing and fine-mapping tropical maize mega-environments, mapping the incidence and severity of major abiotic/biotic stresses, identifying ideal regions for maize seed production, hybrid deployment and commercialization, and modeling and risk mapping of trans-boundary diseases/pests (CoA 3.1 to 3.5, in collaboration with FP1).

- Mainstreaming DH, precision phenotyping tools, mechanization of breeding operations, molecular markers and genomic prediction, breeding informatics for discovering novel genetic variation, improving heritability, reducing cycle time and increasing selection intensity (across CoA 3.1-3.3).
- Portfolios of best-bet options, including variety and management options, developed for key stakeholders (CoA 3.1 and 3.6).
- Application of remote sensing in yield quantification to assist seed producers in evaluating seed quantities prior to harvest to assist in the development of marketing plans (CoA 3.1 and 3.6).

2.5 Lessons learnt and unintended consequences

- **A dynamic maize breeding pipeline capable of responding to changing conditions is key to ensuring farmers' access to improved maize varieties with appropriate trait combinations**: The sudden emergence of MLN as a major threat in eastern Africa and the susceptibility of breeding materials and commercial maize varieties in SSA posed a great challenge, triggering a rapid response from CIMMYT to identify/develop new products with MLN tolerance along with other adaptive traits. FP3 will intensify efforts to deal with transboundary pests/pathogens and fast-track breeding for multiple stress-tolerant and genetically diverse improved maize varieties to protect farming communities from present and future threats.

- **Quantification of genetic gains should be an integral part of breeding programs, and is essential to measure and monitor breeding progress and efficiency:** In Phase-I, CIMMYT and IITA conducted era studies in SSA to assess the genetic gains attained in stressful environments. The results highlighted the need to increase gains under drought and low N stress as an integral part of the MAIZE breeding programs. MAIZE Phase-II will use disaggregated cohort analysis to monitor genetic gains of different breeding approaches to allow reassessment of resource allocation for long-term genetic progress. Similarly, individual breeding programs in different target geographies will be assessed using genetic gain estimates from cohort analysis and rates of line and hybrid advancement through common trials.

- **Focus on specific individual traits with many separate breeding pipelines will not necessarily lead to successful commercial products that meet farmers' requirements**: MAIZE partners have successfully established decentralized tropical maize breeding and testing networks for screening advanced and commercial products in the target regions, and establishing strong product pipelines. In Phase-II, particular emphasis will be placed on MAIZE product profiles encompassing aggregate key traits with comparative advantages in specific agro-ecologies in SSA, Asia and LA. Breeding pipelines will rapidly adapt and incorporate new diversity and trait combinations to enhance genetic gains for multiple stress tolerance and nutritional quality and improved grain yield using novel tools, including DH and breeder-ready markers for prioritized traits (e.g., MSV and MLN).

- **Affordability and timely availability of quality seed:** Affordability and timely availability of quality seed of improved varieties is a major bottleneck in remote rural areas in several countries. In partnership with both public and private sector institutions, FP3 will intensify efforts to strengthen the seed sector in those areas, by providing options for low-cost improved maize seed and other types of hybrids.

- **Quickly bridge the knowledge and adoption gaps among men and women to facilitate access to improved varieties and foster women's participation across maize value chains**: Understanding the need to strengthen women's participation in seed production, processing, distribution, promotion, and retail is critical to developing gender-responsive research and development strategies. FP3 will strive for equitable maize seed systems where women and men farmers have equal opportunities to adopt new products, and benefit from opportunities available in maize value chains.

- **Need to systematize and institutionalize germplasm exchange and trialing in Asia**: CGIAR's global seed exchange is largely controlled by biodiversity regulations of the countries in which it operates. In the context of Asia, germplasm exchange in several countries is highly regulated and follows a slow process. To make continued breeding progress, it is essential that (a) new germplasm is tested in diverse environments; and (b) new models/initiatives that promote rapid germplasm exchange and evaluation are implemented, including putting private sector germplasm in the public domain.

2.6 Clusters of activity (CoA)

MAIZE FP3 consists of six CoAs. CoA 3.1 focuses on developing multiple-stress tolerant maize cultivars for targeted agro-ecologies in SSA, LA and Asia (**Annex 3.11** and **3.12**) and increasing genetic gains. CoA 3.2 will tackle the existing/future trans-boundary pathogens, insect pests and parasitic weeds in maize systems, while building the capacity of local institutions to effectively address such challenges. CoA 3.3 focuses on developing maize varieties with enhanced nutritional quality and end-use traits, with defined trait priorities and countries (**Annex 3.12** and **3.13**). CoA 3.4 focuses on increasing genetic gains through high-throughput and precision field phenotyping, mechanization of breeding operations, and establishment of well-equipped regional phenotyping hubs to provide phenotyping support to NARS and SMEs. CoA 3.5 will provide the bridge between product development and delivery, by testing the seed producibility of new maize hybrids and providing seed production recommendations to reduce the cost of goods sold. CoA 3.6 will implement innovative models for rapidly scaling-up and scaling-out improved maize cultivars in the target geographies, in close collaboration with the private sector and farmer-producer groups.

CoA 3.1, 3.3 and 3.4 will be strongly linked to MAIZE FP2 and the Genetic Gains Platform, while receiving inputs from MAIZE FP1 on technology targeting, impact assessment, gender and M&E&L. CoA 3.1 and 3.3 will provide promising maize germplasm for integration through FP4 in appropriate maize-based systems, and will receive feedback on their performance through G × E × M analyses. Products from CoA 3.3 will form the core for developing novel technologies/processes/products through FP5.

CoA 3.1: Climate resilient maize with abiotic and biotic stress tolerance

MAIZE Phase-II will build on the long-term achievements in the development of a diverse array of abiotic and biotic stress tolerant/resistant maize germplasm, and the continual introduction of novel alleles/traits to generate improved maize cultivars for target geographies. Considering the heterogeneity among target regions and the diverse stakeholder demands, breeding for stress tolerant and nutritious maize has identified priority traits and product profiles (see **Annexes 3.11, 3.12 and 3.13)**. Strategic interventions through CoA 3.1 will include:

1. Targeted products with packages of traits relevant to smallholders in the tropics: Product profiles have been redefined for SSA, Asia and LA based on extensive stakeholders' feedback during Phase-I and during formulation of the MAIZE Phase-II proposal. MAIZE will develop and integrate key GIS information into breeding pipelines for developing new varieties with traits required for future environments. FP3 incorporates stress tolerant genes through conventional and molecular tools, and also conducts focused R4D on transgenic approaches for improving stress resilience, especially in SSA. MAIZE made the first major test of transgenes for drought tolerance and *Bt*-based insect pest resistance, with requests for commercial release currently in process in SSA. Transgenic traits will be introduced under humanitarian license in partnership with technology providers, with MAIZE germplasm serving as a platform for introgression of transgenes for identified traits.
2. Integrated deployment of novel tools to enhance genetic gains: The breeding pipeline must be flexible to rapidly incorporate new traits and technologies. Based on the success achieved in Phase-I with regard to DH technology (Prasanna et al., 2012), and discovery-validation of novel markers associated with tolerance to abiotic stresses (drought, heat, NUE, waterlogging and soil acidity) and resistance to important diseases (MLN, MSV, TLB, GLS, tar spot complex) (Prasanna et al., 2013a; Babu et al., 2013; Nair et al., 2015; Gowda et al., 2015; Semagn et al., 2015), forward breeding strategies will be designed and implemented. The utility of MARS and GS for improving genetic gains, reducing cycle time and allowing increased selection intensity has been demonstrated (Beyene et al., 2014, 2016a,b); these strtaegies will be more extensively deployed in Phase-II.

CoA 3.2: Tackling emerging trans-boundary disease/pest challenges

The emergence and rapid spread of MLN in eastern Africa has posed a serious challenge to food security and livelihoods of farming communities, and the commercial maize sector in the region (Prasanna, 2015; Mahuku et al., 2015). Without intensive multi-institutional measures, MLN may become a continent-wide problem. The parasitic weed *Striga* infestation is increasing and threatens maize yields in farmers' fields in SSA, particularly in drought-affected areas with limited input use. Similarly, the larger grain borer (LGB, *Prostephanus truncatus*) is another postharvest trans-border grain insect pest that has spread rapidly in Africa (Golob, 2002). Effectively controlling the spread and impact of such trans-boundary diseases, pests and parasitic weeds is a complex challenge that can only be addressed through several concurrently implemented strategies.

In Phase-II, while intensifying breeding and deployment of genetically diverse maize varieties with resistance to MLN, *Striga* and LGB (through CoA 3.1 and 3.6), intensive inter-institutional efforts will be launched to establish and operate a functional Community of Practice (CoP) to address trans-border pathogens/pests; create awareness among farming communities of effective agronomic management practices; strengthen the diagnostics and phytosanitary capacity in SSA; and foster the production and commercialization of clean, MLN pathogen-free seed.

CoA 3.3: Introgressing nutritional quality and end-user traits

Maize alone contributes over 20% of total calories in human diets in 21 countries, and over 30% in 12 countries that are home to more than 310 million people. Chronic deficiencies of essential vitamins and minerals are particularly severe in SSA, Asia, and specific regions in LA, where many people do not consume enough essential micronutrients to lead healthy and productive lives (Bouis et al., 2011). Biofortified maize varieties are particularly impactful in rural areas with limited access to dietary supplements and fortified foods (Chomba et al., 2013). Significant progress has been made in developing, testing, and deploying biofortified maize, especially Quality Protein Maize (QPM) and provitamin A-enriched maize worldwide in collaboration with A4NH (Atlin et al., 2011; Babu et al., 2013). CoA 3.3 will focus on:

1. Introgressing relevant nutritional and end-use quality traits: Developing and deploying maize varieties with relevant nutritional and end-use quality traits can promote diverse uses of maize in the food/feed sector (Grings et al., 2013), increase income-generating opportunities for farmers and processors, reduce women's labor requirement at the household level and contribute to waste reduction. CoA 3.3 will also devote efforts to developing maize varieties with prioritized nutritional and end-use quality traits (**Annex 3.13**) to enhance the use of maize as food/feed, and improve its storability, processing and palatability (linked to FP5 in maize value chains).
2. Specialty maize for improving smallholders' income opportunities: There is an increasing market demand for specialty maize in urban and peri-urban areas, including blue maize varieties (Hellin et al., 2013), sweet corn, popcorn and baby corn. CoA 3.3 will explore opportunities for developing and deploying specialty maize varieties for SSA, Asia and LA (as an uplift activity).

CoA 3.4: Precision phenotyping and mechanization of breeding operations

Field-based high-throughput and precision phenotyping using low-cost, easy-to-handle tools, should become an integral component of the breeding pipeline, especially for NARS and SME seed companies (Prasanna et al., 2013b; Araus and Cairns 2014). The focus of CoA 3.4 will be on:

1. Developing/validating and using new phenotypic innovations in selection decisions: Digital and hyperspectral imaging will be used to rapidly collect data on key agronomic traits, including stand count, anthesis date, senescence index, leaf area/biomass index, canopy architecture, nitrogen stress index, disease and pest damage ratings. This will have strong linkages to the Genetic Gains Platform for inputs on high-throughput/remote-sensing phenotypic data capture, storage, and analysis and, with CoA 2.3, will facilitate automated image analysis.
2. Establishing well-equipped regional phenotyping hubs to provide phenotyping support to NARS and SMEs: Well-equipped regional phenotyping hubs, ideally linked to site integration hubs across CRPs/Centers, will enable economies of scale for collecting precision phenotypic data at different stress intensities. These hubs will also offer practical training to scientific/technical personnel from NARS and SMEs on new developments in field-based phenotyping technologies.
3. Mechanization of maize breeding operations: CoA 3.4 will focus on mechanization of breeding operations, particularly (a) automated seed preparation and seed treatment; (b) planting field trials and breeding nurseries, (c) fully mechanized and automated harvest, and (d) modern postharvest operations. Trial operations will be streamlined and mechanized to the extent that 3-4 well-qualified (M.Sc.) technicians should be able to manage >100,000 trial plots with 100% electronic data collection. Training of NARS and SMEs with smaller-sized maize breeding operations, and targeted co-investments by MAIZE and other organizations will enable adoption of selected mechanization approaches for trial and nursery operations.

CoA 3.5: Seed production research and recommendation domains

MAIZE works with over 200 local seed companies that are crucial for bringing improved maize seed to the 40-50% of farmers that are inadequately served by the established seed sector. Information on seed production potential (producibility) of parental lines and hybrids is critical for successful adoption of these products by small- and medium-sized seed companies. They rely on high seed yields which often need to be produced under rainfed conditions. Seed production research is therefore an integral component of MAIZE FP3, and will be conducted in close partnership with seed company partners. Key considerations are female parent yield, synchronized flowering of the male and female parents, and agronomic characteristics of inbred lines and single-crosses. Particular focus will be on: (a) evaluation of parental lines of hybrids for yield, herbicide sensitivity and other desirable agronomic traits; (b) web-based documentation and dissemination of recommendation domains for cost-effective seed scale-up; (c) development of male sterility-based seed production systems to make seed more affordable by reducing the cost of seed production; and (d) identifying and adopting the best male-female ratios to increase seed production per unit area.

CoA 3.6: Stronger maize seed systems

Delivering low-cost improved hybrids to smallholder farmers with limited purchasing capacity and market access requires that indigenous SMEs be supported with information on access to new products, besides adequate and reliable supplies of early-generation (breeder and foundation) seed. This CoA helps emerging seed enterprises in SSA, Asia and LA to become increasingly market-oriented, diverse and dynamic, so as to provide smallholders with greater access to affordable improved maize seed. Strategic interventions through CoA 3.6 will include:

1. Improving the availability and affordability of MAIZE-derived novel varieties in target geographies: The uptake of improved maize seed by smallholder farmers is a function of the cost of seed and expected returns from investment compared to existing varieties. CoA 3.6 will focus on: (i) catalyzing replacement of obsolete maize varieties (in the market for more than 15/20 years) with new climate-resilient MAIZE cultivars; (ii) facilitating on-farm testing to identify women and men farmer-preferred improved varieties; (iii) databases with on-station and on-farm trial results, along with GIS data; (iv) licensing and targeted deployment of promising pre-commercial maize hybrids through seed company partners committed to providing quality seed to smallholders in target geographies; and (iv) catalyzing scale-up and delivery of quality seed of selected products through public-private partnerships.

2. Promoting sustainable breeder, pre-basic and foundation seed supply systems, especially in SSA: This will be accomplished by: (i) testing different models for sustainable third-party production and provision of foundation seed of MAIZE hybrids to SME seed companies; (ii) supporting women-owned foundation seed production companies; and (iii) strengthining capacities of key local seed regulatory agencies and SMEs for QA/QC (Quality control/Quality assessment) across the seed value chain.

3. Catalyzing sustainable commercialization, marketing and promotion of new varieties to enhance both local production and adoption: Sustained demand for good quality seed of new varieties will be catalyzed by: (i) improving smallholder farmers' knowledge of new maize varieties and complementary crop and land management practices; (ii) generating information on technology adoption patterns and key drivers to design marketing strategies (linkage with FP1); (iii) building the capacities of SME seed companies in business management and marketing strategies; (iv) promoting community-based production of improved seed with the requisite quality for areas difficult to reach through seed companies; and (v) promoting linkages among seed companies, community-based organizations, financial institutions and end-user markets.

4. Gender-responsive approaches to promote women's participation across the maize seed value chain: Huge gender gaps exist in entrepreneurship along the maize seed value chains in SSA, Asia and LA. CoA 3.6 will therefore focus on: (i) fostering equal access by women and socially disadvantaged farmers to seeds of improved varieties, training, financing and information; (ii) providing seed company partners with tools/guidelines for gender-responsive promotional activities; (iii) giving priority to development partners who are committed to gender-inclusive approaches; (iv) conducting gender capacity assessment for partners and providing support for integrating gender into seed business development; and (v) organizing exchange visits and short-term training for women entrepreneurs along the entire value chain.

5. Farmer producer groups as a vital component for scaling-out technology and as a key pathway for reaching women and youth: Strong local farmers' and women's groups can promote dissemination of information on new varieties and appropriate management practices, develop effective approaches for improved seed delivery, foster output market linkages, and transfer nutrition and utilization skills and messages. Existing farmers' groups in target geographies will be strengthened to foster rapid technology adoption and and reach women and youth. Seed companies, agrodealers, and stockists will be encouraged to deploy their products through farmers' groups.

6. A consortium-based approach in SSA for targeted product development and deployment: Based on the success achieved in Phase-I through the International Maize Improvement Consortium (IMIC) in Asia and LA, we will establish and implement an ESA-wide IMIC. This consortium will strive to: (a) create a forum for public-private partnership to catalyze adoption of improved varieties; (b) facilitate collaborative testing of improved pre-commercial hybrids; and (c) strengthen the capacity of seed company partners in modern maize breeding.

2.7 Partnerships

The maize breeding programs at CIMMYT and IITA have established broad regional maize breeding and product testing networks, comprising over 100 collaborating institutions, including NARS, private seed companies and NGOs. MAIZE also engages several advanced research institutes and universities in conducting collaborative research using cutting-edge science for developing stress tolerant and nutritious maize germplasm. One of the major strengths of MAIZE is the strong partnership with the private sector to develop and deploy products adapted to SSA, Asia and LA for greater impact. MAIZE is also providing direct linkages between national programs and advanced research institutes to accelerate the transfer of new technologies. These efforts are fully aligned with the CGIAR Principles on the Management of Intellectual Assets. Large multinationals, including DuPont-Pioneer, Monsanto and Syngenta, collaborate as providers of distinct germplasm, knowledge and, in some cases, technologies that are acquired under humanitarian licenses. Indigenous regional and national seed companies receive elite breeding materials, pre-commercial hybrids and training to develop and deploy products for commercialization and in support of their own breeding programs. Special efforts are made to continuously forge new strategic partnerships through germplasm exchange, as well as joint projects with advanced research institutions, universities and multinationals to exploit complementary germplasm, broaden genetic diversity and access intellectual property for public use. Particular focus will be placed on partnership with farmers, youth and the socially disadvantaged in participatory evaluation of improved maize cultivars in target environments in order to gain better insight into their distinct needs for breeding and developing gender-responsive products.

Docking with Other Agri-Food Systems CRPs, and Integrating Programs and Platforms

FP3 shares a significant number of breeding and testing locations with other rainfed crops and associated agri-food systems CRPs, especially RICE, WHEAT, DCL and RTB, and with CGIAR centers and NARS. MAIZE in Phase-II will aim at more strongly leveraging phenotyping competencies and best practices through site integration, and will explore how best to rapidly translate insights of extensive research on genetics and breeding of maize, wheat, and rice to smaller crops with lower research intensities. FP3 will have strong linkages with the Genetic Gains Platform. Some of the key tools for cross-cutting areas, such as phenotyping, genotyping, breeding information management, and decision-making tools, will be validated and deployed in FP3. The FP3 team in turn will also help determine priorities to guide development of new tools in this platform. Details of what MAIZE "provides and receives" from various AFS-CRPs and platforms are provided in **Table 1 in** **Section 1.7** (Cross-CRP collaboration and site integration).

2.8 Climate change

Yield loss and year-to-year variability in most of the target MAIZE areas are related to climate-induced stresses. Climate projects show maize yields are likely to decrease further in many of these areas (IPCC, 2014; Tesfaye et al., 2015). Breeding programs targeting large regions with highly heterogeneous environments tend to subdivide the regions into several relatively homogenous areas, known as mega-environments, where germplasm will perform similarly. Climate projections show that the demarcation of these mega-environments will change in several areas. In order to address changing environments and offset potential losses due to climate change, maize breeding pipelines must take into account changes in future environments and the trait combinations within these environments required to maximize yields. To address this, FP3 will incorporate the outputs of GIS climate and crop modeling to identify future stresses, hotspots of vulnerability and phenotyping sites suitable for screening for future environments (analogue sites). Current phenotyping sites within MAIZE countries may not provide the environments required for developing climate resilient maize, and therefore identifying analogue sites within phenotyping networks will be crucial. This process will be particularly pertinent for countries whose current internal phenotyping networks do not contain screening sites representative of future target environments. Breeding pipelines will target key trait combinations required for future target environments. This process will be dynamic with advances in GIS continuously incorporated into breeding programs to refine target environments and align product folios, building on the lessons learned in Phase-I. These actions will ensure products coming out of MAIZE breeding programs will provide farmers with the most appropriate maize varieties for their environments.

2.9 Gender

FP3 places priority on product development and deployment, addressing the needs and preferences of both women and men farmers. This includes mainstreaming gender work in FP3 activities, and standardizing sex-disaggregation data collection, analysis and farmer feedback for maize genetic improvement and seed systems work. In addition, the findings of gender and maize seed sector development studies in Phase-I will form the base to raise investment in gender-responsive seed sector development. Relevant gender research questions for FP3 include:

- What are the needs, preferences and constraints of men and women maize farmers with regards to maize varietal traits? Are these similar or different for men and women farmers? To what extent are these considered in maize variety development?
- What shapes men and women farmer's ability to access, use and benefit from improved maize varieties?
- Under what conditions do smallholder women and men farmers engage with the seed retail sector? What kinds of maize seeds, what quantities, and what frequency? What factors do they consider when acquiring seed? What are the challenges they face in relation to acquiring improved maize seed? In what ways and to what extent do these aspects differ between men's and women's maize seed acquisitions?
- How do small- and medium-size seed companies and agro-dealers perceive and segment their markets? How do they address gender as a customer attribute? What constraints are faced by agro-dealers and by women farmers?
- How do farmers, especially women, access information about seed? What are the key issues for developing gender-sensitive variety promotion and decision support information?

2.10 Capacity development

Capacity development of partners through short-term and long-term training courses and technical backstopping is essential to increase genetic gains and breeding efficiency, catalyze uptake of improved MAIZE germplasm, and improve frequency of varietal turnover. Sensitizing partners to trait requirements in the target environments has also increased regional strength. For example, extensive training and partnership for improving NUE resulted in at least five seed companies developing low-N phenotyping sites for improving their product development pipeline.

In Phase-II, capacity development activities of MAIZE FP3 and FP2 will be more effectively coordinated to achieve synergies. FP2-FP3 will jointly organize training courses for NARS and SME seed company breeders/technicians on modern maize breeding, especially DH, precision phenotyping, molecular marker-assisted breeding, environmental characterization, experimental error control and mechanization of breeding operations. Breeding data management tools will be disseminated to increase breeding efficiency. Another key element is the improvement of small-scale farmers' knowledge of new maize varieties and complementary crop and land management practices, and enhancing the seed business management and marketing capacities of SME seed companies. Dissemination of tools/guidelines for gender-responsive promotional activities will be strengthened. Local production of improved seed will be supported by short-term training and on-farm demonstrations.

Both short- and long-term visiting scientist fellowships and postgraduate research support will be provided, with at least 50% of fellowships granted to women and youth. Training course lectures/videos will also be disseminated through web-based modules. Exchange visits and short-term training will be organized for women entrepreneurs.

2.11 Intellectual asset and open access management

Under FP3, scientists will validate/deploy new tools for data management, data stewardship (including open-access), and data mining or analysis to enhance breeding efficiency that results in faster genetic gains. The new tools will be designed with OA/OD in mind, from a technical and user perspective. As often as possible, the data generated in FP3 will be collected and stored according to CRP standards using CRP tools to facilitate their regular export to established data-sharing platforms. As much of these data will be collected from both public and private sector partners, all projects with partners shall include robust data-sharing and intellectual asset management agreements to ensure that the rights to data and intellectual assets, including germplasm, and the responsibility for data curation and sharing are clearly established. MAIZE FP3 researchers will make well-described raw and/or analyzed data available to the public through CRP-approved OA/OD repositories and data warehouses, such as Dataverse, or through public portals such as Ensembl Plants. MAIZE germplasm will be disseminated based on international regulations and Standard Material Transfer Agreements (SMTAs).

2.12 FP management

MAIZE FP3 will be co-led by scientists from the two lead centers in the CGIAR (CIMMYT and IITA), who have significant expertise and a track record in generating impacts through maize breeding and product deployment in the target geographies, especially Africa, Asia and Latin America, which gives FP3 a distinct comparative advantage over any other institution operating in those regions. **Table FP3.3** provides the names of the FP3 coordinators and CoA management team, while details of their leadership capacity, technical expertise on maize R4D, and track record are provided in **Annex 3.8**. The FP3 leadership team also has long-term and successful partnerships with a wide array of public and private institutions that add value at different levels, including discovery research, validation/proof of concept, and deployment/scaling-up. Since FP3 is geographically widespread, co-leadership allows both centers to have clear roles and responsibilities in specific target geographies, with CIMMYT coordinating the MAIZE FP3 work in Asia, LA and ESA, and IITA doing the same in WCA. Co-leadership also eases integrating MAIZE FP3 with other FPs and CRPs/Platforms, including site integration.

Table FP3.3. MAIZE FP3 and CoA management team

FP3/CoA Structure	FP3 Coordinators and CoA leaders	
	CIMMYT	IITA
FP3 Stress tolerant and nutritious maize	B.M. Prasanna	Abebe Menkir
CoA 3.1 Climate resilient maize with abiotic and biotic stress tolerance	Jill Cairns (SSA); Felix San Vicente (LA); B.S. Vivek (Asia)	Abebe Menkir
CoA 3.2 Tackling emerging trans-boundary disease/pest challenges	B.M. Prasanna	Lava Kumar
CoA 3.3 Introgressing nutritional quality and end-user traits	Natalia Palacios	Bussie Maziya-Dixon
CoA 3.4 Precision phenotyping and mechanization of breeding operations	P.H. Zaidi	Abebe Menkir
CoA 3.5 Seed production research and recommendation domains	Tsedeke Abate (SSA); Arturo Silva (LA); A.R. Sadananda (Asia)	Buffour Badu-Apraku

2.13 Budget summary

Details of FP3 projected base and uplift budgets for Phase-II, including analysis by funding sources, are provided in **Annex 3.19**. FP3 base/uplift budget is the largest among the five flagships of MAIZE Phase-II. FP3 receives nearly 90 percent of its budget from W3/bilateral projects, such as STMA, WEMA, HTMA, DTMASS, MasAgro-Maize. Some of these projects will come to a close in a few years (within 2-3 years in some cases). While we anticipate resource generation through W3/bilateral resources to continue based on the highly-appreciated work undertaken by the MAIZE breeding programs, W1/2 resources are critical for the MAIZE breeding pipelines to remain strong and impactful.

MAIZE in Phase-I has been successful in providing kick-start resources through W1/2 for implementing strategic/core areas; for example, initiating breeding for MLN resistance and mobilizing international partnerships on MLN R4D when the disease suddenly emerged in eastern Africa in 2012. However, within a year, we have been successful in generating resources through W3/bilateral projects for establishing the MLN Screening Facility at Naivasha and for focused work on breeding for MLN resistance (with highly encouraging results). This has allowed us to free-up W1/2 resources and reallocate the same for other strategic areas under FP3.

Within the overall FP3 strategic priorities and funding availability, the scope and geographies of W3/bilateral funding will largely influence how W1/2 resources can be strategically used for implementing priority areas for Phase-II. W1/2 resources are also vital to secure the core of the MAIZE breeding programs, especially in Asia and Latin America, and to strengthen MAIZE R4D in SSA. The overall uses of W1/2 may vary over the duration of the MAIZE Phase-II based on our ability to secure strategically relevant W3/bilateral in each of the CoAs. As in the case of other Flagships, we envisage each CoA to have at least 1-2 substantially active W3/bilateral project closely aligned with the CoA priorities. W1/2 will add strategic value by integrating the trait pipelines in MAIZE breeding programs across SSA, Asia and LA, ensure effective linkages among the breeding pipelines in the three continents, and maximize the value for money.

W1/W2 resources, under the FP3 base budget, enable addressing the following priorities:

- Increasing yield potential, stress tolerance, input use efficiency and agronomic architecture of tropical maize through temperate germplasm introgression.
- Determining portfolio of G x E x M options for major maize-producing regions in SSA.
- Improving rainfed maize productivity in South and SE Asia through high-yielding, stress resilient MAIZE hybrids, and introduction of client-preferred traits.
- Implementing a Latin American tropical maize regional testing network for experimental, advanced and elite hybrids and OPVs, with emphasis on rainfed yield potential and tolerance to major diseases (TSC and ear rots)
- Identifying/developing maize lines, hybrids, and source materials with desirable characteristics for stover production, and for deriving dual-purpose maize hybrids.
- Increasing yield potential and stress tolerance of QPM varieties for SSA and Asia.
- Improved MAIZE germplasm and technical backstopping support to NARES and SME partners in major maize-growing countries in SSA, Asia and LA that are not targeted under W3/bilateral projects.

Uplift W1/2 budget (circa 1.56 M per year) for FP3, if received, will be helpful in addressing the following areas:

- Expanding phenotyping network and breeding capacity for tolerance to heat stress, soil acidity, salinity and relevant trait combinations in SSA, Asia and LA.
- Establishing a Global MAIZE Phenotyping Network (GMPNet) as a one-stop shop for abiotic and biotic stress phenotyping protocols, databases, data-sharing, on-line learning courses, and other updates (linked with GIS and weather data repositories).
- High-throughput phenotyping system using spectral image analysis for drought and nutrient responses and for key foliar diseases (e.g., MLN) integrated in the MAIZE breeding platforms.
- Improving mechanization of breeding operations (nurseries and trials) at key breeding hubs in SSA, Asia and LA.
- Developing improved MAIZE varieties with specialty corn traits (e.g., blue maize, sweet corn) developed and tested in SSA, Asia and LA, based on client demands, for enhanced income opportunities for smallholders.
- Catalyzing enhanced adoption of climate-resilient MAIZE hybrids in Latin America and Asia through multi-location on-farm participatory testing and public-private partnerships.

Scope and geographies of future W3/bilateral funding and emergence of new biotic threats to regional or global maize production will influence how we strategically prioritize and allocate W1/2 resources in Phase-II.

FP4: Sustainable Intensification of Maize-based Systems for Improved Smallholder Livelihoods

2.1 Rationale, scope

Strategic efforts to boost maize productivity can increase smallholders' food and income security, while also improving livelihoods, natural resource integrity, equity, nutrition and health, and resilience against biophysical or socioeconomic shocks. These are all urgent development priorities. However, most smallholder farmers' livelihoods do not depend exclusively on maize. Their farming systems are characterized by complex strategies that integrate crop, tree and livestock production, with increasing reliance on off-farm income, and a strong risk management component that can hamper the adoption of innovations that focus on maize alone.

Working in high-poverty maize-based systems in Latin America, sub-Saharan Africa and South Asia, FP4 focuses research on sustainable intensification (SI). SI encompasses: (a) production of more food, feed, fuel and/or fiber per hectare, labor and/or capital used, by closing yield gaps and increasing yield per unit of time and area; (b) conservation of critical agroecosystem regulatory and provisioning services; and (c) farming system resilience to shocks and stresses, including those posed by climate change and market shocks. It also seeks to address social justice, gender equity, and youth inclusivity and human well-being (Loos et al., 2014; Pretty et al., 2011; Vanlauwe et al., 2014; Zurek et al., 2014). Research within FP4 has the potential to simultaneously address a number of sustainable development objectives, all of which are central to SI. These include eliminating poverty and hunger, improving access to clean water, facilitating responsible production and consumption, addressing climate change, and protecting natural areas from conversion to agricultural use, while arresting or reversing land degradation.

Understanding smallholder farmer livelihood strategies (including their human, natural, social, financial and physical capital) and capturing the complexity of maize-based systems (specifically their trajectories in response to external drivers of change such as access to input/output markets, population and land pressure, changing demographic dependency ratios, and climate change) are prerequisite to co-developing technologies and management practices suitable for resource-poor farmers, while adapting and integrating them into smallholders' diverse farming systems. Through this process, improved agronomic practices and innovations can be brought to scale. Such innovations must be assessed not only on their potential to increase maize productivity, but also in terms of overall farm productivity, profitability, stability, resilience, market risks, nutritional outcomes, as well as the interest and capacity (knowledge, financial) of individual farmers to sustainably adapt and adopt innovations (López-Ridaura et al., 2002; Tittonell et al., 2005). Technical innovations applied to maize also interact with other production units and institutions within smallholder farming systems, especially when resources such as land, labor and capital are in short supply. While co-developing interventions, it is also important to acknowledge that there is no one-size-fits-all solution to address livelihood constraints. Within smallholder farming communities, different families and family members have varying levels of access to land, labor and capital resources (Tittonell et al., 2010). Farmers' production objectives may range from subsistence to commercial, which consequently influences their interest in intensified farming practices.

These tensions and interactions result in trade-offs or synergies (Tittonell et al., 2015). The overarching hypothesis underlying the research conducted under FP4 is that trade-offs between investments in different fields and crops, crops and livestock, labor allocation alternatives, and between short- and longer-term benefits are to be expected when smallholders adapt and adopt SI approaches, and that in order to successfully scale-up SI interventions, these trade-offs must be continuously monitored, minimized and reflected on in order to simultaneously leverage observed synergies. Improving the livelihoods of a section of society or household should not occur at the cost of another. FP4 embraces this complexity, providing interdisciplinary expertise and analysis that focus on specific objectives and targets, all of which strongly contribute to the CGIAR Strategic Results Framework, and ultimately to the Sustainable Development Goals of ending poverty, hunger and gender inequity, while responding to the call to protect terrestrial ecosystems and biodiversity through the development of a more sustainable agriculture and improved food and nutrition security.

FP4 is designed around four mutually-reinforcing clusters of activities (CoAs):

4.1 Multi-scale farming system framework to better integrate and enhance adoption of sustainable intensification options;

4.2 Integration of technological and institutional options in rural livelihood systems;

4.3 Multi-criteria evaluation and participatory adaptation of cropping systems;

4.4 Partnership and collaboration models for scaling.

This structure, while similar to the one utilized in the MAIZE-I extension (2015 and 2016), has proven efficient for articulating the complex and diverse R4D challenges related to SI research conducted from a systems analytical perspective. As highlighted by the recent external review of MAIZE, this structure provides clear benefits in terms of economies of scale, mobilization of a critical mass of diverse scientific expertise, overall quality and relevance of FP4 research, knowledge, and product flows between disciplines, institutions and geographies of interest. The structure will assist in the prioritization of limited W1/2 resources to the most strategic components of the Flagship to distill and put scientific knowledge into action through W3/bilateral projects.

2.2 Objectives and targets

FP4's primary outcomes will be measured in MAIZE's comprehensive Results-Based Management Framework. Those outcomes include three SRF sub-IDOs: (a) more efficient use of inputs; (b) yield gaps closed through improved agronomic and animal husbandry practices; and (c) agricultural systems diversified and intensified in ways that protect soil and water (detailed below; see section 2.3). FP4 also contributes to the five cross-cutting sub-IDOs, namely: (a) enhanced capacity to deal with climatic risks and extremes; (b) improved decision-making capacity of women and young people; (c) increased capacity of beneficiaries to adopt research outputs; (d) enhanced institutional capacity of partner research organizations; and (e) increased innovation capacity of actors involved in SI. The theory of change underlying FP4 is aligned with the CGIAR SRF, clarifying how the FP's R&D outcomes contribute through MAIZE's sub-IDOs to reducing poverty, improving food and nutrition security for health, and improving natural resource systems and ecosystem services SLOs. Progress toward the sub-IDOs will be measured and documented through indicators and metrics appropriate to SI goals. See **Table FP4.1** below for FP4's contribution to the CGIAR Grand Challenges and **Table FP4.2** for FP4 indicators of progress towards sub-IDOs.

Table FP4.1: FP4 Contribution to Grand Challenges

Grand Challenge	MAIZE FP4 Contributions
GC1: Competition for land from multiple sources: food and feed crops, livestock, biofuels and biomaterials, forest products, conservation, urban expansion, and a host of other ecosystem services.	• Development of diversified cropping systems (provision of multiple crop products) and increased crop and system intensity to reduce pressure on land. • Improved resource allocation within farming systems improves resource use efficiency and spares land for multiple purposes. Also, multifunctional farming systems satisfy a multiplicity of individual and societal goals. • Diversified and highly productive cropping systems contribute to the reduction of population pressure on land and expansion of agriculture into more marginal lands. • Scaling out high yielding and stress resilient hybrids, along with sustainable intensification options, will contribute to improved productivity and make feed and food available without expanding maize cultivation to marginal areas. • Acquisition of new skills by researchers, extension specialists, seed companies and farmers is expected to increase production per unit area, thus releasing land for non-farm activities and community use.
GC2: Soil degradation on land already farmed in circumstances where new lands brought under production are often poorly suited for intensive agriculture.	• Better understanding of Genotype x Environment x Management (G x E x M) interactions could lead to identification of new genes useful for tolerance to poor soils or of germplasm adapted to various kinds of soils (2.3). These data could be used to deliver better genotype- and environment-specific recommendations for field management (in 4.2 and 6.2). • A better understanding of soil conditions will allow improved targeting of input (organic inputs and fertilizer) management strategies and identify those areas that require rehabilitation investments. • Research for understanding beneficial microbiome associations with maize. • Development and extension of crop management practices that stop soil degradation (reduced depletion of nutrient stocks, soil C, erosion, degraded soil structure and acidification). • Through research on the integration of grain legumes in maize-based cropping systems along with crop residue retention, cover crops and ISFM practices, FP4 contributes to developing scalable interventions that reduce soil degradation. • By increasing productivity, farmers will not need to bring new marginal or fragile land under cultivation. • Capacity building among researchers and farmers can lead to better/less-destructive farming methods.
GC3: Overdrawn and polluted water supplies threaten social breakdown and rising levels of conflict.	• More efficient use of water resources to lessen competition with non-agricultural user groups, reduced off-farm pollution (particularly in South Asia, less so in Latin America or ESA).

GC5: Climate change threatening agriculture, while at the same time agriculture is a substantial producer of greenhouse gases	• Farmers' integration of water use and nutrient use efficient technologies (agronomic practices and new germplasm) reduces crop losses due to climate change (linking with CCAFS). • Targeting of improved crop and soil management practices against changing and variable weather conditions can improve overall productivity and reduce production risks. • By expanding the adoption of climate resilient varieties, both food supplies and incomes will be more adaptable to climate change, while reduced inputs will reduce greenhouse gases. In addition, more productive varieties would help reduce the need for expansion into new frontiers, thus contributing to minimizing production of greenhouse gases. • Capacity building among researchers and farmers can lead to better agricultural management through the use of climate-smart technologies that reduce the negative effects of climate change.
GC7: Nutritious and diverse agri-food systems and diets are becoming more important. Increased consumption of animal products, fruits and vegetables alongside traditional cereal staples offers to improve nutritional and health outcomes among the undernourished.	• Diversified farming systems (e.g., maize-legume and maize-vegetable intercropping systems) improve the availability of higher dietary quality products and diverse and healthy diets.
GC9: Employment and income opportunities created for men, women and youth as a result of the development of value chains for staple products and the provision of improved seeds, husbandry practices and small-scale mechanization.	• Increased involvement of the private sector in small-scale mechanization, development of business management and marketing skills, and linkages to markets and finance are assured ways of increasing income and youth self-employment.

Table FP4.2: FP4 Indicators of progress towards sub-IDOs.

Sub-IDOs	Nature of FP contribution	Key indicators
More efficient use of inputs	(1) Increased labor use efficiency through scale-appropriate mechanization and integrated weed management (2) Increased water use efficiency in irrigated systems through reduced tillage, crop diversification, and decision support tools for irrigation scheduling (3) Efficient precipitation use in rainfed systems through adoption of conservation agriculture (CA) (4) Increased nutrient use efficiency through Integrated Soil Fertility Management (ISFM), decision support tools, and enhanced nutrient cycling	(1) Labor use efficiency (gender and age disaggregated) (2) Water productivity at field, farm, landscape levels (3) Nutrient use efficiency field, farm, landscape levels (4) Land degradation/erosion/soil health indicators at the field, farm, and landscape levels including populations and proxies for critical soil faunal species (5) Field and farm productivity (yields, income) (6) Gender and age-disaggregated CA and ISFM adaptation/adoption data (7) Gender-disaggregated data on NARS scientists trained and student degrees completed (8) Evidence of knowledge put to use by NARS (methods), extension, NGOs and other development partners (training materials) (9) Indicators of gender and youth involvement in small- and medium-sized enterprises, and institutions **Targets**: Asia: Bangladesh, Cambodia*, India, Laos*, Pakistan, Myanmar*, Nepal, Vietnam* SSA: Cameroon**, DRC**, Ethiopia, Ghana**, Kenya, Malawi, Mali, Nigeria, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Zimbabwe LAC: Mexico, Guatemala, Haiti, Nicaragua
Yield gaps closed through improved agronomic and animal husbandry practices	As for previous IDO: Framework to better target and tailor development investment at the farm and landscape levels taking into consideration the multi-commodity aspects of smallholder farms (which technical innovation on which commodity and for which farmers).	
Agricultural systems diversified and intensified in ways that protect soil and water	As for previous IDO: Soil conserving /reclamation technologies (CA, ISFM). Bioeconomic trade-off analyses	
Enhanced capacity to deal with climatic risks and extremes	"Climate-Smart Agriculture" practices. CA and ISFM. Reducing production risk through system and income diversification options	
Improved decision-making capacity of women and young people	Innovation systems research inclusive of gender and youth. Design of gender/youth specific knowledge products. Proactively embedding gender/youth lenses in partnerships. Inclusive business models for mechanization and service provision	
i) Enhanced institutional capacity of partner research organizations, and ii) Increased innovation capacity of actors involved in SI	(1) Co-designing, testing, refining of SI options with range of stakeholders (2) Knowledge product generation (3) Well-targeted short and long training courses	

* Countries to expand to in Phase-II if W3/bilateral funding allows (possible W1/2 for scoping studies).
** Humid tropical CRP countries to be integrated into MAIZE-II.

Appropriate indicators and metrics for monitoring progress towards the SI of maize-based farming systems are paramount to FP4's success. FP4 is currently working with the International Institute of Applied Systems Analysis (IIASA), ORNL and Africa RISING to develop a comprehensive SI indicator and monitoring framework. Two broad types of indicators are envisioned, including *contextual/informative indicators* that will be monitored in alliance with FP1 (e.g., potential envelope for adoption of a particular technology, stability of adoption trends given market and political fluctuations, etc.), and *impact indicators* that are aligned with validating the MAIZE ToC and with W3 donor requirements (e.g., hectares and farmers utilizing SI approaches, involvement of private sector enterprises, poverty reduction and smallholder access to services – all with an emphasis on understanding why indicators may vary for women and youth). Because FP4's interventions seek to catalyze change in maize agri-food systems through indirect actors (e.g, the private sector) and processes (e.g., market development, institutional change, capacity development for innovation generation) that may take time to mature, "process" change indicators (farmers' and the private sector's awareness of, and demand for, SI approaches, progress towards critical levels of adoption to spur spontaneous change, shifts in institutional support, etc., all of which are mapped onto region-specific impact pathways) will also be monitored to assess the development of an environment that enables the scaling of SI interventions, as indicated in **Figure 2.4** below.

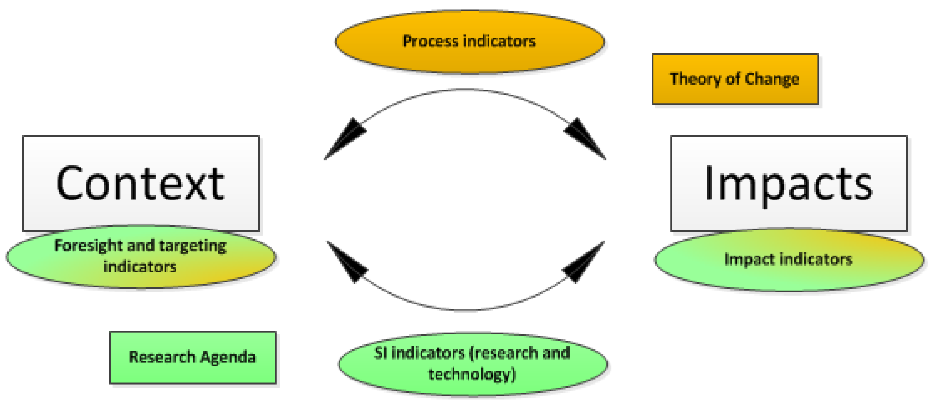


Figure 2.4: FP4 Process Indicators

Process indicators will be complemented with multi-criteria SI indicators of relevance to science quality, with emphasis on bridging yield gaps, resource use efficiency, and indicators of beneficial biological and ecological processes at the field level. Moving to the farm and landscape levels, measures of food security, land conversion reduction, land rehabilitation, biodiversity, ecosystem services, and livelihood measures including food security and nutrition (particularly of women and young children), income, investment (land, labor, cash), assets and social networks (capacity) will be included. Lastly, institutional indicators will also be recorded, for example, private sector investment in extension, incorporation of MAIZE technical materials into public and private extension systems, university curricula, etc. Large economies of scale and improved M&E&L are expected from more harmonized approaches, better definition and development of SI indicators and metrics across CG centers, CRPs, and in response to donor requirements (see **Table FP4.2)**. In particular, cost-efficiency will be achieved by utilizing proxy data, creditable inference methods, secondary data (where appropriate) and remote sensing, within the framework under development with IIASA.

2.3 Impact pathway and theory of change

The FP Sustainable Intensification's theory of change was developed during a workshop with the Flagship Program teams from both MAIZE and WHEAT CRPs. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. Workshop participants increased their understanding of the CGIAR Strategy and Results Framework and awareness of results-based management concepts. The workshop was structured to encourage sharing and learning on a variety of topics and across both CRPs.

Using the CGIAR Results Framework's sub-intermediate development outcomes (sub-IDOs), the team agreed to focus on three sub-IDOs and five cross-cutting sub-IDOs:

- 1.3.4 More efficient use of inputs;
- 1.4.2 Closed yield gaps through improved agronomic and animal husbandry practices;
- 3.2.2 Agricultural systems diversified and intensified in ways that protect soil and water;
- A.1.4 Enhanced capacity to deal with climatic risks and extremes;
- B.1.3 Improved decision-making capacity of women and young people;
- C.1.1 increased capacity of beneficiaries to adopt research outputs;
- D.1.1. Enhanced institutional capacity of partner research organizations; and
- D.1.3 Increased capacity for innovation in partner research organizations.

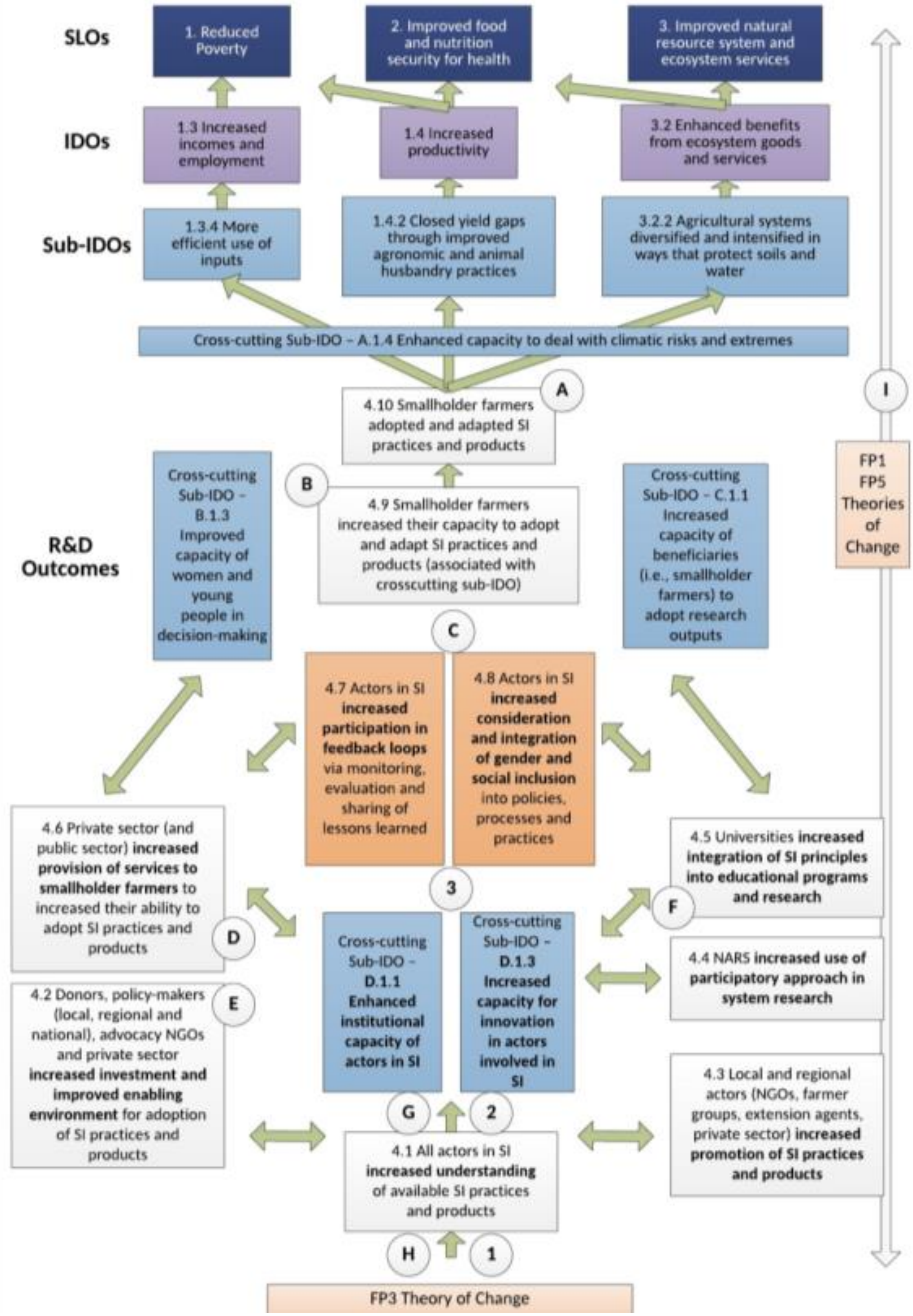
Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs. The team identified several of the cross-cutting sub-IDOs as part of the research and development outcome component of the impact pathway, noting their importance in contributing to the achievement of immediate and intermediate outcomes.

Based on these areas of focus, the team agreed that this Flagship Program contributes to reducing poverty (SLO 1), improving food and nutrition security for health (SLO 2) and improving natural resource system and ecosystem services (SLO 3) by increasing incomes and employment (IDO 1.3), increasing productivity (IDO 1.4), enhancing benefits from ecosystem goods and services (IDO 3.2) and enhancing the cross-cutting issues of climate change (A), gender and youth (B), policies and institutions (C), and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory as well as the risks that may undermine success were documented.

This theory of change will be the foundation of the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of data collection and analysis based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the Flagship Program and reflecting on lessons and program improvements.

Figure 2.5: Theory of Change for MAIZE FP4



<table>
<tr><th>Assumptions and Risks</th><th>Interventions and Outputs</th></tr>
<tr><td>
A

SI practices and products are adaptable to other environment and systems
Smallholder farmers see benefits and are able to adopt/adapt SI practices and products

B

Smallholder farmers see value in achieving more efficient input use, closing yield gaps, and diversifying and intensifying agricultural systems
Smallholder farmers are aware and have access to SI practices and products

C

Actors in SI are willing and able to participate in research, capacity building and/or improving the enabling environment for adoption of SI practices and products
Alignment of common interests among actors in SI
Actors in SI act to contribute to gender responsiveness and social inclusion

D

Private sector recognizes the importance of SI practices and products
Risks: business interest negatively effects the adoption of SI practices and products; potential for emergence of ethical issues

E

Donors, policymakers, advocacy NGOs and private sector have interest and power to share the enabling environment
Risk: Frequent conflicting and competing priorities negatively affect research and adoption of SI practices and products

F

Co-research processes lead to integration of SI principles into educational programs and research

G

CRP has understanding of the institutional landscape and the means to influence it

H

Actors in SI are reached, the right message is delivered and understood
Existence of need and incentive for intensification
SI practices and products address locally important challenges and opportunities
Organization sufficiently recognizes or incentivizes the importance of networking, communicating, knowledge-

</td><td>
1

Research:

Technological options for sustainable intensification of cropping systems
Sustainable farming system and livelihood intensification strategies
Enabling policies and sustainable intensification landscape
<u>Outputs</u>: Technologies, policies, decision support tools, extension programs, publications

Develop and implement communication and marketing strategy

<u>Outputs</u>: Communication and marketing strategy

Develop and implement a partnership/networking strategy

<u>Outputs</u>: Partnership/networking strategy

2

Provide training (on the job, workshops, short- and long-term training)
Arrange exchange visits
Brokering (management and dissemination) of knowledge (to all partners)
Contribute to the development of decision support materials
Contribute to business promotional materials
Business model development
Joint product development

<u>Outputs</u>: Training materials, promotional products, decision support tools, communication products

3

Creating innovation platforms
Gender and social inclusion analysis and identification of appropriate interventions
Gender and social inclusion sensitization workshops

<u>Outputs</u>: Innovative platforms,

</td></tr>
</table>

sharing, innovation, necessity of rebranding and critical thinking • Risks: Focus placed on publications instead of the overall results of the theory of change • Risks: Financial, social and political instability, climate change	gender-responsive and socially inclusive interventions, gender and social inclusion sensitization training materials

2.4 Science quality

FP4 builds on a solid scientific foundation from MAIZE Phase-1. The peer-reviewed publication list from the lead CGIAR center team (CIMMYT SIP and SEP programs under MAIZE, WHEAT and CCAFS) during the 2012-Jan2016 period is given below (**Table FP4.3**). It comprises 195 publications (many in journals having an impact factor above 2), and a number of additional high-impact journals in which one publication was logged, for example *PNAS* and *Energy* (9.674 and 4.844, respectively). A large majority of these publications are co-authored by CGIAR colleagues and collaborating scientists from ARIs and NARS. The contribution of HT scientists to Phase-II will further strengthen the scientific team involved in FP4.

Table FP4.3: Journals in which the SI team has published more than twice since January 2012 (representing only 59% of all publications registered).

Journal	Number of pubs (co-)authored by SI group	Journal H-index	Impact Factor (2014)
Field Crops Research	35	89	2.976
Agriculture, Ecosystems & Environment	14	67	2.906
Agricultural Systems	13	110	3.402
Soil and Tillage Research	9	84	2.622
Crop Protection	6	67	1.493
Food Security	6	13	1.495
Experimental Agriculture	6	28	1.079
Food Policy	4	55	1.192
International Journal of Ag. Sustainability	4	15	1.659
Renewable Agriculture and Food Systems	4	29	1.355
Advances in Agronomy	3	74	3.893
Agricultural Water Management	3	70	2.286
Crop Science	3	100	1.575
Journal of Agricultural Economics	3	36	1.278
Nature Climate Change	3	50	14.547

There is a clear evolution regarding the scope of SI publications. In the early CRP-I period, the focus was primarily on field-level research. But since then, the publication portfolio has evolved to a more balanced one including increasingly SI-oriented systems research at the farm/landscape level, utilizing multi-criteria analyses, modeling and the stronger application of systems-oriented methodological approaches to address the complexity of SI challenges (as seen from the number of papers in *Agricultural Systems* and *Agriculture, Ecosystems, and Environment*). Lessons learned in Phase-I indicated that interdisciplinary collaboration sheds light on the key factors limiting the success of SI interventions, while also highlighting new opportunities for research and development to overcome them. To this end, the FP4 SI team is comprised of soil scientists, systems agronomists, farming systems analysts and researchers involved in innovation systems and adoption research. By CoA, key research themes include:

CoA 4.1: Dealing with farming systems complexity (without getting lost in it) is a major challenge of this flagship. It therefore must be supported by quality and relevant systems research. This challenge cannot be addressed by CGIAR expertise alone; rather, our approach relies on strong collaboration with key ARIs (see partnership section). Major research foci will be on:

- Clear articulation between FP1 and FP4 on down- and up-scaling information from global to landscape and farm levels (and back) for better identification and targeting of site/farm-specific intensification options combining social, economic, agroecological criteria (relying on data science, data fusion, remote sensing and modeling) and making greater use of field-level agronomic data through contextual and geospatial analyses.
- Development of SI indicators and metrics at various scales/levels. Feasibility and cost/benefit of such baseline studies and indicators will also to be realistically assessed in the first year of Phase-II.
- Systems-oriented research has been critiqued as being more of an academic exercise than a guiding tool for development. This CoA purposefully breaks with this trend by utilizing systems analytical tools to generate actionable information to be fed into scaling efforts through CoAs 4.2 and 4.4.

CoA 4.2: Bringing SI to fruition requires research into the efficacy and efficiency of different multi-stakeholder participation modalities in the identification, experimentation with, and evaluation of socio-technical options (that is, technologies and/or new institutional arrangements). This CoA integrates insights generated by ex-ante studies (CoA 1.4), multi-scale farming systems research (CoA 4.1) and multi-criteria cropping systems research (CoA 4.3) on the integration of socio-technical options for SI. It focuses on the incentives/drivers of such integration through research aimed at:

- Understanding agricultural innovation systems and, particularly, the role of multi-stakeholder interaction mechanisms – notably Innovation Platforms – in generating socio-technical options for sustainable intensification. What makes them succeed or fail?
- Understanding farmers' and other stakeholders' decision-making processes on the integration of socio-technical options, in the context of diverse rural cultural and livelihood systems.
- Understanding the impact of different socio-technical options from the farm to institutional scale.

CoA 4.3: This CoA aims to reduce yield gaps while improving the efficiency of crop production by harnessing ecosystem services and limiting environmental externalities. Key research themes include:

- How do cropping systems perform when subjected to multi-criteria evaluation of their agronomic and economic productivity/efficiency, environmental impact and sociocultural appropriateness? How can they be improved?
- How can nutrient use efficiency be improved in the context of smallholder agriculture? How can ecosystem services be leveraged to improve soil quality while reducing GHG emissions?
- How do the genotype products of FP3 perform in the context of smallholders' diverse management strategies, as assessed through networks of G × E × M trials?

- How can rainwater use efficiency be improved using appropriate species and methods for dead and live mulching, and timing and method of sowing, in combination with CA? How can irrigation be made more efficient through targeting and scheduling using remote-sensing tools?
- What are the benefits of biologically diverse maize-based rotations for smallholders? What options reliably boost cropping intensity and contribute to high yields and profits unit area^{-1} time^{-1}? What role do relay and intercrops with nutritious leafy vegetables and dual-purpose legumes have in the context of increasingly land-scarce smallholder agriculture?
- How can farm machinery be made more energy efficient and appropriate for smallholders in marginal environments?
- Can an understanding of the ecological structure and dynamics of weed communities in maize-based cropping systems and landscapes improve integrated weed management efforts? How can environmentally-sensitive and labor-saving weed management practices be fine-tuned?

CoA 4.4: This CoA addresses key research themes related to scaling up the products of the other CoAs, by focusing on the following meta-questions:

- What factors, including modes of brokerage and facilitation, enable success in scaling-up? What are the drivers and determinants of scaling up? What are the impact, obstacles, opportunities and critical success factors?
- How effective and efficient are the business models of rural enterprises in providing supporting goods and services that foster adoption, adaptation and scaling-up of improved technologies?
- What kind of support services, capacities, policies, and modes of delivery are needed to link farmers to input-output markets that have the strongest links to, and ability to influence the maize agri-food system?
- What are the most suitable business models that strengthen the ability of poor women farmers and youth to access and benefit supporting goods and services provide by SMEs?
- How do public sector extension, private sector partnerships, ICT approaches, etc. compare in different country contexts? What are the costs and benefits of different scaling modalities?
- What should be the role of the public/private/NGO sectors in providing market-oriented services to smallholder farmers? How inclusive are these services regarding women and youth in particular?

2.5 Lessons learned and unintended consequences

Multi-scale farming system framework to better integrate and enhance adoption of sustainable intensification options: (a) smallholder communities are diverse, strongly affecting the adoptability of SI interventions. “One-size-fits-all” solutions are not viable (Baudron et al., 2014b; Valbuena et al., 2012; Vanlauwe et al., 2007); (b) methods for better targeting are needed, as are clear metrics to understand the contribution of interventions to livelihoods (Frelat et al., 2016); (c) there remains a need for better understanding smallholder farming systems, their diversity and trajectories (which drive adoption of SI interventions), and the feedback mechanisms between farming systems and their landscapes; and (d) guidelines for complex knowledge-sharing and dissemination are crucial to engage stakeholders in implementing SI (Andersson and D’Souza, 2014).

Integration of technological and institutional options in rural livelihood systems: (a) participatory approaches, while crucial for technology adaptation, are somewhat limited in scale; (b) there is poor understanding of the usefulness of innovation platforms for scaling; more research is needed on the principles and dynamics of innovations systems; and (d) the low success of ICT4Ag interventions requires rethinking. ICT tools that are not designed around clear end-user needs are likely to fail. Although collaboratively developed tools may hold greater promise, this calls for new engagement with farmers as technical partners.

Multi-criteria evaluation and participatory adaptation of cropping systems: (a) plot-level or single-criterion assessment of SI interventions, while intrinsically important, do not provide comprehensive or robust assessment. Understanding farmers' perceptions, farmer diversity, and farm-level trade-offs and synergies with cropping systems and management approaches is essential; (b) efforts to reconcile nutrient and water use efficiency with high-yielding production should be matched with G × E × M assessments; and (c) significant opportunity exists to harness ecosystem services for more resilient cropping systems.

Partnership and collaboration models for scaling: During Phase-1, improved germplasm, SI technologies and value chain options were deployed in SSA, LA and SA through key projects (DTMA, CSISA, MasAgro, FACASI, SIMLESA, WEMA, IMIC-Asia). They were deployed through innovation platforms, farmer organizations, public-private partnerships (PPPs) and public extension. PPPs are crucial in South Asia, with evidence of > $1 million of private investment in scale-appropriate farm machinery. This CoA will have clear actionable outcomes and a strong research agenda that focuses on higher-level institutional and partnership interactions by increasing the capacity of actors (ToC IDO D.1.1) and institutions (ToC IDO D.1.3) involved in R4D. Lessons from Phase-I also highlight the need to address agriculture's social context, especially its gender and youth dimensions, and their implications for research and development interventions (Beuchelt and Badstue, 2013; Farnworth et al., 2015). Lack of opportunity and resources, rigid social norms and traditions, power relations, assumptions and domestic and caring responsibilities can limit especially women's and youth's ability to access new opportunities (van Eerdewijk and Danielsen, 2015).

Additional lessons learned from other CRPs (WHEAT, DS, HT, RTB, CCAFS) and the Borlaug Institute for South Asia (BISA) are actively shared across the MAIZE CRP, which has earmarked funds in the 2016 budget to distill those lessons, identify/ consolidate legacy products, and review benchmark site integration. This constitutes a promising first step towards an active community of practice across CRPs on farming systems research, which was weak during Phase-I.

2.6 Clusters of activity (CoA)

Moving SI from science into action and impact requires the inclusion of both biophysical and socioeconomic research agendas. For this reason, FP4 consists of four Clusters of Activity (CoAs), each led by scientists competent in their respective CoAs, with established interdisciplinary relationships. This structure reduces the risk of SI research becoming a purely biophysical or agronomic endeavor, while drawing on the unique skills of the FP4 team. While CoA 4.1 provides a farming system analytical framework, CoA 4.3 evaluates targeted interventions using multiple tools and criteria, and CoA 4.2 provides the necessary decisions support tools and institutional environment to ensure that validated interventions provide livelihood and landscape benefits derived from SI. CoA 4.4 then provides innovative models for scaling products for maize-based areas.

These CoAs are interlinked by knowledge feedback loops for methodological improvement. CoA 4.1 will interact with CoA 1.1 using meta-level targeting information and will provide feedback for systems analysis information, CoA 4.2 will provide institutional landscape insights to leverage scaling research and interventions under CoA 4.4. CoA 1.4, which monitors adoption figures and process indicators, will receive feedback for methodological improvement and design, feeding back into FP4's Monitoring Framework for SI. Finally, CoA 4.3 will use promising germplasm from CoA 3.1 for targeted environments and cropping systems and provide feedback on their performance (cf. Herrera et al., 2013).

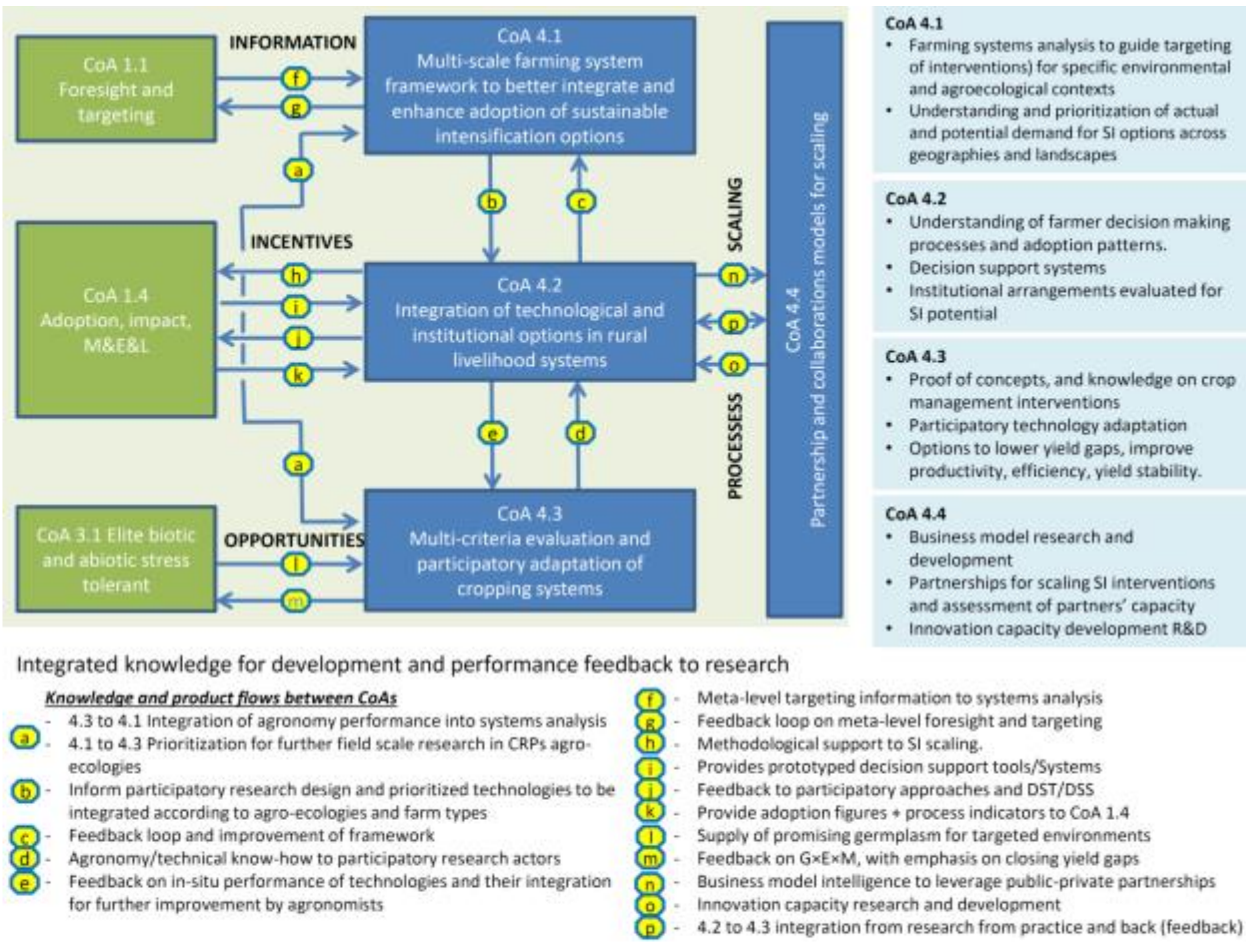


Figure 2.6: FP4 CoAs and knowledge/product flows and feedback loops. CoA 4.1 and 4.3 provide targeting information and cropping systems opportunities, respectively, and operate at different analytical scales (region, landscape, farm and field), while integrating research from CoAs 1.1 and 3.1. CoA 4.2 operates as the central node by which farmer decision-making and instructional incentives can be assessed, providing feedback to CoA 1.4. This results in the identification of scalable research products and technologies that are extended through research results that inform scaling processes in CoA 4.4.

CoA 4.1 Multi-scale farming system framework to better integrate and enhance adoption of sustainable intensification options

CoA 4.1 provides an overarching methodological and farming systems analytical and operational framework to guide the targeting of technical as well as institutional interventions for SI (e.g., Baudron et al., 2014a; Delmotte et al., 2016; Giller et al., 2010). This takes into account the specific environmental and socioeconomic contexts, household resource endowments and production objectives, as well as the most limiting production factors at the farm and landscape scale, and aims to identify interventions for households to move towards SI, based on the principles of maximizing resource use efficiencies, minimizing trade-offs between productivity and natural resources, and integrating diversity. This analytical framework will prioritize actual and potential demand for SI options across geographies with contrasting socioeconomic and biophysical environments, and within geographies according to farm household characteristics, assets, and objectives.

This CoA will provide tools and approaches for the spatially explicit assessment of SI at different scales to (i) allow more effective delineation of extrapolation domains (van Bussel et al., 2015; van Wart et al., 2013), underpinned by the agroecological spatial framework from the Global Yield Gap Atlas (GYGA, www.yieldgap.org); (ii) better target SI options within geographies by capturing spatial variability and processes relevant to the performance and adoption/adaptation of SI by households and local actors; and (iii) underpin responsible scaling strategies, recognizing that assets and objectives vary between households and communities.

This CoA will deliver:
1. Participatory and multivariate approaches for categorizing communities by functional or structural typologies, including their trajectories in time and distribution in space;
2. Analyses of large datasets including geo-spatial, remote sensing and climate models and their analysis through data mining techniques;
3. Farm level system analytical tools and participatory approaches for targeting interventions within heterogeneous farms;
4. Modeling tools and metrics to understand the variability of farming systems, landscapes and SI options;
5. Landscape analyses of SI options and their effect on local food and nutrition security, resource conservation and ecosystems services.

CoA 4.2 Integration of technological and institutional options in rural livelihood systems

As an enabling institutional context is a necessary condition for agricultural change (Hounkonnou et al., 2012), this CoA aims to understand the incentives and decision-making processes at the farm and institutional landscape scale that drive the integration of SI technologies in rural livelihoods. The combined technology and institutional environment focus of CoA 4.2 builds on previous research, which revealed that plot-level assessments are not enough to sustain change. Institutional constraints shape the applicability of SI technologies (Andersson and D'Souza, 2014; Schut et al., 2015). They therefore constitute prerequisites for smallholder farmers' integration of new technologies into their livelihoods (Giller et al., 2015; Sumberg, 2005).

The goal of this CoA is to understand why so few "proven" technologies have gone to scale, and to find solutions for their adoption. Focusing on technology and the institutional arrangements required for smallholder integration, it develops and implements methodologies to locate and evaluate SI within the context of institutional arrangements. CoA 4.2 seeks to identify scalable products – combinations of SI technologies, decision-support tools and new institutional arrangements through different scaling modalities as studied and developed in CoA 4.4.

In conjunction with the CRP RTB, and building on agricultural systems research within Phase-I, MAIZE and the systems-focused CRP Humid Tropics, CoA 4.2, will develop analytical frameworks, methodologies and tools including: (1) methods for assessing agricultural (innovation) systems for SI using Rapid Assessment of Agricultural Innovation Systems (RAAIS) tools (Schut et al., 2015, 2014), and the design and implementation of new institutional arrangements and experiments with agricultural system stakeholders; (2) (ICT-based) decision-support tools for farmers, service providers and development actors; (3) new quantitative and qualitative methods for assessing the (uneven) integration of socio-technical SI options into livelihood systems (addressing inequality effects), thereby acknowledging that adoption is not a linear process in both spatial and temporal terms (Sumberg et al., forthcoming).

CoA 4.3 Multi-criteria evaluation and participatory adaptation of cropping systems

CoA 4.3 provides proof of concepts and knowledge of cropping systems that reduce yield gaps while increasing resilience. This CoA addresses the hypothesis that productivity can be increased while reducing environmental externalities and poverty (Pretty and Bharucha, 2014). Building on CIMMYT and IITA's expertise in systems agronomy, CoA 4.3 will develop, evaluate and adapt promising cropping systems, management tools and technologies, by delivering the following:

1. Multi-criteria assessments and participatory adaptation of cropping systems to minimize trade-offs and optimize synergies among agronomic, socioeconomic and environmental criteria, linked with CCAFS's and BISA's work to reduce GHGs in South Asia. Research products will include life cycle analysis methods, minimum data guides and decision support tools (DSTs) to evaluate trade-offs and recommend alternatives. Trial data will be made available using systems such as DataVerse (http://data.cimmyt.org/dvn/).
2. Innovative tools, methods, and multi-media extension materials developed with NARS to enhance soil quality, and nutrient and water use efficiency using integrated soil fertility management, biologically diverse rotations and appropriate tillage practices.
3. Feedback to FP3 on the performance of, and farmers' preference for, new stress tolerant maize genotypes ($G \times E \times M$).
4. DSTs for nutrient and irrigation management using remote sensing and geospatial frameworks. Research products will include studies into the scientific basis of attainable maize yield targets, water and nutrient requirements under different rotations, management practices and environments, and information for DST and precision sensor development under varying tillage practices (linkages to BISA).
5. Recommendations and extension materials developed with NARS for biologically diverse and intensive cropping systems, with emphasis on nutritious leafy vegetable and dual-purpose legume relay and intercrops.
6. Analysis of the ways that crop management and environmental factors interact to structure weed community diversity and competition in maize-based systems. Products will include improved integrated weed management (IWM) practices that decrease drudgery, particularly for women. Approaches will include dust, live and dead mulching with CA, weed-suppressive intercropping and rotational systems, and low-environmental impact herbicides.
7. Improved planting, intercultural operation and irrigation machinery appropriate for smallholders' small and fragmented fields. In Phase-I, advances were made on two-wheel tractor (2WT)-based CA and irrigation equipment, with zero-till maize planters and fuel-efficient irrigation pumps

commercially deployed in SSA and SA. These and other machines will be refined for increasingly marginal environments.

CoA 4.4: Partnership and collaboration models for scaling

This CoA will develop and validate scaling models that will facilitate the uptake of SI interventions. Systematic research on evaluating alternative dissemination and scaling up models, and designing institutional innovations that achieve equitable outcomes is limited. While this represents an opportunity for CRP Maize, it also creates the challenge of developing new research to support this work. MAIZE will draw upon existing collaborations with KIT and Humid Systems colleagues.

This CoA will deliver:

1. Business models for providing goods and services in support of smallholder intensification; conducting business model appraisals of local SMEs; strengthening relations among actors in the appropriate-scale mechanization supply chain; developing linkages with financial service providers and extension services (public/private) to reduce risk; organization of farmers with emphasis on youth and women; and evaluating the performance and impact of different business models.

2. Partnership and collaboration in support of scaling SI technologies and practices; developing public-private partnerships with corporate-level seed companies, agro-dealers and mechanization; conducting negotiations and developing partnership agreements with input companies and manufacturers of machinery and implements; facilitating linkages among farmer organizations, input/output market actors and financial institutions; developing collaborative arrangements with public and private sector service providers; developing new ICT tools for scaling technologies.

3. Developing the capacity to innovate among multiple stakeholders; evaluating innovation platforms; horizontal scaling of technologies and feedback to research; evaluation of meso- and central level platforms for advocacy among policymakers; strengthening the capacity of farmer organizations to link with value chains; awareness raising and technical support to extension, national research organizations and NGOs; training of trainers, farmer organizations, private sector actors and service providers; and formulation of policy options to address institutional constraints.

2.7 Partnerships

In addition to the long history of fruitful collaboration with NARS in all the countries where we work, under MAIZE Phase-I, a large number of strategic partnerships were initiated with leading universities and advanced research institutions worldwide to help the CRP tackle the most challenging methodological and research issues related to SI. For example, in CoA 4.1, a close collaboration has evolved with Wageningen UR in the domain of systems analysis, especially in the area of synergies, trade-off analysis, and targeting of SI interventions. In the case of CoA 4.2, MAIZE has teamed up with the Royal Tropical Institute (KIT) to expand expertise in Agricultural Innovation Systems and gender and development research capacity. KIT is working closely with MAIZE to improve the efficiency and effectiveness of our Innovation Platforms and also serves as a sounding board for our investments in gender. In CoA 4.3, MAIZE works with a number of world leading partners to take technology break-through innovations in remote sensing and precision agriculture [ITC at University of Twente, Holland, and Institute for Sustainable Agriculture (IAS)/National Research Council, Cordoba, Spain], geospatial science [Oak Ridge National Laboratory (ORNL), USA; University of Nebraska, USA], and mechanization

(Georgia Tech University, USA; Charles Sturt University, Australia). MAIZE also has a large number of inter-CRP and inter-CG center collaborations through various W3/bilateral projects, as well as private sector collaborations that have proven crucial for scaling research results up and out.

Scaling-out partnerships in ESA have to date been project-oriented rather than strategic. For technology and knowledge transfer, we have worked with and through NARS on scaling, most commonly using Innovation Platforms (e.g., the SIMLESA model with NARS throughout ESA) or directly with NGOs on specific technologies (e.g., TLC in Malawi, Mozambique and Zambia; SG2000 in Ethiopia). We also work with the private sector on seeds and small mechanization, and scaling focuses on direct partnerships with many SMEs (e.g., Alliance Ginneries in Zimbabwe, Meru Seeds in Tanzania) and some parastatals (e.g., METEC in Ethiopia, CARMARTEC in Tanzania) to develop business models and improve the enabling environment. We also work with NARS and regional organizations such as ASARECA in ESA to influence policy (resulting, for example, in the recent Entebbe declaration on sustainable intensification) and participate in national CA-task forces (e.g., in Ethiopia and Zimbabwe). In Phase-2, our strategy in ESA will be to more purposefully engage with bigger development organizations (e.g., Norwegian Government CA programs in Ethiopia and Zambia), NGOs (e.g., CARE in Zimbabwe, One Acre Fund in Kenya, Tanzania and Rwanda), and national farmer organizations (e.g., NASFAM in Malawi) to credibly demonstrate the technologies we have available and to support their scaling through knowledge products and capacity development of users.

2.8 Climate change

MAIZE FP4, with its focus on systems approaches to develop socially equitable SI-based best practices, provides a natural home for climate-smart agriculture (CSA) and will continue to generate the scientific evidence needed to inform decisions regarding which CSA practices in maize systems are suitable, for who and where? Working closely with MAIZE FP1 and CCAFS, the evidence produced by this flagship will be used to model future climate effects on production, together with synergies and trade-offs, and target adaptation domains with potential mitigation co-benefits, thereby contributing to CC strategies and plans at the regional, national and local levels. More specifically, MAIZE FP4 will work closely with CCAFS on research activities related to: (a) participatory evaluation of MAIZE technologies and practices in climate-smart villages (CSVs) and other sites where appropriate; (b) improved resource use efficiency, particularly nitrogen and water, and impacts of GHG emissions; (c) evaluation of the C sequestration potential of SI interventions (Powlson et al., 2016, 2014); and (d) creation of minimum datasets for climate-smart technologies.

Through CSVs and other CCAFS research, collaboration with important climate-related actors in both the public and private sectors will be strengthened. FP4 will also integrate with CCAFS in terms of data: (a) to generate multi-criteria minimum datasets for maize-based systems and standardized methods and metrics to quantify climate-smart agricultural technologies and practices over a range of scales; and (b) to build a community of practice around climate resilient GxExM technologies and improved cropping system models that better characterize the effects of climate extremes on maize-based systems in terms of yield performance, resource use, GHG emissions, synergies and trade-offs. The GYGA spatial framework will provide the means to explicitly evaluate climate-smart options in both current and future climates.

2.9 Gender

Lessons from Phase-I highlight the need to better understand and frame gender and youth dimensions in sustainable intensification of maize-based systems (Beuchelt and Badstue, 2013; Badstue et al., 2015; Farnworth et al., 2015). Lack of opportunity and resources, rigid social norms and traditions, power relations, assumptions and domestic and caring responsibilities are factors that can limit women's and youth's abilities to engage in and benefit from new opportunities (Eerdewijk et al., 2015 Baudron et al., 2015).

FP4 will integrate gender analysis into its agricultural innovation systems approaches. R4D interventions will proactively engage women, men and youth of both sexes in technology development, evaluation, and validation, and systematically disaggregate their feedback by sex and age. Gender, age and other social characteristics will be integrated as key variables of farmer typologies and related farming system analysis. Research questions include:

- How do gender and age differences in farmers' access to and control over production means and resources influence technology choices?
- What are the factors underlying the differences in male and female maize farmers' technology adoption and productivity? And how can this information be used to design gender-positive interventions?
- What types of institutional arrangements and business models can enhance the ability of poor women farmers, youth and marginalized groups to access and benefit from more efficient and labor-saving technologies?
- How do social and gender norms constrain/enhance individuals' ability to engage in agricultural innovation processes? And what are effective measures to address barriers to social inclusion in technology development and dissemination?
- How do social norms and values contribute to shaping the outcomes of agricultural innovation systems (AIS)? And vice-versa: how do AIS influence social norms and values?

2.10 Capacity development

In view of the wide range of actors that the innovation systems approach encourages, specific capacity development activities will cover leadership, coordination and facilitation expertise including negotiation, conflict management and resolution skills, participatory approaches, and collective action and extension methodologies. Capacities for advocacy are required for policy dialogue, building strong partnerships, and making linkages with policy decision-makers to support the required institutional change for further up-scaling. Effective skills and competencies will be developed in communications, marketing and product promotion strategies to enhance the adoption of improved maize seed. This will be accomplished by: (a) improving farmers' knowledge of new maize varieties and complementary crop and land management practices; (b) building capacities in seed business management and marketing strategies (business planning, demand forecasting, branding, market segmentation, product mapping, etc.); and (c) developing linkages among seed companies, farmers/community-based organizations, financial institutions and end-user markets.

A key element in FP4 is strengthening the capacity of multi-stakeholder innovation platforms for scaling-up and scaling-out. Key components will be the inclusion of farmer-based organizations, extension services and NGOs in the research so as to strengthen their capacity to scale-out appropriate technologies to support sustainable intensification.

Training and mentoring of trainers, farmers, farmer organizations, private sector actors and service providers in aspects of scaling up technologies will be organized. Formulation and advocacy of policy options to address institutional constraints for SI-based technologies will support policy advocacy. Promotional materials to create awareness of market opportunities for value chain actors will also contribute to partners' capacity development. Training will be organized on gender and social inclusion.

2.11 Intellectual asset and open access management

The FP will comply with the overall CGIAR policy and W3/bilateral donor requirements on IP and open access.

2.12 FP management

FP4 management will be shared by co-leaders from the two leading centers at the FP and CoA levels, as presented in **Table FP4.4** below.

Table FP4.4. MAIZE FP4 and CoA management team

FP4/CoA Structure	FP4 Coordinators and CoA leaders	
	CIMMYT	IITA
FP4 Sustainable Intensification of Maize-based Systems for Improved Smallholder Livelihoods	Bruno Gerard	Bernard Vanlauwe
CoA 4.1 Multi-scale farming system framework to better integrate and enhance adoption of sustainable intensification options	Santiago Lopez-Ridaura	Bernard Vanlauwe
CoA 4.2 Integration of technological and institutional options in rural livelihood systems	Jens Andersson	Alpha Kamara
CoA 4.3 Multi-criteria evaluation and participatory adaptation of cropping systems	Timothy Krupnik	Stephen Boahen
CoA 4.4 Partnership and collaborations models for scaling	David Kahan	Alpha Kamara

We recognize that the management structure does not follow the CO guidelines, but our experience is that it is very difficult to get firm commitment and understanding of CRP complexity from non-CGIAR partners. In addition, having the lead centers managing the FP will ensure proper complementarity/synergies between the meager W1/2 budget allocated to FP4 and the large W3/bilateral portfolio being mapped under this FP.

Guidance for FP science quality and relevance will be provided by a group of scientists recognized for their tremendous expertise and experience in the field (mentoring committee). The committee will be comprised of Ken Cassman (ULN), NARS representatives from countries in South Asia, Africa and LAC where we have major investments, and high-level representation from one or two international NGOs.

The FP4 management and mentoring committee will meet once a year to plan and review. Additional virtual meetings will be organized as needed.

2.13 Budget summary

Details of FP4 projected base and uplift budgets for Phase-II, including analysis by funding sources, are provided in **Annex 3.19**. FP4 base/uplift budget is the second largest among the five flagship projects of MAIZE, after FP3. FP4 has significant funding contribution from W3/bilateral projects with similar budgets mapped by CIMMYT and IITA for 2017. Beyond the 2017-2018 horizon, only predictions can be made for W3/bilateral component as most project lifespans are 2-5 years but it is expected that resource mobilization during Phase-II will lead to either an increase or at least stable funding. Proportionally, FP4 W1/2 funding is relatively small (less than 11% of total FP4 budget). It is worth noting that, following the priorities of most donors, a large proportion of W3/bilateral resources under FP4 is towards 'downstream' research and scaling work, with more than one-third of the funds directly allocated to NARES, NGOs and other out-scaling partners. Hence, **W1/2 resources (under base budget) will be used to implement some of the strategic components of the flagship, particularly addressing the following priorities**:

- Reinforce our system analysis capabilities for better framing and assessing sustainable intensification options (including social equity and environmental services aspects) in various landscapes and geographies, and linking that component to the more meta-level analyses taking place in FP1.
- Contribute to the development of SI indicators and metrics at farm and landscape levels for baselining and impact assessment of FP4 R4D interventions (SRF has not provided much methodological assistance so far).
- Maintain and reinforce long-term experiments to assess the long-term benefits of improved agronomy practices on productivity, stability, resilience, resources use efficiencies, soil conservation in key agro-ecologies with increasing focus during Phase-II on G x E x M.
- Support lateral learning (cross-regional and cross-CRP) so that knowledge generated by W3/bilateral is better used, and future W3/bilateral are better designed and benefit from coherent and sound methodological approaches.
- Provide seed investment on emerging research priorities leading to funding of W3/bilateral project proposals (e.g., precision agriculture and geospatial research during Phase-I).
- Scoping to develop project proposals in new geographies (FP4 out-scaling in South East Asia, Central Africa, and Latin America).
- Facilitate collaborations with key advanced research institutions.

Uplift W1/2 budget (circa 1,250K USD per year), if received, will be used to:

- Speed-up the development of SI indicators and metrics in 2017 so that methodological guidance can be implemented ASAP in MAIZE landscapes (50%).
- Improve linkages and synergies with Big Data initiative (25%).
- Addition of few additional long term trials in key agro-ecologies not presently covered by on-going agronomy research (25%).

Scope and geographies of future W3/bilateral funding will somehow influence how we strategically prioritize and allocate W1/2 under FP4 in Phase-II.

FP5: Adding Value for Maize Producers, Processors and Consumers

2.1 Rationale, scope

Maize is one of the three leading global cereals, but in contrast to wheat and rice, it has multiple uses, particularly as food and feed, both of which offer various opportunities to add value in agri-food systems. Maize is of paramount importance as a staple in the diets of many in developing countries, particularly in Africa and Latin America (Nuss and Tanumiharjo, 2010). Maize food products can be very diverse; for instance, in Mexico there are more than 600 food products derived from maize. However, in other countries, maize-based diets tend to be monotonous and associated with micronutrient deficiency. In view of the CGIAR's commitment to move from commodity-based systems to agri-food systems (AFS), optimization of value chains and integration of nutritional dimensions will provide opportunities to improve incomes, employment and the diets of poor and vulnerable people. Maize AFS are well placed to help feed Africa, the only continent that has seen an increase in the number of undernourished people over the last decades and that will have an additional billion mouths to feed by 2050 – double the current population (FAO, 2015).

Consumer preferences for maize products may change with time and economic development; for instance, urban consumers in some countries have shifted from maize meal to wheat and rice for ease of preparation (Louw et al., 2010). In other countries, cheaper maize flour is mixed into more expensive rice or wheat flour to provide less expensive food for the urban poor. There is a need to develop new nutritious and affordable maize-based products. In rural areas, we know very little about how sustainable intensification affects diet diversity, the nutritional intake of farm household members, and the underlying rationales and incentives, or how the greater competitiveness of local value chains would stimulate local production and processing, and employment of the poor (Dogliotti et al., 2014). For example, an analysis of the competitiveness of small- and medium-scale maize millers indicates that, on average, 59% and 30% of the costs incurred by small- and medium-scale maize mills, respectively, could be avoided without reducing maize meal output (Abu and Kirsten, 2009). Current industrial uses are mostly in food processing, including maize flour, porridge, baby food and so forth.

Postharvest losses are linked to various farm-to-fork activities and practices, and include both quantity and quality losses; but quality data are scanty and spotty across regions, commodities, and along the value chain (Affognon et al., 2015). Poor postharvest practices, such as insufficient drying and poor storage conditions, also increase the probability of aflatoxin contamination (Kaaya et al., 2006); the adverse impact of aflatoxins on human and livestock health is well established (Wu, 2004). Reducing food losses offers an important way of increasing food availability; more than 15% of grain may be lost in the postharvest system (Partiff et al., 2010; Hodges et al., 2012). In Africa, poor postharvest management leads to between 14 and 36% loss of maize grains and aggravates hunger (Tefera, 2012). Reducing losses in maize AFS would also contribute to rural development and poverty reduction by improving agribusiness opportunities and livelihoods.

The use of maize for feed is expected to continue to grow rapidly. Maize is one of the most important ingredients in poultry feed, and this demand will continue to grow in developing countries, as demand for poultry is expected to rise rapidly, driven by population and income growth (Hellin et al., 2015). The use of by-products offers particular opportunities for maize as a dual-purpose food-feed crop (Grings et al., 2013).

MAIZE Flagship Project 5 (FP5) assesses value-addition opportunities for maize producers, processors and consumers and has numerous implications for the societal grand challenges (**Table FP5.1:**). It will contribute to various SDGs, including ending poverty, zero hunger, good health and well-being, gender equality and responsible consumption and production. In FP5, CIMMYT and IITA, with significant expertise in maize nutrition, processing, product development and postharvest (storage), will join forces with Wageningen UR, which has vast experience in developing and adapting processing technologies. MAIZE FP5 will seek to create a wider range of synergies and strategically partner with leading worldwide research institutions and the private sector to enhance impacts from farm-to-fork for producers, processors and consumers. FP5 will work in specific countries in sub-Saharan Africa (SSA), Latin America (LA) and Asia. FP5 will focus on developing diverse novel and nutritious maize-based products (CoA 5.1); improving technology and knowledge for small-to medium-scale processors (CoA 5.2); and reducing postharvest losses (CoA 5.3). As part of the uplift scenario, and subject to the mobilization of additional funding and strategic partnerships, we envisage pursuing livelihood opportunities through maize and maize by-products for animal feed (CoA 5.4).

Table FP5.1: FP5 contribution to the CGIAR Grand Challenges

Grand challenge[1]	**MAIZE FP5 contributions**
GC1 - Competition for land from multiple sources	Better maize storage and processing technologies improve access to quality food and reduce food insecurity.
GC7 - Nutritious and diverse agri-food systems and diets	Better storability of maize grains through hermetic storage leads to food security, higher prices/income, and possibility of diet diversification. Better storability and stability of biofortified crops will ensure greater nutritional benefits. Combined use of maize with other crops and protein-rich foods that supply complementary nutrients will improve the diets of vulnerable groups.
GC8 - Postharvest losses	Developing low-cost and efficient storage structures can reduce postharvest storage losses and enhance food safety. Grain processing is an efficient way to reduce cereal postharvest losses and enhance food safety. Processing serves to extend the availability of foods beyond the area and season of production, thus contributing to reducing losses of raw materials, stabilizing supplies and increasing food and nutrition security at the household level.
GC9 - Employment and income opportunities created for men, women and youth	Value-adding options provide new entrepreneurial and job opportunities, including for input supply, production and processing.

[1] Summary of grand challenges listed in CGIAR Strategy & Results Framework 2016–30 (SRF, 2015).

2.2 Objectives and targets

Today more than 795 million people suffer from chronic undernourishment (UNF, 2015). That means one in nine people does not get enough food to be healthy and lead an active life. Most of the hungry people (780 million) live in developing countries, representing 12.9%, or one in eight, of the population of developing counties (FAO, 2014). Hunger and malnutrition are the number-one health risk worldwide. Maize provides more than 25% of total calories in human diets in Africa and Latin America; therefore, maize and maize-based diets can help reduce malnutrition.

Global trends that influence food consumption and AFS (such as urbanization, dietary transitions and increased globalization) demand new interventions and focus on the consumer side to complement agricultural development programs. The CGIAR's commitment to move from commodity-based systems to AFS will provide opportunities to improve incomes, employment and diets of poor and vulnerable people. FP5 is a new flagship in MAIZE Phase-II that seeks to improve food and nutrition security in maize AFS through value-addition opportunities for maize producers, processors and consumers. Depending on the funding available, we envisage four objectives (each with an associated cluster of activities):

- To develop diverse novel and nutritious maize-based products for maize AFS;
- To improve technology and knowledge for small-to medium-scale processors in maize AFS;
- To reduce postharvest losses in maize AFS; and
- To enhance livelihoods through maize and maize by-products for animal feed in maize AFS.

FP5 will variously contribute to six sub-IDOs: diversified enterprise opportunities; increased livelihood opportunities; reduced pre- and postharvest losses, including those caused by climate change; increased availability of diverse nutrient-rich foods; enhanced capacity to deal with climatic risks and extremes; and development and dissemination of technologies that reduce women's labor and energy expenditure (**Table FP5.2**).

Progress towards the sub-IDOs will be variously measured and documented (**Table FP5.2**). The investment made in FP5 will generate multiple outcomes (**Table FP5.1**) and contributions to sub-IDOs (**Table FP5.2**). Prioritization is based on malnutrition prevalence, maize uses and maize consumption, farming systems, current maize uses and trends, and alignment with efforts by FP1, FP3, FP4, A4NH and PIM and site integration. The first users of FP5 are NARS and NGOs that promote consumption of nutritious food products and improved processing technology, small- and medium-scale processors, policy- and decision-makers, and extension agencies. The ultimate beneficiaries of FP5 are consumers, especially women and preschool children, through the consumption of nutritious food products; women's groups through best practices for the production of novel nutritious food products; men and women farmers through access to storage and feed solutions; specialty maize producers and sellers; and the young through new employment opportunities.

Table FP5.2: FP5 contributions, indicators and targets

Target Sub-IDOs	Nature of FP5 contributions	Indicators and targets
Diversified enterprise opportunities	• Mapping consumer preferences and characterizing germplasm for quality and processing traits • Labor- and cost-saving devices for maize processing • Value chain analysis for maize and maize-based products in the target regions	• Number of maize germplasm characterized for quality and processing traits • Number of improved/developed maize processing equipment, especially labor-saving devices • Number of value chains analyzed and concise actions proposed
Increased livelihood opportunities	• Identification of end-use quality germplasm • Labor- and cost-saving devices for maize processing • Development of maize and maize-based food products • Identify the need and opportunity for street food processors and vendors	• Number of maize germplasm characterized for quality and processing traits • Number of improved/developed maize processing equipment, especially labour saving devices • Number of food standards established
Reduced pre- and postharvest losses, including those caused by climate change	• Development and deployment of effective grain storage technologies • Recommendations to reduce grain losses at critical stages such as harvesting, drying, shelling and milling	• Number of households using improved postharvest storage technologies • Number of farmers adopting better crop management practices to reduce post-harvest losses
Increased availability of diverse nutrient-rich foods	• Nutritious maize hybrids/varieties with superior agronomic performance and desirable gender-informed traits (processing properties, palatability and storability) developed and deployed in targeted geographies in SSA, Asia and LA. • Availability of improved maize-based food products that are nutrient-enriched • New/modified food processing methods that contributes to enriched micronutrient retention • Value chain studies for nutritionally-enhanced maize	• Number of nutritious maize-based food products available • Number of households consuming nutritious maize-based food products • Number of value chains analyzed and nutritionally enhanced
Enhanced capacity to deal with climatic risks and extremes	• Development and deployment of effective grain storage technologies • Recommendation to reduce grain losses at critical stages such as harvesting, drying, shelling and milling	• Number of households using improved postharvest storage technologies • Number of farmers adopting better crop management practices to reduce postharvest losses
Development and dissemination of technologies that reduce women's labor and energy expenditure	• Identification of maize varieties with end-use qualities • Development and deployment of effective grain storage technologies • Development and deployment of maize processing equipment, labor and cost saving	• Number of households using improved postharvest storage technologies • Number of improved/developed maize processing equipment, especially labor-saving devices

2.3 Impact pathway and theory of change

The FP5 Adding Value for Maize Producers, Processors and Consumers' theory of change was developed during a workshop with the MAIZE Flagship Program team. A participatory approach was used to capture all views, experiences and known evidence into the theory of change. Workshop participants increased their understanding of the CGIAR Strategy and Results Framework and awareness of results-based management concepts. The workshop was also structured to encourage sharing and learning on a variety of topics.

Using the CGIAR Results Framework's sub-intermediate development outcomes (sub-IDOs), the team agreed to focus on four sub-IDOs and two cross-cutting sub-IDOs:

- 1.3.1 Diversified enterprise opportunities;
- 1.3.2 Increased livelihood opportunities;
- 1.4.1 Reduced pre- and postharvest losses, including those caused by climate change;
- 2.1.1 Increased availability of diverse nutrient-rich foods;
- B.1.2 Technologies that reduce women's labor and energy expenditure developed and disseminated; and
- D.1.1 Enhanced institutional capacity of partner research organizations.

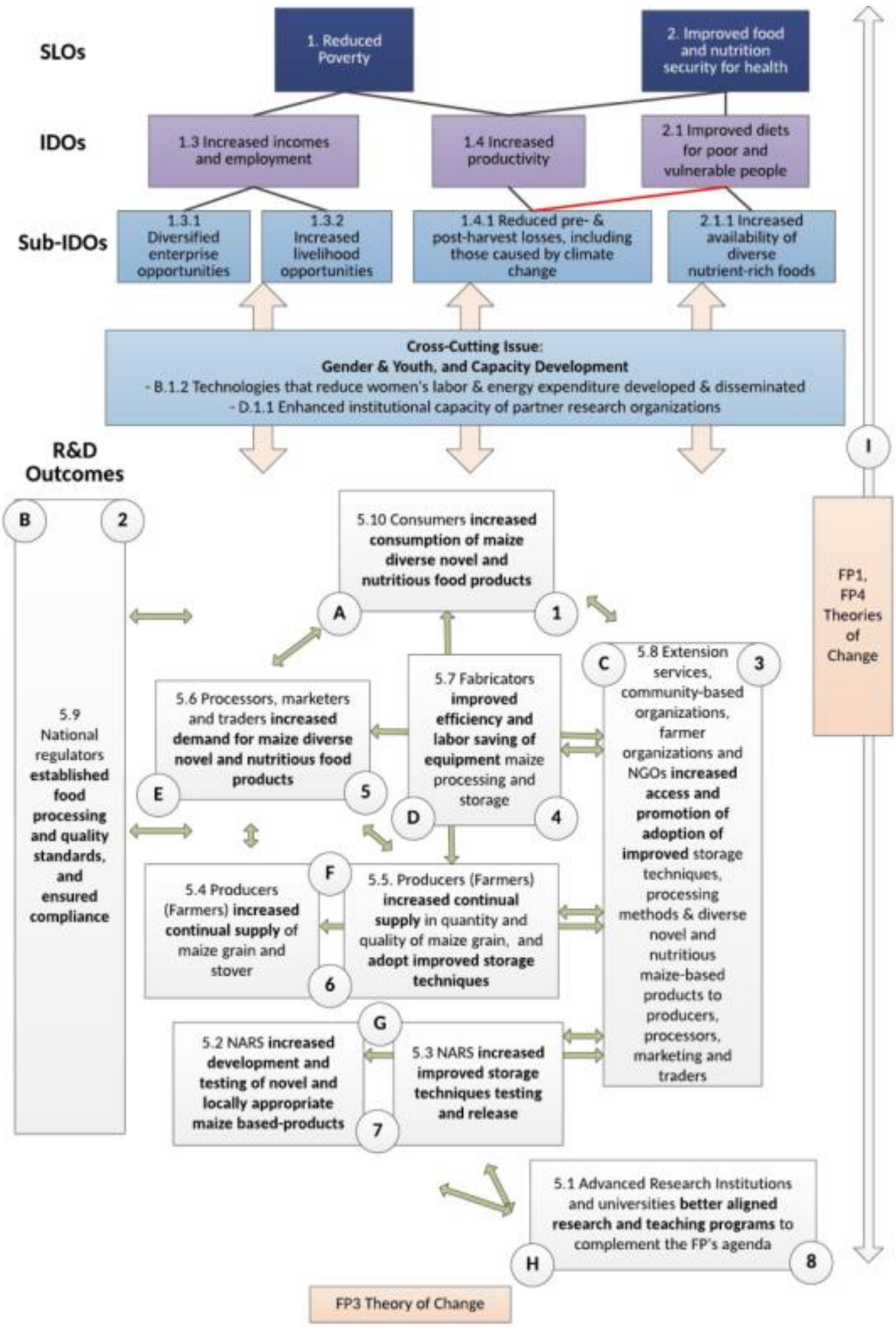
Other sub-IDOs were noted by the team as important to programming given that they overlap with the above sub-IDOs of focus.

Based on these areas of focus, the team agreed that this Flagship Program contributes to reducing poverty (SLO 1) and improving food and nutrition security for health (SLO 2) by increasing incomes and employment (IDO 1.3), increasing productivity (IDO 1.4), improving diets for poor and vulnerable people (IDO 2.1), and enhancing the cross-cutting issues of gender and youth (B), and capacity development (D).

A number of research and development outcomes were identified and a pathway of change was created demonstrating the causal relationship between outcomes and sub-IDOs. During this process, partners involved in the pathway of change were identified. Current and proposed interventions and associated outputs to support the achievements of the outcomes were mapped. Assumptions describing the contextual underpinnings of the theory, as well as risks that may undermine success, were documented.

This theory of change will be the foundation of the monitoring, evaluation and learning plan. The monitoring plan will consist of a continuous process of data collection and analysis based on a set of indicators directly related to the performance of the CRP at the output and outcome levels; the key assumptions of the theories of change; and the critical risks. The theory of change will also be the basis for evaluating the FP as well as reflecting on lessons and program improvements.

Figure 2.7: Theory of Change for MAIZE FP5: Adding Value for MAIZE Producers, Processors and Consumers



Assumptions and Risks	Interventions and Outputs

A
• Diverse novel and nutritious maize food products are responsive to consumers
• Consumers have access to and accept these novel products
 	
B
• Existence of enabling policy environment and government support to establish food processing and quality standards, and ensure compliance
• CGIAR influence on national decision-makers
• Risk: National regulators and national nutritional programs lack financial and human capacity
 	
C
• Existence of an enabling policy environment and government support to extension services
• Existence of financial and human capacity in extension services
• Development agents see value and are willing to promote new technologies and products
 	
D
• Manufacturers see value and are willing to improve efficiency of labor-saving devices and maize processing equipment and storage structures
• Existence of an enabling policy environment and government support for manufacturers
• Risks:
  ○ Lack of financial incentive for manufacturers to make these improvements
  ○ Communities do not adopt new processing methods
 	
E
• Diverse novel and nutritious maize food products available
• Existence of an enabling policy environment and government support for processors, marketers and traders in novel and nutritious food products
• Partners are willing to share and exchange data and information
• Risk:
  ○ Non-competitive prices for novel and nutritious food products
  ○ Non-organized and stable market chain
	1
	• Seek feedback from consumers on product quality needs:
	  ○ Outputs: Communication materials, documented consumer needs and product acceptability
	• Promote novel products using demos and field days to increase awareness
	  ○ Outputs: Dissemination and marketing information, training documentation, training sessions
	
	2
	• Advocate for harmonization of quality standards systems across regions
	  ○ Outputs: Technical advice, dissemination information, recommendation for standards
	
	3
	• Exchange of data, information and market intelligence
	  ○ Outputs: Data, information, marketing intelligence, dissemination documentation
	• Advocate for improvements
	  ○ Outputs: Technical advice, dissemination documentation
	
	4
	• Advocate for improvements
	  ○ Outputs: Technical advice, dissemination documentation
	
	5
	• Exchange of data, information and market intelligence
	  ○ Outputs: Data, information, marketing intelligence, dissemination documentation
	• Demonstrate maize-based products
	  ○ Outputs: Dissemination and product marketing information
	
	6
	• Promote improved grain and storage techniques using demos and field days to increase awareness
	  ○ Outputs: Dissemination and

F • Producers' grain is responsive to consumer quality needs
• Storage techniques are responsive to producer needs
• Producers have access to and seed markets and storage capacity
• Risks:
  ○ Variability of local prices and instability of global prices for grain and stover
  ○ Non-organized and stable market chain
 	
G • NARS see value and are willing to test and adopt novel products and improved storage techniques
• Existence of an enabling environment and government support
• Risk: NARS lack financial and human capacity
 	
H • ARIs are willing to collaborate and share knowledge
• ARIs have the capacity to collaborate
• Benefits of collaboration outweigh transaction costs
 	
I • Risks:
  ○ Financial, social and political instability
  ○ Climate change
	marketing information, training documentation, training sessions
	• Share feed formulations
	  ○ <u>Outputs</u>: Formulation information, dissemination documentation
	
	7 • Exchange of novel products and improved storage techniques
	  ○ <u>Outputs</u>: Novel products and improved storage techniques and associated data
	• Provide support for testing, release and promotional activities (e.g., demos, field days)
	  ○ <u>Outputs:</u> Data on new novel products and improved storage techniques, training materials, training sessions, dissemination and marketing documentation
	• Provide capacity development and infrastructure
	  ○ <u>Outputs</u>: Training materials, training sessions, infrastructure information and services
	
	8 • Define and regularly revise a collaborative research agenda
	  ○ <u>Outputs</u>: Collaborative research agenda (e.g., areas of research, associated institutions)

2.4 Science quality

FP5 is a new flagship project for MAIZE Phase-II that builds on a body of published work from MAIZE Phase-I and learned experiences. FP5 will use several new and innovative multidisciplinary and inter-institutional approaches and tools.

Co 5.1: In collaboration with A4NH, MAIZE Phase-I, through the HarvestPlus project, provided an excellent platform and learning experience on using agriculture as a human nutrition delivery pathway by developing agronomically superior and nutritionally enriched maize varieties (Pixley et al., 2013; Babu et al., 2012; Menkir et al., 2014, 2015; Dhliwayo et al., 2014; Suwarno et al., 2014). Retention of nutrients, stability in storage and food products were investigated and challenges identified, especially for provitamin A (Alamu et al., 2014a; Rosales et al., 2015). Strategies are needed that add value for

producers, processors, and consumers with synergistic impacts on nutrition, health and income, and considering the diversity of options in maize AFS (Charles et al., 2010). Other MAIZE Phase-I relevant work includes: Alamu et al., 2015; Akinola et al., 2014; Alamu et al., 2014b; Awoyale et al., 2011, 2013; De Groote and Kimenju, 2012; Galicia et al., 2012; Miranda et al., 2013; Keleman et al., 2013).
MAIZE Phase-II envisages:

- Use of robust, high-throughput methodologies and tools for rapidly assessing the nutritional and end-use quality of raw materials and linking them to sensory and consumer preferences.
- Development of a database on the nutrient content of maize products consumed in different regions and linking it to processing methods.
- Integrating farming systems and dietary knowledge in maize-based food product development.
- Guidelines for using new maize varieties, making a clear link with FP3 and A4NH.
- Use of a consumer-driven food/diet design and product development approach; South-South exchange of best practices and uses of maize among different countries.
- In collaboration with FP1 and CCAFS, development of models that predict the impact of climate change on likely diet changes.
- In collaboration with A4NH and depending on resources, coordinate efforts for nutrition studies.

CoA 5.2: The proposed project builds on a body of published work (Arinloye et al., 2015a; 2015b; Fogliano, 2014). An important prerequisite of any attempt to improve food technological practices and increase nutritional quality, is that the sensory characteristics of the newly processed food should not be altered to the extent that the intended consumers do not like to eat the food anymore (Sijtsema et al., 2002; Linnemann et al., 2006). When two different foods of a known nutritional quality are mixed, the nutritional quality of the mixture is not the sum of the constituting ingredients; the resources impact each other, making it necessary to assess the nutritional quality of the mixed food separately and thus adding a hurdle to defining the optimal combination of ingredients. Another challenge in food product development is the bioavailability of the nutrients present in the food product. Thus, there are many options for technological interventions along a food production chain and it is important to make the proper choice (INREF, 2010).

MAIZE in Phase-II envisages:

- The creation of value and product diversification along the entire production chain, from producers to processors to (street) vendors.
- Designing locally-adapted and cost-efficient processing equipment.
- Evaluation of existing traditional processing methods to develop more nutritious maize-based food products adapted to consumers preferences.
- Use of robust methodologies and tools for assessing nutrient retention in newly developed products.
- In collaboration with A4NH and depending on resources, coordinate efforts for nutrition studies.

CoA 5.3: Previous research in MAIZE Phase-1 has shown the technical and economic feasibility of improved storage methods (Tefera, 2012; De Groote et al., 2013b). Access to improved storage technologies not only reduces postharvest losses, in quantity and quality, it also helps farmers to keep their harvest longer and take advantage of increased prices in the future (De Groote et al., 2013b; Bokar et al., 2014; Bartisbuta et al., 2014; Gitonga et al., 2013; Moussa et al., 2014). MAIZE Phase-I focused mostly on hermetic storage technologies, in particular metal silos and hermetic bags. Metal silos in SSA were shown to be effective in controlling maize weevils and the larger grain borer without the use of pesticides such as Actellic Super and Phostoxin (Ndegwa et al., 2015a; 2015b). The major outcome of metal silos was a change in marketing behavior: farmers sell later (five months after harvest), which increases their income (Gitonga et al., 2013). Farmers also appreciate the improved quality of the grain stored in hermetic bags or silos. Results in West Africa have shown that farmers are interested in the technology as it offers them a low-cost method, especially for short-term storage for family consumption (Baoua et al., 2014). Economic analysis indicates that hermetic containers are cost efficient if losses are sufficiently high and maize is stored long enough. For smaller quantities, hermetic bags are economically feasible, while metal silos become interesting for quantities over one ton (Kimenju and De Groote, 2010). Uptake of the products developed and tested can be increased by greater consideration of sensory attributes, consumer preferences and availability of competing products and market potential (Tefera, 2011).

MAIZE in Phase-II envisages:

- Use of improved experimental design to test livelihood outcomes of the adoption of storage technologies.
- Use of robust, high-throughput methodologies and tools for rapidly assessing the nutritional and end-use quality of raw materials and linking them to sensory and consumer preferences.
- In collaboration with FP3, FP4 and A4NH develop recommendations for best agronomic practices to reduce post-harvest losses; in collaboration with FP1, develop recommendations on enabling policies to ensure adoption of effective post-harvest management practices.

CoA 5.4: In Phase-I, MAIZE conducted extensive research on the use of maize for food and feed, including the potential and the economics of using maize grain and maize stover in animal feed. Livestock raising in mixed cropping systems is increasingly important for income and nutrition. Improving livestock value chains can be of particular interest to women, who are often in charge of feeding and milking, as in Ethiopia (De Groote et al., 2014). MAIZE Phase-I showed the potential of using maize as a dual-purpose food-feed crop (Grings et al., 2013, a special issue), albeit there can be significant trade-offs in residual biomass use (Erenstein et al., 2015). Positive correlations between grain yield and stover yield in maize have been demonstrated in India (Zaidi et al., 2013) and East Africa (Ertiro et al., 2013). Farmers in East Africa (De Groote et al., 2013a) and in Latin America use stover for feed and are interested in dual-purpose varieties that do not compromise other important field and consumer qualities. Such varieties would have the potential to increase the productivity of maize-livestock systems and the income of these farmers, while reducing the pressure on the environment. Other work on maize feed in Phase-I work includes (Hellin et al., 2015; Krishna et al., 2014; Muttoni et al., 2013).

MAIZE in Phase-II envisages:

- Use of robust, high-throughput methodologies such as near-infra-red spectroscopy (NIRS) for rapidly assessing the stover and feed grain quality.
- In collaboration with FP3, identify cultivars with higher potential as dual-purpose maize.
- Development of maize-based feed formulations.
- In collaboration with FP1 and FP4, recommend the best practices to use with dual-purpose maize that have less impact on biomass use.

2.5 Lessons learnt and unintended consequences

Compared to MAIZE Phase-I, FP5 is a new FP built on the R4D and lessons from MAIZE Phase-I and a significant body of MAIZE Phase-I scientific work (see previous section). FP5 pulls these together in a coherent FP and expands it towards a more comprehensive coverage of maize AFS. Some generic lessons learned are as follows:

Diverse novel and nutritious maize-based products required to improve nutrition and generate income: The pattern of maize consumption within countries usually varies along a continuum from rich to poor. In highly maize-based diets, there are opportunities to enhance maize-based products nutritionally in order to supply essential nutrients for a healthy and productive life. Agronomically competitive nutritious maize (such as Quality Protein Maize [QPM] and provitamin A maize) is already available. However, studies have demonstrated that acceptability of this maize improves with strong public awareness campaigns adequate to the target public. Building the capacity of nutrition and health partners to speak the same language is essential to impact consumers. It is equally important to ensure biofortified maize fulfills end-user and sensory preferences.

Stability of nutrients during processing and storage: Maize is often stored for 6-12 months between harvests but can deteriorate in quality (e.g., 42% carotenoid loss after 6 months, Weber et al., 1987). Beta-carotene is also lost due to spontaneous fermentation, during soaking and milling, and during cooking. Research will focus on further evaluating the effect of different traditional processing and storage methods on micronutrient content (provitamin A carotenoids and zinc) and anti-nutritional factors such as phytates.

End-use quality of maize grain, sensory preferences and consumer acceptability of maize food products are key for industries and consumers: Variety and harvesting time had significant effects on most of the physical properties, except porosity. Differences in kernel characteristics caused by genetic inheritance and harvesting time can influence the processing, utilization and consumer appreciation of maize. Therefore, FP5 will evaluate end-use quality and functional properties and determine the relationship among quality characteristics, sensory profile and consumer acceptance of food products to enhance acceptability and consumption of novel products and target varieties for the different industries. Ensuring food supply and reducing postharvest losses are equally important to increase consumption and improve nutrition.

Better links between agriculture and consumers through appropriate food systems (storage, transport, processing and marketing): Processing losses are less noted at small- and medium-scale food industries. Inappropriate raw material may add time, energy, additives and cost to food processing. Research will focus on developing tools and methods to be used in assessing postharvest losses. In addition, research will be undertaken in collaboration with the Postharvest Losses Innovation Laboratory, which will provide expertise in entomology, facilitate pilot-testing of a low-cost moisture meter, monitoring aflatoxin levels and research on drying technologies.

Unintended consequences. Promotion of nutritious (biofortified and QPM) maize varieties inevitably focuses attention on specific nutrients and new varieties as vehicles for supplying them. FP5 will integrate these interventions to ensure that they are designed, implemented, and evaluated in a holistic nutrition context (a "food basket" approach). When creating demand for processed products such as snacks, however, there is a risk of promoting increased consumption of fats, salt and refined sugars, which results in overweight and obesity and increases the incidence of non-communicable diseases. FP5 will build capacity for promoting healthy food options and choices of maize products together, with nutrition education on the potential benefits of products along the whole value chain.

2.6 Clusters of activity (CoA)

CoA 5.1: Develop diverse novel and nutritious maize-based products

Strategic interventions through CoA 5.1 will include:

1. Linking consumer preferences to sensory and physicochemical properties of maize grain: Quality, stability and storability of maize grain is a key factor for adoption of varieties by processors and consumers (De Groote and Kimenju, 2011; Sahai et al., 2001). These traits are determined by genotype, environment and management (crop development and postharvest) (Cirilo et al., 2011). Interaction of kernel physical and chemical characteristics is crucial as well as processing methods and final products, which in turn will affect sensory preferences (Flint-Garcia et al., 2009; Blandino et al., 2013). This intervention will map maize end-use quality to enable targeted breeding (FP3 and A4NH) for consumer-preferred traits and the development of new nutritious food products. Research will include profiling sensory quality traits for commonly consumed traditional maize products.

2. Developing nutritious and novel maize-based food products to increase diet diversification: Maize AFS can provide a more nutritious diet when maize is nutritionally enhanced (with micro- and macro-nutrients) through biofortification, by combining maize with nutrient-dense crops (e.g., legumes), by improving processing methods and/or developing new nutritious food products. This key intervention will map the quantity and quality of women's and children's diets in selected agri-food systems, understand local and traditional food processing and storage, and the potential for using biofortified maize or combining maize with nutrient-dense crops derived from common farming systems in target countries (FP4) for improving the nutrition of the poorest. Also, when maize spread from Central America, food preparation processes (nixtamalization) that have been found to improve nutritional quality by enhancing calcium uptake and availability of some amino acids (Serna-Saldivar et al., 1990) did not spread to Africa or Asia. Co-development of alternatives with local communities will hence assess acceptability and ability to make sustainable nutrition shifts among the poorest and most malnourished who continue to rely mostly on plant-based diets.

3. Explore the use of specialty maize for income generation: There are untapped market opportunities for specialty maize landraces and their improved versions (e.g., maize with colored grain, vegetable maize, or grain types with special food characteristics), especially in (peri-)urban areas (Keleman et al., 2009; Keleman and Hellin, 2009; Bellon and Hellin, 2011). With support from FP1, participatory value chain action research and development of maize landraces aims to develop such opportunities with key actors in the informal sector and relying on poor women. There is limited knowledge of the size of these informal markets, the mechanisms through which they operate and potential interventions. Different options for gender-transformative and gender-inclusive specialty maize product value chains will be explored, directed both at higher value specialty markets and street food chains. This will be coordinated with efforts in FP3. Selected improved maize varieties are commonly harvested as

"green maize." Green maize is valued as a basic component of the diet during the hungry period and also as an important cash crop and source of income (Keleman et al., 2013). As a perishable commodity, price fluctuations and marketing risks are high. In spite of its importance in the diet and as a source of income, there is lack of information on various aspects of green maize quality, shelf life extension, processing and utilization in informal markets. Areas to be researched include defining what constitutes green maize quality, varietal characterization for organoleptic quality, and developing green maize value chains.

CoA 5.2: Improved technology and knowledge for small-to-medium-scale maize processors

Cultural differences and consumer preferences are key drivers for food acceptance. New technologies must be introduced considering the needs and preferences of the target group (Mestres et al., 2009) as well as the local processing methods in a holistic way. By improving processing technologies and knowledge of small-to-medium processors in maize AFS, new commercialization opportunities open for producers and better quality foods become available to consumers. Moreover, we often also observe positive spillover effects, for instance, stimulation of other economic activities such as urban agriculture (Zezza and Tasciotti, 2010). The continued existence of small- and medium-scale maize enterprises producing maize-based products in a very competitive market dominated by large capital-intensive food companies depends to a large extent upon the competitiveness of local enterprises that are able to keep production costs lower than their competitors and cater to specific markets knowing the consumers' needs (Arinloye et al., 2015) . Processing maize into primary and secondary products is dominated by small- and medium-scale processors whose challenges include poor market access for their products, inadequate packaging, inefficient processing equipment and poor product quality.

This CoA will work on two strategic interventions:

1. <u>Optimization of small- and medium-scale (SME) processing systems in maize AFS:</u> There are many industrial options for high-grade maize products (plywood, paper board, textiles, sugar syrup, industrial alcohol, bakery products, glue, etc.), which are currently imported by developing regions. The projected high population growth and increased urbanization will require a greater supply of easily accessible maize-based food products as well as feed for the peri-urban livestock production systems that will support urban demand in years to come. However, current processing practices used by small- and medium-scale processors are not sufficient to sustain such trends. Research will focus on analyzing the efficiency of processing equipment and technology requirements to meet end users' demand for product development (traditional and new products) by small- and medium-scale businesses; designing/adapting and disseminating improved and profitable processing equipment developed in each region or available elsewhere for the production of maize products for defined markets; in collaboration with regulatory agencies, evaluating different packaging materials and storage for identified food products produced by SMEs; formulating product quality standards through low-cost quality assurance systems; and enhancing the capacity of small- and medium-scale processors within the public and private sectors to promote entrepreneurship, strengthen managerial skills and enhance food product standards and grades.

2. <u>Optimization of processing methods in maize AFS for enhanced product nutritional and storage quality, greater labor productivity and income generation:</u> Processing is one of the key drivers of increased production in developing countries. To cope with the demand for labor, there is a need to introduce simple and efficient labor-saving devices and procedures. At the same time, there is a need

for introducing/evaluating new or improved traditional processing methods that could result in products with higher micronutrient content (e.g., using fortification, see Seleka et al., 2011), enhanced nutritional and storage quality, and greater market potential. This will require involvement of consumers and local processors in order to add value to the various actors in the food chain. Street food is becoming very popular in rapidly growing cities, where it constitutes a significant part of the diet. Street food vendors can be a very effective target to promote the use of new processing practices. Building on the lessons learned from MAIZE Phase-I, this activity will focus on adapting milling fractionation technologies, fermentation and lime cooking to meet the needs of processors and consumers; conducting limited market studies on identified products; identifying appropriate packaging materials; and empowering rural communities with knowledge of sustainable maize processing technologies to improve nutritional quality and reduce food losses, and small-scale maize flour extrusion technologies for development of value-added products.

CoA 5.3: Reduce postharvest losses

Building on the postharvest storage work of MAIZE Phase-I, Phase-II will expand to include other upcoming technologies developed by private partners. Public-private partnerships will be key to developing this CoA, which will work on a number of strategic interventions:

1. Tools and methods for assessing postharvest losses: Although a methodology for assessing postharvest grain losses will not in itself reduce those losses, it is essential to postharvest operations so that priorities for loss reduction can be determined. The enormous variability of local postharvest situations means that no complete or definitive loss assessment methodology for all situations is available. Thus tools and methods will be developed that can provide postharvest grain loss assessment and yield standardized and reproducible results so that effective grain loss reduction efforts can be undertaken.

2. Storage technologies to reduce postharvest losses and improve grain quality of stored grain: Research will be undertaken in collaboration with the Postharvest Losses Innovation Laboratory, which will provide expertise in entomology, facilitate pilot-testing of a low-cost moisture meter, monitoring aflatoxin levels and conduct research on drying technologies (also with the Food Processing Lab of Purdue University). Tools and methods mentioned above will be used in assessing postharvest losses.

3. Effectiveness and impacts of on-farm storage using randomized control trials (RCTs): RCTs will be used to assess the on-farm effectiveness and impacts of hermetic storage on health (nutritional status, exposure to aflatoxins), livelihoods (income, food security) and behavioral change (increased consumption and marketing). In another experiment, a system for testing and labeling maize products for aflatoxins will be piloted.

4. Scaling storage technologies: In partnership with the private sector and development agencies, dissemination methods and supply chain development for promoting improved postharvest technologies will be explored and scaled in maize AFS.

CoA 5.4: Use of maize and maize by-products for animal feed (uplift)

Maize is a multi-purpose feed crop (both maize grain and by-products are used as livestock feed) that offers opportunities to add value in agri-food systems. Compared to other grains used as livestock feed, maize grain has the highest meat, milk and egg conversion ratio due to its high starch and low fiber content, which make it a very concentrated source of energy for livestock production. Maize grain is missing some essential amino acids as feed for poultry, which thus far has been challenging to address in a cost-effective manner through purposive quality maize (Krishna et al., 2014). More promising to date in MAIZE Phase-I was the use of maize as a dual-purpose food-feed crop (Grings et al., 2013), albeit there can be significant trade-offs in residual biomass use (Erenstein et al., 2015). Building on recent research, this CoA will work on two strategic interventions:

1. Enhancing dual-purpose use of maize: Low-cost feeding systems that utilize maize crop residues and processed waste can provide promising opportunities for gender-equitable livelihoods. Building on and complementing recent research, this intervention will review the state of men's and women's knowledge of the use of maize residues as animal feed; assess the potential for incorporating greater value maize by-products as feed input into selected livestock value chains to generate higher incomes as well as determine potential differences in market access and shifts in gender labor burden.

2. Developing innovative and affordable animal feed formulations that can generate income and impacts: Popular released and advanced pipeline maize cultivars used as animal feed in maize-based systems will be investigated for exploitable variations in food, feed and fodder quality traits at regional or national near-infra-red spectroscopy (NIRS) hubs in close collaboration with fodder traders and feed processors. Trait relationships will be investigated to explore possible trade-off effects. Research will be conducted on the development and adoption of suitable processing technologies; formulation of compound feeds based on maize by-products (including cassava leaves, groundnut and cowpea hay) for feeding ruminants; determination of nutritional composition using NIRS and monitoring of anti-nutritional components; and refinement of maize by-products for inclusion in feed for monogastric species such as poultry. Information and findings from CoA 3.2 will be synthesized and, in combination with food, feed and fodder market surveys, used to build scenarios for context-specific feed optimization and appropriate information and delivery systems.

2.7 Partnerships

FP5 is largely the result of reflective analyses of feedback from clients, partners and stakeholders to assess the value-chain and nutrition nexus in maize AFS in selected geographic areas where MAIZE engages in sustainable intensification approaches (FP4) and where strong contextual knowledge already exists. Internally, FP5 will draw on methodological strengths that exist within FP1 (identification of market opportunities, technology and gender targeting, impact assessment), FP2 (germplasm characterization), FP3 (variety options; high-throughput analytical know-how; and seed scaling) and FP4 (intervention areas, livelihood approaches and scaling). Externally, FP5 has and will form stronger or new strategic partnerships with advanced research institutions (Wageningen UR, Purdue University) and the private sector. Wageningen UR will lead one of the CoAs (improved technology and knowledge for small- to medium-scale processors); Purdue University and Tecnologico de Monterrey will contribute to research on reducing postharvest losses; and EMBRAPA will be involved in product development, and small- and medium-scale processing (**Table FP5.3:**). Subject to mobilization of additional funding, FP5 expects to further its strategic partnerships with both research and private sector partners.

Table FP5.3: Partners by CoA for FP5

CoA	Type	Partner name	Key contribution
5.1	CGIAR	A4NH	Food systems, nutrition
	Research	Purdue University, EMBRAPA	Product formulation and scale out
	Private sector	Kellogg's, Nestle	
5.3	ARI	ICIPE (Tadele Tefera)	Entomology; storage pests
		Feed the Future (FtF) Innovation Lab for the Reduction of Post-Harvest Loss, Kansas State Uni	Postharvest Loss
		FtF Food Processing Lab at Purdue Uni	Drying methods, storage and aflatoxin testing
		Harvard School of Public Health	Impact of storage technologies on human health, nutrition
		Wageningen UR (Ham (Henry) Boerrigter)	Controlled atmosphere
5.4	CGIAR	ILRI (Michael Blummel)	Dual-purpose maize quality/nutritional analysis

Docking with other Agri-Food Systems CRPs

FP5 will preferentially work within a sub-selection of agri-food systems where partnerships with other agri-food systems CRPs have already been established by FP4, and especially with DCL and Livestock CRPs, given that the combination of maize, grain legumes and livestock is the backbone of several traditional farming systems and within the context of site integration. Docking the activities with Livestock/ILRI and RTB will be essential for using maize and its by-products as animal feed. Other opportunities exist in the shared approaches to processing and storage options (e.g., with DCL or RTB).

Docking with Integrating Programs

Nutrition is a multi-level, multi-cultural and multi-sectorial challenge. Collaborative work with A4NH in MAIZE Phase-I has focused on developing biofortified crops and advocating for research products that decrease consumption of aflatoxin-contaminated maize, especially in Africa. During Phase-II, FP5 will develop stronger collaboration with A4NH and PIM for the adoption and dissemination of biofortified products, approaches and lessons to be learned on diet shifts, advocacy for better data capture and integration of value chain research into agri-food systems research.

Several areas of iteration and complementarity with A4NH have been identified, including food systems and understanding the dynamics of consumption and the differential roles in food systems for people by socioeconomic status, age and gender, particularly among adolescent girls and women of reproductive age. There is a need for effective innovations with food suppliers to improve diets through maize AFS, but this requires an enabling environment from regulators and policymakers.

2.8 Climate change

Climate change is one of the societal grand challenges and a cross-cutting theme for the CRP MAIZE overall. Postharvest losses are aggravated by climatic variability (Hodges, 2012; Stathers et al., 2013) and a better understanding of the consequences of climate change from farm-to-fork is needed, including its effect on the nutritional characteristics of food. When food prices rise, healthier foods may become too expensive and consumers may choose less healthy foods (Cummins and Macintyre, 2006). Of particular concern is that food with high energy density (usually more processed foods with high sugar and fat contents) is often cheaper than its less energy dense counterparts and less affected by price rises. This may reduce the nutritional quality of dietary intakes, lower the nutritional status of some groups and increase the risk of obesity. Changes in how foods are grown, processed, stored, prepared and cooked (all of which could alter with climate change) may affect the nutritional content of food. Higher fuel costs could also reduce cooking options for poorer groups (Lake et al., 2010).

Strategies focusing on better integration at the AFS level, increased biomass production and improved diet diversity are likely to offer opportunities for climate mitigation while also having the potential to improve food and nutritional security and incomes. FP5 will monitor and collect data on types and amounts of foods consumed by vulnerable groups (women and children) and monitor trends in diet changes, which is essential for highlighting changes in nutritional intake and status resulting from climate change. Some postharvest technologies may result in increased fossil fuel consumption. Where possible, renewable energy sources will be examined for their potential to support processing-related interventions and, where necessary, basic life cycle analyses will be used to ensure climate-neutral impacts across the flagship.

2.9 Gender

FP5 will align with the MAIZE gender strategy. Women play a key role in postharvest management and processing, including food preparation and the nutrition of the family, particularly children. This makes them important actors whose input should be sought when addressing issues related to maize quality traits, as well as improved processing and storage technologies, or new and nutritious maize food products. However, women's decision-making and bargaining power are often influenced by local gender dynamics and household power relations. It is critical understand these dimensions and take them into account in R&D interventions (**Table FP5.4**). FP5's work to link consumer preferences to sensory and processing characteristics of diverse maize materials will involve participatory trials with both women and men, and nutrition education initiatives will include women and men as well as youth of both sexes.

While respecting, capturing and understanding the division of labor and cultural context of diets, food, food processing and consumer preferences, FP5 activities will aim to make livelihood and nutrition changes with a preferential focus on the poorest households within a community, and women and children within those households, given their vulnerability for under- and malnutrition. New market opportunities can, in principle, benefit women and youth as well as men through new openings for income generation, as producers, processors and market participants but women and youth often face a number of gender related challenges. Therefore, a thorough gender analysis of the targeted value chains will be undertaken to inform research interventions, and efforts will be made to prioritize a focus on small- and medium-scale female and youth processors and their specific technology needs and preferences, supported by business skills building, entrepreneurship strengthening and gender-friendly processing equipment.

Table FP5.4: Overarching gender research questions for MAIZE FP5

FP5: Adding Value for MAIZE Producers, Processors and Consumers
• What traits, or combinations of traits, related to quality do farmers and consumers in different contexts, or from different social groups, prioritize? For example, what are the post-harvest/ processing /consumption/ nutrition or fodder related traits that poor men and poor women of different age groups demand? • What factors may influence the ability of poor men and poor women of different age groups to access, use and benefit from these technologies? And do these factors affect these sub-groups (sex x age) in the same or different ways? • From a gender and social perspective, what are the potential trade-offs of the technology or value-chain intervention in question?

2.10 Capacity development

FP5 will align with the CRP MAIZE overall Capacity Development plan and CGIAR CapDev Framework. In FP5, activities will focus on developing stakeholders' capacity to support enhanced adoption of improved processing methods and labor-saving technologies, increased adoption of improved storage and drying technologies and optimized feed processing options using maize and its by-products. Women and young people will be empowered by new market opportunities, as producers, processors and market participants. Efforts will be made to focus on upgrading of the capability of small- and medium-scale female processors to conduct research on gender-friendly processing equipment. Special attention will be paid to improving the skills of women and youth in relevant technologies to increase the efficiency and profitability of agribusiness ventures, as producers, processors and market participants.

Other activities that will contribute to capacity strengthening are the production and sharing of knowledge and communication materials, the promotion of novel products and field days to increase awareness. Capacity development of technology dissemination partners (NGOs, private sector, extension) will be done through train-the-trainer workshops; hands-on training; mentoring; graduate student supervision; postdoctoral and visiting scientist placements; and short courses.

In all FP5, strengthening the capacity of R&D partners will be important for knowledge development and transfer. This will help build a core of competent and experienced individuals who are prepared to assume scientific and leadership roles in advancing research and scale-out linkages on maize value-addition for farmers, processors, and consumers.

2.11 Intellectual asset and open access management

FP5 will align with the CRP MAIZE intellectual asset and open-access management, and as such adhere to the associated CGIAR and institutional principles. Co-location of FP5 activities within selected FP4 focal areas provides a unique opportunity to integrate nutritional and value chain data with the wealth of available data and to characterize production systems, their opportunities, links to market realities, climate change challenges and other external shocks (failed harvests, price fluctuations) at farm landscape and country levels. Such integration will overcome disconnects between agricultural and nutrition research in an agro-food system perspective, and arrive at economically sustainable interventions and recommendations for policy- and decision-makers. More accurate and relevant data on postharvest losses and the types and amounts of foods consumed by populations in maize agri-food systems will be generated and combined with other data sets, including nutrition studies.

2.12 FP management

FP5 is managed jointly by CIMMYT-IITA – with both joint FP coordination and co-CoA leaders and Wageningen UR co-leading 5.2 (**Table FP5.5**). Co-leadership allows centers to have a clear co-leading role and provides clear focal points within each organization for each CoA and the FP as a whole. CIMMYT-IITA co-leadership is further warranted by the geographic complementarities between the two centers. The FP5 leadership team has a long-term and successful partnership with a wide array of public and private institutions that add value at different levels, including diagnostics, processing at household and SME levels, nutrition, postharvest storage, and community testing and scaling up of interventions.

Table FP5.5: FP5 management team.

FP/CoA Structure	FP5 Coordinators and CoA leaders		
	CIMMYT	IITA	Wageningen UR
FP5	Natalia Palacios	Bussie Maziya-Dixon	
CoA 5.1	Natalia Palacios	Bussie Maziya-Dixon	
CoA 5.2		Bussie Maziya-Dixon	Vincenzo Fogliano/ Anita Linneman
CoA 5.3	Hugo De Groote	Tahirou Abdoulaye	
CoA 5.4 [uplift]	Hugo De Groote		

2.13 Budget summary

Details of FP5 projected base and uplift budgets for Phase-II, including analysis by funding sources, are provided in **Annex 3.19**. Flagship 5 is a new FP in MAIZE Phase-II. Currently its funding base is very limited compared to the other flagships. FP5 W1/2 base is also correspondingly small and funding from W3/bilateral projects is slowly gaining importance. Given the limited MAIZE W1/2 funding, as per CRP full proposal development guidelines, the limited W1/2 funding will be targeted to the first 3 CoAs (5.1, 5.2 and 5.3). CoA 5.4 (on animal feed), also not having any active W3/bilateral projects, was thereby moved completely to the uplift budget – albeit retained in the narrative. Given the potential relevance of all these CoAs in MAIZE target geographies, we remain optimistic in our ability to at least attract additional W3/bilateral resources. We envisage each CoA to have at least one substantial active W3/bilateral project closely aligned with the CoA priorities. Similar to the preceding FPs, FP5 relies on a strategic combination of a limited W1/2 base to complement the W3/bilateral components. Within the overall FP5 strategic priorities and funding availability, the scope and geographies of W3/bilateral funding will influence how we strategically (re-)prioritize and (re-)allocate W1/2 in Phase-II. W1/2 resources will be used to secure the core base and continuity in at least the first 3 CoAs (and dependent on uplift, CoA 5.4) but the overall uses may vary over the duration of the MAIZE Phase-II based on our ability to secure the W3/bilateral in each CoA and the FP.

W1/2 resources will primarily be used for the more strategic components of the first 3 CoAs, and addressing in particular the following priorities:

- Building and maintaining the critical capacity and scope for MAIZE to develop diverse novel and nutritious maize-based products for women and children dependent on maize in our main target areas and to attract strategic W3/bilateral funding, including investment in strategic research in maize nutrition, nutritional enhancement and corresponding R4D opportunities.
- Establish the potential for MAIZE to improve technology and knowledge for small-to-medium-scale maize processors, particularly in target countries in SSA, and then through partnerships build up the corresponding capacity and scope for MAIZE and build up the funding base.
- Building and maintaining the critical capacity and scope for MAIZE to reduce post-harvest losses, particularly in target countries in SSA, and to attract W3/bilateral funding, including investment in strategic R4D in maize post-harvest losses.

Uplift W1/2 budget, if received, will be used to:

- Build strategic nutritional expertise to strengthen the nutritional dimensions and impacts of MAIZE AFS.
- Initiating partnerships on CoA 5.4 on maize for animal feed use.
- Substantially strengthen and enhance the scope of the CoA's.
- Develop diverse novel and nutritious maize-based products, improved technology and knowledge for small-to-medium-scale maize processors, and reduce post-harvest losses.

Section 3: Annexes

3.1 MAIZE Accountability Matrix - Caveats to address during development of CRP2 full proposals

As set out in Annex 1 to the Final Guidance for the 2nd Call for Full Proposals, the collective portfolio submitted by the Centers/partners in response to this call for full proposals must be accompanied by a summary of how the 23 caveats raised in that annex by the respective stakeholders have been addressed. This annex sets out those caveats, grouped by the body putting forward the topic for added attention in the full proposals

1.1 Caveats expressed by the Joint Consortium Board/Centers/Fund Council Working Group, in its Memorandum to the Fund Council to express support for a 'green light' to move to full proposal development, dated 30 November 2015

Recognizing the advances already made in the re-submitted portfolio in the highly constrained time available, **the full proposals submitted by 31st March 2016 for ISPC review must address to the satisfaction of the ISPC, and contributors, the points set out below, to strengthen further the rationale and coherence of the planned research agenda,** thereby delivering increased confidence that with funding from 2017 onwards, it has the capacity to deliver on SDGs in general and the Results Framework and CGIAR targets as set out in the SRF:

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed (Full Proposal sections are referenced)
1	Greater attention to discerning the role of regionally focused yield-gap closing/ sustainable intensification research in the system, as distinct from and a complement to global public goods research in areas such as crop breeding, livestock health, food policy, and others.	AFS programs; Genetic Gains Platform	✓ Greater maize-specific focus on facilitating increased rate of genetic gain on the farmer's field by improving the trait pipeline development, capacity building, and by increased replacement of obsolete/less productive varieties. ✓ Increased investment in: i) better understanding of system diversity, dynamics and livelihoods, and ii) better understanding of ecosystems services as they link to sustainable intensification. These areas of work will be greatly enhanced through integration of expertise from the Humid Tropics CRP into MAIZE AFS.

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed (Full Proposal sections are referenced)
			✓ Changes to FP4, including a new CoA 4.4 on Partnership and collaborations models for scaling, and a new partnership on scaling out with GIZ.
2	More clearly articulating the strength of the arguments for maintaining genebanks and genetic gain as two separate platforms rather than an integrated effort[5]	Genebank; Genetic gain platforms	Not relevant for MAIZE. See Genetic Gains Platform proposal.
3	Crosschecking that consolidation at the cluster of activities or flagship level has not delivered unintended adverse consequences such as removing clarity for key research priorities and/or increasing transaction costs	All	✓ MAIZE-ISC and Management Committee agreed to integrate FP6 into FP3 and FP4, following donor requests to reduce the number of FPs in the pre-proposal portfolio. ✓ Major caveat: Bilateral funding dominates most FPs and CoAs, limiting the opportunity to better align FP/CoA project portfolio and to better link with other CRPs' projects. Unpredictable W1&2 funding makes it worse.
4	Providing a clearer understanding of National Partners' requirements, and how the scientific and financial program elements support them	All	✓ Not a deficit for MAIZE (see IEA Report on MAIZE, submitted in April 2015). ✓ See MAIZE Partnership strategy, section 1.8 and Annex 3.2; Capacity Development strategy, Annex 3.3.
5	Setting out more clearly the interconnection and resources available for the proposed Communities of Practice in gender/youth and capacity development, with particular attention to ensuring engagement of partners in the respective Communities of Practice. Specifically, ensuring that the proposed communities of practice operate in a way that will result in meaningful progress towards sustainable engagement and impact	All	✓ See PIM FP6 (Cross-cutting Gender Research and Coordination) Major caveat: Communities of Practice rely on voluntary commitments by people who have a full-time job. Expectations about their 'impact' must be commensurate with this level of investment.
6	Reducing as many transaction costs as possible, particularly regarding management burden	All	✓ The MAIZE AFS has been designed to operate as efficiently as possible. The Program Management Unit (PMU) comprises only of core functions. When needed, it leverages additional support from CIMMYT and IITA. The cost of

[5] There were a number of different views expressed during working group deliberations on this topic. Whilst there was no fundamental opposition to separate platforms, there was a call for making a much stronger case as to why they should be separate.

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed (Full Proposal sections are referenced)
			running the PMU is approximately 2% of the overall CRP budget.
7	Providing greater emphasis on soils, animal genetic conservation and the potential impact of big data across the portfolio, not limited to genetic gain	WLE, all AFS, Livestock, Big Data platform	✓ MAIZE identified key Big Data opportunities in each of the Flagship Projects, especially FP1, FP2, FP3 and FP4. ✓ MAIZE FP4 has an enhanced focus on ensuring that agri-systems diversification and intensification is achieved in ways that protect soil and water (see Table FP4.1 for details). ✓ See Big Data Platform proposal (IFPRI/CIAT), Table 1.4 and 1.5 and FP1 and FP4.

1.2 Caveats expressed by the ISPC, dated 9 December 2015

ISPC comments on the portfolio (a paraphrase of a longer document)

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
Portfolio level			
8	Seek explicit prioritization within CRPs (and also between CRPs); balancing research on 'upstream' science with research on how to scale out and up relevant new knowledge and technologies (while leaving the delivery of impact at scale to organizations with that remit)	All	✓ MAIZE explains its up-/downstream research mix in section 1.6 and elaborates key partners involved at different stages in Table 3.1. ✓ MAIZE has a balanced mix of Discovery-Validation-Scale-out in its portfolio of CoAs (see Section 1.6 on Program structure and flagship projects; Figure 1.6). The balance between upstream research, downstream research, and interaction with partners for large-scale delivery is explained in the flagship project narratives, specifically in the impact pathways, theories of change, and science quality sections. ✓ FP4 CoA 4.4 focuses solely on key research themes related to scaling-up the products of the other CoAs, including analysis of the roles of development actors vis-a-vis research actors in

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
			MAIZE.
9	Important to capture synergies between CRPs so that the System delivers more than the sum of the CRPs (the One System One Portfolio mantra)	All (statement of portfolio synthesis required)	✓ MAIZE proposes a net increase in inter-CRP collaboration, leveraging the current work on Site Integration (see section 1.7 and Annex 3.7).
10	Clearer explanations of what W1&2 funding will be used for	All	✓ The budget management narrative in each of the MAIZE FPs clearly highlights how W1&2 funding effectively complements the W3/bilateral resources, in addressing the key priorities under both the base and uplift budget scenarios.
11	CRPs should not be expected to adhere to the 'prioritization' undertaken in a very short time-frame to produce the 'Refreshed' submission, but should hold serious discussion with their partners on which activities to prioritize according to the principles which were agreed at FC14	All	✓ The MAIZE R4D portfolio is continuously being shaped by the priorities expressed by the stakeholders, including farmers, public and private R4D partners, high-level experts, and donors. Annually, more than 10,000 farmers, seed companies, extension agents, NGOs and NARES partners provide crucial feedback through more than 3000 maize field days and on-farm demonstrations. At least 800-900 of these clients attend one or more of the 30 annual project workshops/review meetings. ✓ During the past four years, MAIZE has organized e-consultations and phone interviews with dozens of high-level experts and donors. For example, 350 MAIZE partners provided crucial advice during the launch meeting of MAIZE Phase-I in January 2012. In 2014, 2015 and 2016, MAIZE received crucial prioritization advice annually from at least 60 partners.
Platforms			
12	2 new platforms are proposed: Genebanks and Genetic gains. The ISPC is comfortable with the platform on Genebanks	Not applicable	NA
13	Have concerns about the focus of the proposed Genetic Gains and what the creation of such a platform will mean for the AFS CRPs (and theories of change). The ISPC also found the title of 'Genetic gains' to be inappropriate as what is proposed is only part of the research required	Genetics Gain platform	NA

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
	to deliver 'genetic gains'. The budget needs to be reviewed		
14	Supports the concept of an initiative in Big Data and does not want to see this de-emphasized	Big Data platform	MAIZE does see a CGIAR competitive advantage in contributing to a Big Data initiative for IAR4D/ARD, but not leading one. How effectively MAIZE can potentially contribute to the Big Data platform has been outlined in the narratives of each of the Flagships, especially FP1, FP2, FP3 and FP4.
15	Identify where budget is placed for other arrangements to meet cross cutting system work originally considered through Expressions of Interest at the pre-proposal stage	All c.f. Guidance doc	NA
AFS CRPs			
16	DCLAS: The rationale for DCLAS receiving a 'C' rating overall (from the ISPC) related to the breadth of species being considered; the funders are requested to indicate their priorities for this CRP	This addressed to funders not to CRPs	NA
17	FTA has moved tenure and rights to PIM – although PIM don't mention that. FTA also wants to move the restoration work to WLE. Given the decreased budgets overall, these 2 CRPs may not accept these moves and the topics may hence disappear. Clarity on the potential loss of these areas is required	FTA, PIM, WLE	NA
18	Livestock and FISH both wish to move some genetics research across to the new platform as may other CRPs, yet the budget sources for those moves are not clear	Livestock, Fish, Genetic Gain platform	NA
19	MAIZE proposes to move some bilateral projects out of the CRP due to budget cuts. What is an appropriate balance of W1/2 bilateral at the base funding scenario?	MAIZE	The ideal balance for MAIZE is 1 : 3 (W1&2 to Windows 3 and bilateral). The current balance is approximately 1 : 5 (W1&2 to W3/bilateral).

No	Item to address	Relevant CRP(s)	Centers' summary of how the matters has been adequately addressed
20	RAFS (and presumably other CRPs) proposes to reduce the number of targeted IDOs and sub-IDOs – and both RAFS and Wheat make reference to cutting back on capacity development due to budget cuts. Realistic adjustments to current funding and base scenario funding will need to be considered by CRPs and funders	RAFS, WHEAT	NA
Global Integrating Programs			
21	The ISPC is glad that PIM has agreed to take on the role of co-ordination of a System-wide platform or Community of Practice for gender work, although we hope that it will be possible to reinstate the original budget. It is hoped that down-rating gender from a Flagship to 'Cross-cutting work' does not reflect diminishing importance of gender	PIM re role of the FP on gender	NA
22	A4NH and WLE seem to be following the ISPC recommendations (through additional steps for integration with CRPs through defined flagships, while the CCAFS Summary in Annex 2 suggests the budget cuts: 'need a totally new business model', the ISPC understands that only minor changes are now being proposed	A4NH, WLE, CCAFS, PIM	✓ MAIZE is maintaining its traditional linkages with A4NH through FP3 (especially on provitamin A enriched and high-Zn maize) but seeks to expand collaboration with A4NH through the new FP5. MAIZE continues to explore closer collaboration with WLE.

1.3 Additional caveats expressed by the Fund Council during its ad hoc meeting on 11 December 2015.

The Fund Council noted that its granting of a 'green light' to move to full proposal development was subject to the caveats noted by the Working Group and ISPC (in their written submission) and the Fund Council's request for enhanced focus on gender and capacity building. The Fund Council also specifically acknowledged that CGIAR is engaged in an incremental process and some concerns raised by Fund Council members will require additional time and attention before the new portfolio of CRPs is approved.

No	Item to address	Relevant CRP(s)	Summary of how the matters has been adequately addressed
23	Enhanced focus on gender and capacity building	All	✓ MAIZE describes priority investments on gender and social inclusion in Section 1.4 and Annex 3.4. MAIZE invests around 15% of its total resources each year in gender research and gender mainstreaming. ✓ MAIZE describes priority investments under Capacity development in Section 1.10 and Annex 3.3. ✓ See also relevant sections on gender and capacity development in the narrative of each of the MAIZE Flagships.

3.2 Partnership strategy

The global partners' network of MAIZE is essential for addressing global, regional and sub-regional challenges through the co-generation, brokering, and pipeline stewardship of publicly accessible knowledge, often bound in new technologies and approaches. The **MAIZE Partnership Strategy** is based upon these **assumptions**:

1. MAIZE can achieve outcomes and impact only through partnerships outside and within the CGIAR
2. Different partnerships and partners are needed in the different phases of the non-linear continuum, from knowledge discovery to systemic change (e.g., discovery to scaling out). Table **Table 3.1** depicts this by way of examples.
3. The further MAIZE moves along this continuum, the less it can/should lead and influence (Circle of Influence principle).
4. As products, solutions and approaches developed under MAIZE move towards scaling out/up, partners-of-partners (e.g., boundary partners) become the key drivers of change.

Table 3.1: Different types of partnerships along the knowledge discovery–systemic change continuum

	Discovery	Validation	Scaling out
Strategic**			
Regional / Global	PIM and the University of Minnesota for MAIZE foresight. Wageningen UR and the former Humid Tropics CRP for systems characterization and trajectories, synergies and trade-off analysis. Oak Ridge National Laboratory (ORNL) and the University of Minnesota on Big Data. Cornell University on high-density genotyping-by-sequencing (GBS), genomic selection and GOBII.	KIT: Gender and development work. University of Hohenheim: R4D on haploid inducers and DH technology. The University of Barcelona and the private sector on field-based phenotyping. Multinational companies (Monsanto, Pioneer) and partners in SSA (e.g., KALRO, ARC and NARO) on maize transgenic testing under CFTs and stewardship implementation.	GIZ: Build Scaling Out networks. SFSA: Business models and commercialization of scale-appropriate mechanization. CIMMYT-IITA-KIT: Building a functional innovation platform "infrastructure", while simultaneously building on-the-job capacity to facilitate maize system innovation in SSA, Asia and Latin America. KALRO and private sector seed companies on the MLN trait pipeline.

National		A wide array of NARS, seed companies and NGOs are partners in germplasm development and multi-location testing in SSA, LA and Asia Introgression of other institutional germplasm and technologies (e.g., Monsanto under WEMA; Pioneer under IMAS).	NGO collaboration on mechanization business development. Public sector – NARS in Mexico; Guatemala, Haiti, Ethiopia, Ghana, Kenya, Malawi, Mali, Mozambique, Nigeria, Rwanda, Zambia, Zimbabwe; Bangladesh, India and Nepal for adaptive research on maize varieties.
		MasAgro Take It To The Farmer: Innovation Systems Approach	
Program-/Project-based			
Regional / Global	Genomic Selection: The next frontier for rapid gains. Integrated Breeding Platform (IBP), DArT and James Hutton Institute (JHI) on database management, medium-density GBS, and breeding informatics. GENNOVATE (11-CRP multi-case studies)	Cereal Systems Initiative in South Asia *Complex agri impact challenges** SARD-SC/MAIZE in 4 SSA countries (AfDB)	
National		MasAgro *Complex agri impact challenges**	
		Sustainable Intensification of Maize-Legumes Systems in Eastern and Southern Africa (SIMLESA) *Complex agri impact challenges**	

As defined in "Good Practice in AR4D Partnership," ISPC Guidance Paper, Sept. 2015 (draft). ILRI's Partnership Strategy (2011) distinguishes between institutional (e.g., with FARA; at Center Mgmt level), strategic and project-driven partnerships.

This strategy **aims** to

1. Make clear to our current and future partners how we wish to handle partnership and why it is so important to MAIZE, based on their feedback;
2. Support program and project leads, as well as MAIZE-MC, to better plan ahead, set up, manage and close well-functioning partnerships at the strategic and operational levels, be they lead, co-

lead or participating partner (ILRI Partnership Strategy refers to contractor, equal partner and service provider categories);

3. Develop new kinds of partnerships for specific purposes and in specific contexts: work with new kinds of partners (e.g., ORNL, USA), participate in new types of partnerships (e.g., GIZ and SFSA scaling out multi-CRP partnership).

How will this strategy be **implemented?** By:

A. Giving partnership as such more attention:
   a. Integrating methods and tools along the partnership life cycle into the MAIZE project management cycle;
B. Improving upon screening partners:
   a. In many cases, MAIZE cannot choose its partners (e.g., there is only one, donors stipulate partners). Therefore, a better SWOT analysis at the outset is needed, as well as explicit mutual expectations management (e.g., agree on "how to partner")
C. Staying close to partners and fostering partnership management practices (sustaining, partnering capacity) in three critical areas:
   a. Approaches, methods and tools, such as stakeholder and network analysis, mutual self-assessments and targeted capacity development activities
   b. Relationship management: Roles and Competencies
   c. Building and maintaining a Partnership Knowledge Base
D. Exchange of experiences and know-how with other CRPs in the context of country coordination.

Just as important is **committing resources** to developing and maintaining partnerships:

MAIZE uses a mix of **(co)-funding approaches and modalities** to accommodate different partnership purposes and partner co-funding ability (see **Table 3.2** below).

Table 3.2: MAIZE (co)-funding approaches and modalities

					Funding source	
		Decision-maker	**Funding timeframe**	**Partner co-funding**	**W1&2**	**bilateral**
MAIZE Competitive Grants	Research; MAIZE = contractor (to non-CGIAR R&D partner sub-grantees)	MAIZE-MC	1-3 yrs; 1 yr contracts	Sometimes; in-kind (salaries, infrastructure use)	Y (MAIZE partner budget)	
MAIZE Commissioned Grants	See above	MAIZE-MC	1-3 yrs; 1-yr contracts	Sometimes; in-kind	Y (see above)	

Global or regional consortium	Equal partners CRP NARS, other International Maize Improvement Consortium	Consortium mgmt. body, Sci advisory body guides. CIMMYT and private sector seed companies	Multi-year	Yes, in-kind & financial	Y	Could be
National, regional or global coordination of R4D	African SROs (e.g., ASARECA)	Members, by consensus	Varies, for coord. only	NA	X	
Bilateral program or project	Research, development; national implementation partner sub-grantees / CSISA	Program or Project Mgr, steering committee, donor	1-3 yrs, depending on bilateral contract	Sometimes		Y
NEW: Joint CRP project	CRPs = equal partners	CRP-MCs	1-3 yrs	NA	Y	

What **kind of partners** does MAIZE work with? Overall, MAIZE has more than 350 partners that together have a tremendous track record. Instead of providing a generic categorization of partners, we provide some examples of collaboration:

1. MAIZE works extensively with both public and private sector partners. In recent years, work with the private sector has expanded considerably. Currently, MAIZE works directly with DuPont, Monsanto, and Syngenta multi-national seed corporations, more than 180 small- to medium-sized (SME) seed companies and 226 community-based seed producers across Asia, sub-Saharan Africa and Latin America. These partnerships vary from exchange of promising germplasm between CIMMYT/IITA and multi-national seed corporations through to development of varieties, along with technical support, to many of the SME seed companies and community-based seed producers.
2. MAIZE works with the University of Wageningen, CIRAD, SAIL (Sustainable Agriculture Innovation Laboratory), Earth Institute-Colombia University, ORNL, and IPNI to develop strategic, scalable approaches based on farming systems analytical frameworks at multiple spatial and temporal scales to support development partners (i.e., “last-mile providers”) with knowledge products (including policy briefs and other advocacy materials), decision-support and information systems (including GIS and SMS), which enables them to take to scale targeted options that increase system performance and sustainability.
3. MAIZE works with development partners (such as SFSA, GIZ, Total Land Care, One Acre Fund and machinery manufacturers, etc.) on scaling out of innovations.

4. MAIZE’s International Maize Improvement Consortium (IMIC) is the most important source of new genetic variation for maize yield increases, adaptation to climate change, resistance to pests and diseases, and the basis for the rapid response to maize lethal necrosis.
5. MAIZE accesses, develops and transfers scientific innovations to NARS partners as an IPG, through germplasm and data exchange, joint research and capacity development. It uses its convening power to involve ARIs and the private sector in research within pre-competitive domains, e.g., hybrid research, genomic selection, Big Data, mechanization and nutrition research.
6. MAIZE is co-leading an 11-CRP research study on gender norms and women’s and men's decision-making within households related to farm planning and management. The study develops synergies among the scarce gender research capacities in ARIs and NARS to empirically analyze gender roles and social norms in maize growing environments. It also examines the way these factors affect maize production and productivity. The study will develop strategies to address gender-based constraints in maize farming systems and the wider environment.
7. MAIZE partners are an important source for building the capacity of NARS students, scientists, technicians and professionals, with up to 12 PhD and 38 MSc. students finishing their higher degrees every year. In 2015, MAIZE conducted over 1,500 training courses and field days involving over 39,000 farmers and research and development collaborators.
8. The deployment of CGIAR maize staff in regional offices allows close collaboration, understanding of farmer needs, opportunities for engaging local partners in collaborative research and scaling out, which has led to the successful development of sustainable intensification approaches in Asia, Africa and Latin America, as well as south-south collaboration on mechanization.
9. MAIZE shapes the international R&D agenda to address cross-border challenges and foster collaboration among NARS based on delivery of IPG. It engages with sub-regional and regional agricultural research organizations (e.g., ASARECA and APAARI) and launches new international consortia (e.g., IMIC) with partners.

What are MAIZE partners looking for? Surveys underline key elements of the comparative advantage of the centers and their R&D partners:

1. In the first CGIAR Stakeholder Perceptions Survey, research partners rated MAIZE highest among all CRPs on sector-specific knowledge, working effectively with partners and insightful external communications.
2. According to the 2014 IEA Review, “MAIZE has strong research and boundary partners engaged throughout the MAIZE target geographies” and “NARS are appreciative of the collaborations.”
3. Indeed, MAIZE’s “success rests on strong partnerships and good quality science” (IEA, 2014). For example, “strong partnerships with National Research Programs, and increasingly with the private sector, have enabled rapid effective reaction to MLN in Africa” (IEA, 2014).

Major MAIZE partner planning/consultation events between 2012 and 2016 (outside the significant partner consultations held as part of annual planning meetings for the big bilateral projects).

- 2012, Annual Meeting with 350 MAIZE partners 12^{th} – 20^{th} January.
- 2012, Science Leaders Meeting and Mini Symposium with partners in Montpellier 12^{th} – 22^{nd} June.
- 2012, Dublin II meeting on the CGIAR and CAADP in Dublin 17^{th} to 20^{th} June.
- 2012, BISA Work Planning Meeting in Delhi, 15^{th} to 19^{th} September.

- 2012, GCARD2 Meeting in Uruguay 27th October to 1st November.
- 2013, Consortium Office and ISPC Intermediate Development Outcomes (IDO) meeting in Cali, Columbia, 23rd to 26th March.
- 2013, FARA Science Week, in Accra, Ghana, 15th to 18th July.
- 2013, CGIAR ISPC 8th Meeting, IWMI, Colombo, Sri Lanka, 8th to 13th September.
- 2013, Innovation Transfer into Agriculture / Adaption to Climate Change (ITAACC) and Advisory Service on Agricultural Research for Development (BEAF) , Feldafing, Germany, 18th to 22nd November.
- 2013-14: MAIZE Partner Priorities Survey, with 67 responses from 23 countries regarding priorities for IAR4D versus national research.
- 2014, KIT Innovation Systems Workshop, Amsterdam, Holland, 29th September to 3rd October.
- 2014, 12th Asian Maize Conference at Hanoi, Vietnam, 27th to 29th October.
- 2014, ASARECA multi-CRP coordination meetings (Nairobi, June, and Burundi, December).
- 2015, IITA-CIMMYT 'summit' on CGIAR Maize research, 16th of February.
- 2015, CRP Leaders meeting in Montpellier, 1st to 5th June.
- 2015, High Level Policy Dialogue on Investment in Agricultural Research for Sustainable Development in Asia and the Pacific, at Bangkok on 8th and 9th December.
- 2015, Agricultural Innovation Systems (AIS) Workshop, Wageningen, 11th to 13th December.
- 2015, MAIZE & WHEAT Sustainable Intensification write-shop with CRPs HT, DS 15th to 17th December.
- 2016 Selected R&D partners participate in Full Proposal development.
- (Feb.): Online partner feedback to Full Proposal.
- (Apr.): Participation GCARD3 Conference.

3.3 Capacity development strategy

This strategy takes into consideration multiple elements, including the status quo, plus the strengths and weaknesses and opportunities highlighted in the CGIAR Independent Evaluation Arrangement (IEA) Report on MAIZE Phase-I, and review of MAIZE Phase-II Preproposal. The main gaps identified in the MAIZE Phase-I IEA Report[6] can be clustered into the following areas:

a) *Research program management* – The CRP evaluation recommends actions to further improve and maintain science quality through the development of protocols, processes and working instructions for research operations and delivery. Substantial improvements in data sharing and analysis are required. At present there is no formal, structured process to leverage and exchange data globally and among projects. The evaluation highlighted scientists' frustration about the lack of a mechanism for sharing results and experiences across projects.

b) *Strengthening maize science capacity* – a major constraint to AR4D in many developing countries is the insufficient number of skilled scientists and technicians. According to the evaluation, the quality of MAIZE science is good, but greater efforts are needed to enhance opportunities for developing the skills of MAIZE scientists. Another weakness is the lack of skills needed in some key areas such as biotechnology and new techniques and practices. Also, there is a low representation of women among research staff who work on MAIZE. Another challenge facing the research institutions in SSA is the lack of maintenance and the decay of research infrastructure, including the equipment and laboratories, due to inadequate funding.

c) *Gender analytical competencies* – As pointed out in the ISPC commentary on the 2015–2016 MAIZE Extension Proposal and the IEA Report regarding gender mainstreaming performance, this is seen as a high priority to support improved policy, management and decision-making.

d) *Knowledge and technology dissemination, uptake and out-scaling* – Over the years, MAIZE has collaborated with different organizations and applied various research and dissemination approaches to improve the generation and uptake of technologies. Although the CRP has yielded and disseminated successful research outputs, including technologies, approaches and policy outcomes, much more intensive efforts are needed in the coming years.

Key Strategic Actions

The objective of the strategy is to support the development effectiveness of the MAIZE Program. The strategic actions identify high priorities for potential capacity-development activities across FPs, clusters of activities, and technical areas. A set of four strategic priorities have been developed for consideration. These priorities are aligned with the CGIAR CapDev Framework and address all the key elements.

a) *Improving MAIZE science capacity* – Enhancing global maize science capacity is critical for a continual influx of high quality people into careers in maize research. To build a new cadre of maize scientists, the CRP will work closely together with leading universities, NARS, the private sector, and advanced research institutes. Science capacity will be developed through Ph.D. and M.Sc. training. CapDev

[6] Report of the Independent Evaluation Arrangement (IEA) of the CGIAR Research Program on MAIZE, April 2015.

efforts will link closely with other initiatives such as the AWARD program for African women. Particular attention will be given to the training of female scientists who are currently under-represented in MAIZE.

Research capacity will also be built in specific areas such as genetics, genomics, experimental design and data curation to enable staff to harness the potential of these technologies. The plan is to also increase the capacity to more fully understand the impacts of innovations through foresight, targeting and modeling approaches, impact assessment, adoption pathways and factors such as markets, institutions, policies and farmers' risk and preferences. Different types of short-term training will be used to develop and maintain up-to-date knowledge and skills, including coaching and mentoring, workshops, short-term courses and visiting scientist schemes, plus delivery of innovative learning materials, guidelines, tools and protocols.

Given that a major challenge in the NARES is the lack of maintenance and the decay of the research infrastructure, modest support would be provided, especially through W3/bilateral projects, to improve the infrastructure and to enable NARES scientists to successfully conduct their assigned research responsibilities.

b) *Enhancing gender in research design and impact pathways* – CapDev activities will aim at increasing the capacity to analyze the implications of gender for technology adoption and ensuring feedback from analysis to research, conducting strategic gender research for better research prioritization, and developing quality standards for gender analysis, mainstreaming of strategic thinking, theories of change and gender sensitive approaches. In particular, they will increase the capacity of young women and men to participate in decision-making and facilitate their access to markets, value chain opportunities and job opportunities.

Different modes of short-term training will be used in order to develop and maintain up-to-date knowledge and skills of staff in these areas, including coaching and mentoring; workshops, technical short-term courses and visiting scientist schemes; design and delivery of innovative learning materials; and sharing of good practices, guidelines, common tools and protocols.

c) *Improving research-based management, governance, learning and knowledge sharing* – MAIZE recognizes that tools and guidance can make a significant contribution in building the capacity of AR4D practitioners. Therefore, a set of tools, protocols and support materials will be developed to support the development of competency-based approaches and collaboration. Capability in data and information management should also be enhanced, in compliance with CGIAR policies on open-data access. This activity should take root and become an integral part of maize improvement programs and contribute to the sub-IDOs: enhanced genetic gains through tools and methods; efficient management of databases and informatics tools that enhance accessibility of genotypic and phenotypic data; and enhanced use of genetic resources.

Rules and procedures should be developed to guide researchers. All researchers should be required to develop a research data management plan to formalize decisions relating to ownership, retention, storage and disposal of data. This will ensure that researchers continue to understand data in the long term and that re-users of data are able to interpret them.

Capacity for learning and knowledge sharing will be increased in line with the learning strategy to provide opportunities for all partners to update themselves and discuss findings, strengthen their competencies and skills, and hone their research and analytical capabilities. MAIZE relevant resources will be easily discoverable and in accessible formats (appropriate for the audience) and useful for stakeholders. This will be implemented in collaboration with the various learning functions, which include communications, partnerships, research and information technology to develop a range of knowledge products and dissemination approaches. The learning program is also concerned with the packaging of practices, protocols for improving research capacity, and insights/lessons for knowledge sharing, training and policy advocacy.

Strategic actions to implement this priority include graduate training, short-term training courses, theme-based workshops, visiting scientist schemes, internships, a mentoring and coaching scheme targeting mainly young and mid-career scientists, and the development and dissemination of relevant learning resources through the MAIZE Platform and other media. Specific short-term training courses and workshops on data curation and stewardship, software tools for breeding program management, statistical analysis methods and tools, and genomic data analysis will be organized.

d) *Strengthening capacity in technology dissemination and upscaling* – Much of the CapDev in this area will be through "learning-by-doing" in the innovation platforms for upscaling, as well as through the exchange and sharing of practical experiences at different learning workshops and other experience sharing fora. Syntheses of successful approaches with illustrative case studies and other insights drawn from the action research projects and other sources will provide complementary learning materials to be shared through platforms and other channels.

Additionally, MAIZE will organize and facilitate focused, short theme-based training and learning events to achieve enhanced adoption and impacts from improved maize seed in the following areas: improving small-scale farmers' knowledge of new maize varieties along with complementary crop and land management practices; seed production; business management skills; sustainable intensification; processing and value-addition; and strengthening institutions to influence policy. Other actions in CapDev include cross-projects exchange visits and mentoring of young scientists and practitioners. Lessons and practices for upscaling will be packaged in various forms and in appropriate languages for dissemination.

Implementation, management and delivery

Implementation will build upon the experiences of MAIZE Phase-I and other initiatives. The CapDev will operate in a matrix that cuts across clusters and includes input on needs and priorities from the broader scientific and development communities. The CapDev will support activities where MAIZE has high potential impact; high quality results promote inclusiveness and contribute to the CGIAR research outcomes in terms of human welfare benefits. The guiding principles for operationalization are ''participation and alignment, understanding the context, building on strength, interlinking priorities and continuous learning." To implement the plan, the following are needed: (a) a schedule of activities, identification of results and indicators, clarification of roles and responsibilities; (b) integrating the plan with existing plans of other partners; (c) clarifying the levels of financial and human resources required; (c) establishing a CapDev function to coordinate, monitor and evaluate activities within the overall framework of MAIZE M&E; and (d) adjust the plan as necessary to achieve results. While setting priorities is the rational process of allocating limited resources, in practice, priority setting involves a combination of supply- and demand-oriented methods, consultation with stakeholders, and a resource mobilization program.

Measure of success

Results will be assessed against predefined targets and indicators following the MAIZE M&E framework and in alignment with CapDev indicators for the second phase of CGIAR research. In selecting the indicators during the planning process, MAIZE should take into account: the purpose – what it will be and how it will indicate the required change; the availability – how straightforward is it to collect the relevant data; and the cost – how much it will cost, in terms of time and money, to collect the data. For each activity, the desired output and outcome should be determined, as well as the baseline and target for each indicator. The proposed indicators described below are specific to each priority. They should be combined with more generic indicators, such as number of workshops or trainings provided in each strategic priority, number of people trained, etc. **Table 3.3** below outlines the proposed performance indicators for capacity building.

Table 3.3: Proposed performance indicators for capacity building.

Strategic priority	Proposed performance indicators
Improving MAIZE science capacity	▪ Amount of funding for fellowship programs ▪ Number of fellowships provided (disaggregated by level, gender, department) ▪ Number of participants from NARS and research partner organizations attending ▪ Number of knowledge products generated using innovative research approaches and research process management tools and practices ▪ Increase in the number of peer-reviewed publications led by NARS students and faculty ▪ Availability of funding from CRPs for institutional strengthening
Enhancing gender in research design and impact pathways	▪ Funding made available for design/review of gender-sensitive approaches in partner projects /programs/policies (disaggregated by type of organization) ▪ Number of new policies that support gender-transformative measures (disaggregated by country) ▪ Number of CapDev activities in gender approaches/toolkits initiated (disaggregated by type)
Improving research-based management, governance, learning and knowledge sharing	▪ Number of knowledge products generated using innovative research approaches and research process management tools and practices ▪ Increase in engagement activities between NARS and brokers and end users of research (identifying research needs and subjects; sharing research results) ▪ Proportion of learning materials using media formats accessible to the intended audience ▪ Efficiency of MAIZE internal processes; e.g., percentage of tools, guidelines developed and used

	▪ Number of best practices identified, documented and packaged ▪ Increase in learning and MAIZE intellectual assets
Strengthening capacity in technology dissemination and upscaling	▪ Number of collaborations (e.g., joint research, training/workshops conducted jointly, shared funding arrangements, common membership in multi stakeholder platforms) with partner organizations ▪ Number of groups and multi-stakeholder (innovation) platforms facilitated by CRP (disaggregated by gender, socioeconomic status, organizational affiliation) ▪ Adaptation, adoption and spread of innovations associated with participating groups, platforms, households, etc. ▪ Number of NARES-researched and field-tested technologies, patents or practices in valorization (through commercialization or public programs) ▪ Number of technologies/tools adopted across partner organizations

3.4 Gender strategy

Knowledge of gender in maize-based agri-food systems gained in Phase-I and informing Phase-II

Until 2011, the integration of gender and social equity in MAIZE's socioeconomic research was not an institutional priority. It was based on individual interpretations and interests and tended to be donor-driven. Since then, structured, strategic work to create an effective learning research institution able to support, assimilate and mainstream researcher-driven learning on gender in wheat and maize systems has been an important focus. Work to date includes Gender Audits in MAIZE and WHEAT (2013), a Gender Capacity and Awareness Building Program to strengthen scientist research skills in gender (Wong et al. 2015); a Research Management Framework; developing gender in IDO and Flagship Projects (2014-2015); developing gender-responsive Key Performance Indicators; gender budget tracking (DAC); and a Gender Policy (2015 draft). This work has contributed towards a dramatic upsurge in projects integrating gender, from 4 projects in 2012 to 20 in 2014 and 18 in 2015. CRP MAIZE leadership is demonstrating strong support by ensuring gender is addressed at meetings, TOC workshops, reviews, etc.

Challenges to integration between Flagships remain. It can be difficult for upstream scientists to understand how their work on germplasm suited to large environments can address what appear to be trait preferences by small niche groups, including women or particular indigenous communities. Taking gender to the types of scale MAIZE operates on is a further challenge. The increasingly high profile of gender in MAIZE's work can create expectations among scientists and partners for support in gender research and analysis that cannot currently be met with the existing staff capacity. A community of practice is being developed which is expected to help expand analytic skills and knowledge.

Phase 1 Learning on Gender in Maize Systems

Between 2013 and early 2016, MAIZE scientists published 24 journal articles and 9 resources (books, monographs, brochures, reports, etc.) and contributed to numerous blogs on gender research. The majority of research has been in maize-based systems in sub-Saharan Africa and Latin America. These efforts are creating a critical mass of knowledge and expertise which can inform improved scientific priorities and research questions for MAIZE as a whole and its Flagship Projects. Important findings from this work are presented in the Gender Strategy (3.4); a summary is provided here, followed by selected examples.

Strategic and integrative gender research was conducted on small-scale mechanization (Eerdewijk and Danielsen 2015), improved post-harvest storage technologies (Kandiwa et al., forthcoming), conservation agriculture (Farnworth et al. 2015), and participatory varietal selection and seed sector development (Kandiwa et al., forthcoming). Significant progress has been achieved in documenting gender aspects of technology adoption and impact assessment, e.g., Teklewold et al. 2013a/b; Gitonga et al. 2013; Teklewold et al. 2013b; Rodney et al. 2013; Fisher and Kandiwa 2013; Ndiritu et al. 2014; Mutenje et al. 2016; Manda et al. 2016). Ongoing projects (e.g., SIMLESA, DTMA, IMAS, FACASI, WEMA, CSISA) have adopted integrative gender research processes, including gender-responsive technology development and testing; integration of gender in value-chain R4D; assessing life histories of women's and men's plots, and action-oriented pilot projects to motivate and engage young adults in improved crops, post-harvest processing and agribusiness opportunities. The learning trajectories of selected research projects are presented here to show how they will inform and influence MAIZE Phase-II gender research.

Intra-household Decision-Making is Central to Adoption

The Farm Power and Conservation Agriculture for Sustainable Intensification (FACASI) project began with the assumption – which turned out to be flawed – that it would have a strong impact on gender inclusion by developing, testing and promoting "women-friendly" two-wheeled tractors. However, research conducted in Ethiopia and Kenya showed that although women supply most farm labor and do the most-labor intensive tasks, this often fails to translate into demand for mechanization. This is because women generally control few financial resources (particularly in FHH), have little decision-making power in MHH, and because women's work is socially not valued, nor is its high intensity recognized. The key lesson from Phase-I is that focusing on women-friendly machines is far less important than understanding and working with gender relations and dynamics.

Upstream Work Is Increasingly Embracing Downstream Concerns

In Phase-I, research findings on gender and ethnic trait preferences regarding maize landraces in Mexico and other locations, was fed upstream to scientists in FP2 to help inform their germplasm work (Hellin et al. 2010, 2013). In response to this and other CRP MAIZE work on preferred traits, and under the guidance of FP1 regarding priority setting, FP2 began to assess gender preferences and the gender implications of target traits. It worked on trait pipelines for high beta-carotene, high lysine and specialty traits of particular cultural or income-related importance to certain groups.

Developing Partner Capacity Is Vital

In Latin America, MAIZE worked with partners on (1) GENNOVATE, (2) MasAgro Productor, and (3) Feed the Future Buena Milpa Project, Guatemala. In MasAgro, CRP MAIZE partnered with private sector players to develop market-oriented innovation strategies, with public institutions to ensure that research and social inclusion were promoted, and with NGOs to offer training to women and men. While the technologies were the same (improved varieties, conservation agriculture, and soil conservation practices), they were tailored to poorer and mid-level farmers. Socially equitable implementation strategies were central to the Feed the Future Buena Milpa Project, Guatemala, with particular attention on ensuring resource-poor women and indigenous communities (regardless of age) participated effectively. The project partners learned that knowledge among partners on gender, youth and indigenous communities in maize farming systems is low. Integrating gender and social inclusion is a major challenge because of the variety of partners involved and the depth of additional effort required. In Phase II, the implications of soil conservation and other technologies on the labor demand for women and youth will be assessed and interventions adapted accordingly.

Gender in MAIZE Phase-II

Work will continue on mainstreaming gender in the MAIZE Research Management Framework (RMF). Recommendations from the Phase 1 Gender Audit include: (i) deepening the mainstreaming of gender in institutional and programmatic frameworks and procedures; (ii) refining and consolidating mechanisms to support integration of gender in research project design, budgeting and M&E; and (iii) implementing the Gender Equality Competency Framework and the Gender Capacity and Awareness Building Program to support the development of required staff gender equality competencies by level and area of work. Priority areas for gender research encompass: (i) technology development, including on trait preferences, e.g., related to labor- or input-saving, risk reduction, and nutrition and processing qualities; and (ii) technology diffusion and adoption, including access to information, bargaining and decision-making capacity, favorable and inclusive enabling environments, and value chains. Selected projects are presented here. Further R4D is planned in all FPs.

GENNOVATE

MAIZE is a leading actor in GENNOVATE (https://gender.cgiar.org/collaborative-research/gennovate/), a cross-CRP comparative research initiative examining how gender norms and agency influence the ability of men, women and youth to learn about, try out, adopt and adapt new agricultural technologies. In MAIZE, 27 case studies are being prepared in Mexico, Zimbabwe, Malawi, Nigeria, Ethiopia, Tanzania, and Nepal. Phase-II will develop journal papers and other user-orientated data. The findings will provide evidence for contextually grounded systems approaches and actions. This is essential for the design and roll-out of equitable and efficient maize agri-food systems innovations. GENNOVATE will contribute to MAIZE's strategic planning of Phase-II and beyond by: (1) enhancing the gender-responsiveness of targeting, priority setting and theories of change; (2) advancing gender-transformative outcomes of maize research and development interventions at scale; (3) building the evidence base and actions to address the role of gender norms in the adoption of improved maize technologies and related development.

FACASI Systems Analysis Tools for User-Led Empowerment and Change

The Evaluation of Systems Analysis tools in multi-stakeholder Platforms (ESAP) is coordinated by MAIZE. Six systems analysis tools will be assessed for their ability to facilitate discussions, reflections, social inclusion and empowerment leading to systems change among technology end users. They are: Fuzzy Cognitive Mapping (FCM), Social Network Analysis (SNA), Farm Typology FT), Board Games, Ecological Network Analysis, and Efficiency Frontier. FACASI will use FCM and board games with established women's groups in Ethiopia to identify 2WT mechanization entry points for service providers. Analysis will focus on gendered perceptions of the benefits and trade-offs of different types of mechanization. Scenarios will be run to understand the changes in gender-based agricultural labor with each type of mechanization. Scenarios will be presented back to the groups and the efficacy of the tools on reducing women's labor and improving their participation in decision-making assessed over time.

Reducing Risks Associated with Innovation

MAIZE has developed widely available climate-adapted maize germplasm. However, fear of the risks posed by drought prevents widespread adoption. CCAFS is funding research on how index insurance reduces the risk faced by farmers and enhances technology uptake. In Phase-II, research will focus on East and West Africa (Nigeria). Particular attention will be paid to understanding the gender and equity dimensions of insurance initiatives, for example, how socioeconomic differentiation affects farmers' access to index insurance, and how this combines with cultural and geographical features to shape access to markets, institutions and resources required to benefit from index insurance.

Deepening Feedback Loops between Upstream and Downstream Work on Traits

FP2 will continue to draw on research generated in FPs 1, 3, and 5 on traits and trait combination preferences of men and women farmers and consumers in particular contexts. This will include research on novel trait variation and molecular pipelines that address nutritional quality, antioxidants and other issues, for example, herbicide tolerance to help reduce female drudgery. Complementary work in FP5 includes plans to link consumer preferences to sensory and processing characteristics of diverse maize materials through participatory trials with both women and men. Complementary nutrition education initiatives will include women and men, and youth. Additional efforts to address and enhance the nutrient content of maize-based diets (whether through biofortification or diet diversification) will assess and take into account the quantity and quality of women's and children's as well as men's diets.

Sustainable Intensification (SI) in MAIZE
SI knowledge/technology portfolios differentiated for gender, youth and resource-poor communities will be developed. This will include integrating nutrition aspects and crop-livestock systems to promote multi-functional climate-smart farming systems. Moreover, implications of gender-asset gaps for intra-household food security, technology adoption and market participation will be modeled.

Household Methodologies (HHM) in Malawi and Tanzania
Under CCAFS, a small project will work initially in Malawi to evaluate the potential of HHM to promote selection and adoption of climate-smart practices in SIMLESA areas. The ability of HHM to foster gender-transformation will be tracked. Controls will be established. Work will be conducted with National Association of Smallholder Farmers in Malawi (NASFAM) farmer groups. Other partners (the government, the private sector, civil society, research) will be involved to create a learning community of practice.

Two-pronged approach to implement the MAIZE Phase-II Gender Strategy
As described in section 1.4, the Gender Strategy is implemented through:

a) Strategic gender research
b) Mainstreaming gender research into ongoing and future programs and projects while incorporating gender research into institutional frameworks. How is this achieved?

Incorporating the gender research dimension in institutional frameworks
Under the MAIZE Research Management Framework (RMF), funded projects prepare a detailed work plan. Activities planned are assigned to the person responsible in the Research Management System (RMS). This person must provide progress updates at the task and summary task levels. Reports are then aggregated up to the project level and up to the Cluster of Activity, Flagship Project, and CRP levels. Physical progress reported to the RMS is integrated to financial management. This allows the implemented financial and physical issues to be notified and projects to be recalibrated as necessary. Key Performance Indicators (KPIs) are registered at the RMS level. Gender is mainstreamed into all relevant MAIZE research development, implementation and evaluation processes:

- Gender-responsive R4D project design; gender budget tracking (DAC).
- Gender Competency Framework: to strengthen scientist research skills in gender.
- Gender-responsive and sex-disaggregated research implementation in targeting, data collection and analysis, participatory technology testing/evaluation, demonstrations and training.
- Monitoring and evaluation through tracking gender-responsive Key Performance Indicators.
- Accountability for gender-responsive outcomes.

Strong attention will be paid to managing iterative research processes. As results and lessons learned with respect to gender are generated, they will be fed back into FP and CRP learning processes, thus contributing to further development, and calibration of, the programmatic and institutional frameworks. This, in turn, will inform the next generation of research projects and FP implementation.

Tracking and evaluating progress

Under the MAIZE Research Management Framework (RMF), funded projects prepare a detailed work plan. Activities planned are assigned to a specific individual in the Research Management System (RMS). This person provides progress updates at task and summary task levels. Reports are then aggregated up to project level and thence to Cluster of Activity, Flagship Project, and CRP levels. Physical progress reported to the RMS is integrated with financial management reporting. This allows financial and physical issues arising during implementation to be assessed with projects recalibrated as necessary. Key Performance Indicators (KPIs) are registered at the RMS level.

Sex-disaggregated KPIs include the number of: (i) maize lines with characteristics valued by women farmers; (ii) technologies evaluated with explicit relevance for women farmers; (iii) trials conducted with women farmers; (iv) demonstrations conducted with women farmers; (v) technologies demonstrated with explicit relevance for women farmers; and (vi) surveys with sex-disaggregated data. Adoption studies and impact assessments (especially under CoA 1.2) investigate uptake of CRP MAIZE technologies.

3.5 Youth strategy

Introduction

Ninety percent of the world's young people live in Africa, Asia, and Latin America and the Caribbean. Up to 70% of youth in SSA and South Asia live in rural areas (Bennell, 2010), and 47% of rural youth in Africa work in agriculture (Kokanova, 2013). The combined challenges of continued population growth, declining agricultural productivity growth and environmental depletion put pressure on agricultural research and development to work on all fronts to further enhance agricultural productivity and food security. Youth (young women and men) represents a tremendous human resource and development potential, but has often been neglected in agricultural research and development. In recognition of the need to leverage the potential of youth, CRP MAIZE Phase-II will give special attention to exploring avenues for harnessing the capacities, opportunities and empowerment of young women and men as agents of change in maize agri-food systems.

The rationale for a focus on youth in CRP MAIZE

The agricultural sector's declining ability to attract youth causes concern in the face of continued population growth, rising food demands and natural resources challenges (Sumberg et al., 2012). Young people today are generally better educated than their parents. However, with higher levels of education typically come greater expectations –of young people themselves but also parents' expectations for their children. But many rural contexts do not offer options that match youth aspirations (Leavy and Hossain, 2014; Chinsinga and Chasukwa, 2012). According to Kokanova (2013), young people working in agriculture represent the poorest group of working rural youth compared to rural youth engaged in other sectors, often earning significantly less than the common poverty threshold of $1.25 per day. Across the globe, more and more young people do not see the farming sector as offering attractive livelihood options (Leavy and Hossain, 2014). Increasingly, traditional small-scale farming, which in many places continues to involve high levels of drudgery and hardship, is no longer enough to make ends meet and raise a family.

In 2013, global youth unemployment reached 12.6%, with young people almost three times more likely than adults to be unemployed (DS Youth Strategy, Table 1). The situation is particularly critical in developing regions where 90% of the global youth population lives. Moreover, high levels of unemployment and disillusion can lead to social and political instability with the "Arab spring" in 2010-11 as a recent example (see also ILO, 2012). Bezu and Holden (2014) put these and other factors into a migration and push-pull perspective in a study on Ethiopia.

The world needs farmers, as well as professionals and entrepreneurs engaged in dynamic, inclusive agri-food systems, to ensure the food and nutrition security of future generations. However, while hopes for developing the agricultural sector are often pinned on the alleged energy and innovativeness of young people and their willingness to take risks (e.g., IFAD 2013; Adedugbe, 2013), interventions focusing on youth should appeal and make sense to young women and men from their own perspectives and an instrumental approach to youth should be avoided (White, 2012).

Defining youth as a social category

The concept of "youth" as a distinguishable demographic group is socially defined and varies across different contexts.[7] Formal, legal definitions of youth typically apply an age-related definition that is linked to rights or special protective measures and policies, e.g., the right to vote or the uptake of hazardous work. In many countries, the age of 18 marks the boundary to adulthood in the legal sense. The UN system defines youth as persons between the ages of 15 to 24, and children as persons up to the age of 14 years.

Youth is often viewed as a stage in life of transition from childhood to adulthood, associated with physiological and psychological changes and increasing social and economic autonomy (World Bank, 2006; Bennell, 2007; White, 2012). In many contexts, the concept of "youth" does not exist as such or is delimited by entirely different parameters for entry into adulthood, e.g., age-sets, initiation or rites of passage marking the transition from one stage of life to another, the onset of menstruation or childbearing, marriage, death of a parent, working for pay (Keesing, 1981; Potash, 1981, in Quisumbing et al., 2014). However, defining "youth" as being in transition to adulthood, conceals the fact that they are living in the here and now with their own needs, rights and interests (White, 2012; Sumberg in CGIAR Consortium Office 2015).

Though in principle the term "youth" covers both genders, in practice it often refers primarily to young males, thus rendering invisible the gender-based constraints and opportunities young rural women face (Farnworth and Sillah, 2013; Levine et al., 2008; Bertini, 2011). Overall, the social heterogeneity of youth and their embeddedness in different social relations and institutions need to be understood and taken into account in research and development interventions.

MAIZE Youth Strategy

Informed by the commitment to promote equality of opportunity and outcomes,[8] the **objective** of the CRP MAIZE youth strategy is: *To harness the opportunities and capacities to innovate of resource-poor young women and men in maize-based agri-food systems.*

The expected **impacts** are: improved livelihoods due to improved opportunities for young women and men to engage in maize-based agri-food systems.

The expected **outcomes** include:

- Reduced vulnerability of young women and men due to increased livelihood opportunities directly or indirectly linked to maize-based agri-food systems.
- Increased research focus on local opportunity structures and their linkages to sustainable agri-food system development.

[7] This is reflected in national policies; for example, Ethiopia's national youth policy (2004) defines youth as those aged between 15-29, while the National Youth Policy of Nepal (2010) defines youth as "women, men and third gender" persons aged 16-40 years old (http://www.youthpolicy.org/).

[8] See the MAIZE gender strategy: http://maize.org/?page_id=1654.

Overall approach to youth in CRP MAIZE

Agriculture is a viable choice only for those who can access (enough) land and inputs. However, land fragmentation linked to rising populations as well as gerontocratic and very often patriarchal social systems is a key constraint to the development of small-scale agriculture (White, 2012; for Ethiopia, see also Bezu and Holden, 2014). Still, as Leavy and Hossain (2014) note, agriculture, and related fields, was able to acquire status among young people to the extent that it was modern and cash-based, rather than subsistence oriented.

MAIZE's overall approach to youth focuses on understanding and harnessing rural opportunity structures. Limited research has been conducted specifically on the roles of young women and men in agriculture (Farnworth and Sillah, 2013; Proctor and Lucchesi, 2012; Paroda et al., 2014) including maize-based systems, and statistics are rarely disaggregated by age (FAO, 2014, p. xvii). Integrating a perspective on youth in the MAIZE Phase-II agenda therefore has to begin with strengthening the evidence base and establishing a research agenda. Borrowing from Sumberg et al. (2012), key research questions include:

- How are opportunities for engagement in maize farming and maize agri-food system development more broadly structured for young women and men in different places?
- What are the implications of this structuring for subsequent patterns of young women and men's engagement in maize farming and maize agri-food systems, as well as for livelihood, poverty, social justice and sustainability outcomes?
- How might particular policy options affect or modify these outcomes?
- What are the politics around these policy options and associated processes?

Building on current experience

Current examples under CRP MAIZE of research with specific attention to the perspectives of rural youth include the cross-CRP comparative research initiative, GENNOVATE, informed by an agency–opportunity structure conceptual framework, and in which MAIZE plays a lead role.[9] As part of this initiative, through sex-specific focus group discussions in rural communities across Latin America, Asia and Africa, MAIZE is capturing the views of young women and men regarding gender *norms* and *practices* in relation to their aspirations, livelihoods, capacity for innovation, physical mobility, access to economic opportunities and family formation.

While collection and cleaning of GENNOVATE case-study data are yet to be completed, initial findings from Zimbabwe, Mexico, Malawi, Nigeria, Ethiopia and Nepal seem to support the literature, for they indicate that aspirations of young rural men and women are mostly found outside agriculture or NRM activities (See Fig. 3.1 below). For many of these young respondents, owning a business, holding a degree or migrating is fundamental for moving out of poverty. Given that many relate farming activities with economic stagnation and backwardness, they hope for other opportunities. An example of something that concerns young respondents is labor drudgery, as expressed by a young woman from

[9] GENNOVATE involves 11 CRPs and more than 135 community case studies in 26 countries. Of these, 27 are carried out by CRP MAIZE. For more information on GENNOVATE, see: http://gender.cgiar.org/wp-content/uploads/2015/12/GENNOVATE-Flyer_WEB.pdf.

Zimbabwe: “I wish someone could invent tools that dig basins in conservation agriculture so that we do not do it manually since as women we already have the burden of doing all household chores.”

Both young women and men express interest in agriculture-*related* business activities (see Fig 3.2). Yet limited access to knowledge and resources is a common constraint for young respondents in these countries. As a young woman from Zimbabwe points out, “If young women can get land, one can start potato planting projects. I also think that girls should be trained in a number of income-generating activities like poultry, piggery, and mushroom production so that they are equipped in how to earn some cash.” Likewise, a young Zimbabwean man asserts that “availability of inputs, such as fertilizers, [is a prerequisite] to successfully venture into agriculture.” By the same token, young people speak critically about the current mechanisms used to inform about new agricultural technologies and ask for a more inclusive and far-reaching approach. As a young man from Nepal points out, “Information is not reaching up to the grass root level. Like trainings and other programs.”

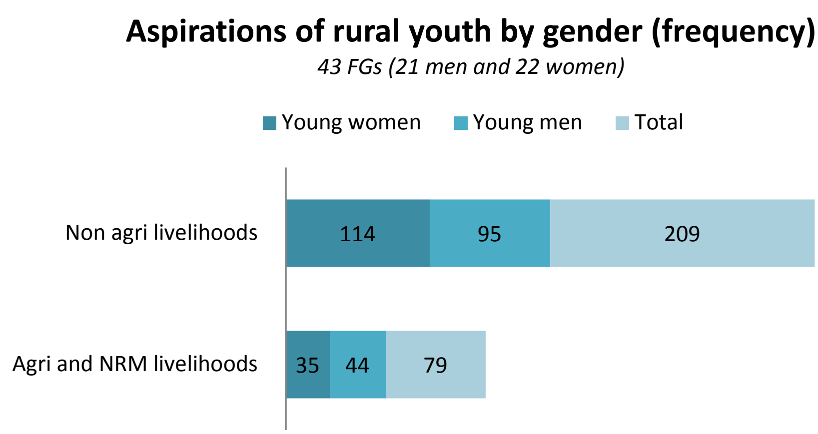


Figure 3.1: Aspirations of rural youth, 2015 data from 23 communities in Zimbabwe, Mexico, Malawi, Nigeria, Ethiopia and Nepal

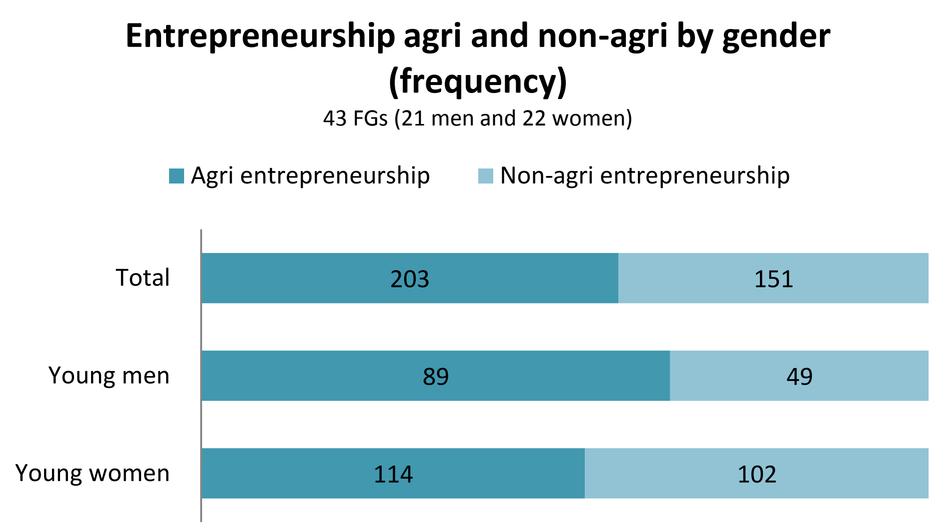


Figure 3.2: Entrepreneurship by gender, agricultural and non-agricultural 2015 data from 23 communities in Zimbabwe, Mexico, Malawi, Nigeria, Ethiopia and Nepal

Other youth-responsive work that CRP MAIZE Phase-II can build on includes, for instance, the project MasAgro Productor, which involves establishing a farmer typology, considering age and gender to promote innovations that are more inclusive. Similarly, one of the priority groups targeted in the Buena Milpa Project in Guatemala is children and youth as key actors in the future feasibility and sustainability of traditional maize systems. Likewise, the IITA Youth Agripreneur Program targets youth via trainings, business development and strategic alliances; it also facilitates market access for them to establish and improve their own agri-businesses along different value chains.

Integrating youth in MAIZE Phase-II R4D agenda

In Phase II, MAIZE will take a two-pronged approach: (i) develop and implement a strategic framework for the systematic integration of youth-related issues in maize agri-food systems research; and (ii) develop and apply key principles and practices for inclusion of youth-related concerns in research.

i) **Strategic framework:** In order to take stock and achieve rigorous input to the process of strengthening the systematic integration of youth into the MAIZE research agenda, in 2016 MAIZE is partnering with IDS to develop a strategic framework for its engagement with young people and youth-related issues. The framework will include a detailed exploration of the distinction between, on the one hand, structural issues and interventions (i.e., that affect or have the potential to affect multiple social groups), and on the other hand, what might be considered "youth-specific" issues and interventions. Structural issues within the agricultural sector include those affecting productivity and access to land, credit, technology and markets. A working hypothesis is that much current policy and development programming that purports to address the youth and agriculture problem is "youth-specific" and therefore fails to address – or even acknowledge – the core structural issues.

   The development of the strategic framework will draw on findings from GENNOVATE, and on relevant research literature, including literature on the structural transformation of agriculture in the developing world; on youth transition, youth employment and young people's imagined futures; and on the "new entrant problem" in developed country agriculture and the use of social protection programs to facilitate the inter-generational transfer of key assets like land. The strategic framework will guide the subsequent steps to integrate youth-related issues in the MAIZE research agenda.

ii) **Integrating a youth lens in MAIZE research practice and procedures:** Where relevant, youth will be targeted purposefully in the design of MAIZE research projects and increased emphasis will be put on gathering feedback on the research and technology development process from young men and women. In addition to sex-disaggregation, people-level data collection and analysis will also be disaggregated systematically by age and other relevant socioeconomic variables. Where possible and relevant, mixed methods will be applied, combining qualitative and quantitative data collection and analysis. To take into account the social heterogeneity of youth, representation of diverse groups will be ensured to the extent possible. For projects with a youth focus or component, this dimension will be incorporated into the monitoring and evaluation frameworks. Similarly, adoption studies and impact assessments, as well as foresight and targeting and value chain analyses, will seek to incorporate consideration of youth issues. The integration of youth-related issues in CRP MAIZE is based on the principle of continuous improvement. As integration of youth in MAIZE research practice and procedures progresses, it is expected that increased awareness and capacity will lead to an increase of research projects paying special attention to youth.

3.6 Results based management

Purpose

In Phase-II, MAIZE will be implementing a results-based management (RBM) framework. This framework will act as a strategic management system that integrates strategy, results, people, resources, processes and measurements.[10] It will also consist of a set of tools for strategic planning, monitoring and evaluating performance, reporting, improvement and learning.[11] RBM seeks to support greater accountability, transparency, informed decision-making, swift corrective actions, learning from experience and better management of risks and opportunities.

Principles

This framework will be implemented based on a set of globally recognized RBM principles: a culture focused on outcomes; strong leadership in RBM to model results-orientation across the system; participatory approaches at all levels, including partners and stakeholders; learning and adaptation through the use of performance information; accountability and transparency where program staff are held accountable for appropriate levels of results that are acquired and reported in a transparent manner; and a utilization-focused and flexible operational system where RBM tools, procedures and practices can be adapted based on contexts and needs.

Steps in Managing for Results

Given that RBM is a management strategy, the framework will be part of the overall ongoing CRP cycle of planning, budget allocation, risk management, and performance reporting and evaluation, including value for money. Key steps that will be used throughout this cycle include:[12] based on lessons, defining and revising the impact pathways at the CRP level and theories of change at the Flagship level; budget allocation based on performance; planning for monitoring and evaluation; establishing responsibilities and accountabilities; monitoring and analyzing performance and risks information; using performance and risks information; and reporting performance results.

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[10] "Results-Based Management Lexicon." Government of Canada, Treasury Board of Canada, Secretariat. Web. 02 Feb. 2016. http://www.tbs-sct.gc.ca/hgw-cgf/oversight-surveillance/ae-ve/cee/pubs/lex-eng.asp

[11] "An Introduction to Results Management." Asian Development Bank. Web. 02 Feb. 2016. http://www.adb.org/sites/default/files/institutional-document/32577/files/introduction-results-management.pdf

[12] Ibid.

3.7 Linkages with other CRPs and site integration

Agri-food system CRPs

Much collaboration currently exists between MAIZE and other AFS CRPs, which will be expanded in MAIZE Phase-II (see **Table 3.5**). The priority areas for enhanced linkages are collaborative work on: 1) pre-breeding; 2) sustainable intensification, and; 3) value addition.

1) Cross-commodity pre-breeding, tools, models and methods will be increasingly shared between AFS CRPs to support research and enhance genetic gains in crops other than maize. This will be achieved in part via the Genetic Gains Platform and through bilaterally funded projects and through promotion of open-access databases, informatics tools, software and breeding support tools (e.g., real-time data curation tools). Cutting-edge biometrics models and methods for genomic selection and high-throughput proxy trait selection developed by MAIZE are widely useful across AFS CRPs. MAIZE's platforms for characterizing and enhancing the use of genetic resources serve as templates or at least serve to inform efforts by other AFS CRPs. High-throughput phenotyping methods and tools, as well as precision phenotyping hubs/sites will be useful to other AFS CRPs. Leveraging phenotyping competencies and best practices, with a view to rapidly translate insights of extensive genetics and breeding research undertaken in MAIZE on other relevant crops with lower research intensities. Other CRPs (such as RICE, WHEAT, DCL) will share knowledge on G x E x M in mixed cropping systems, where maize is an integral component.

2) Sustainable intensification in target geographies shared with other CRPs will be enhanced through the development and application of improved methodological approaches to analyze multi-commodity farming systems and target technical interventions within specific agro-ecological, socioeconomic and institutional environments. In addition, MAIZE's expertise in agronomy (precision agriculture, appropriate scale mechanization, and nutrient/water management) will be developed and applied with an increasing systems perspective. In return, other AFS CRPs will share knowledge on the performance on maize rotation, intercropped or in combination with rice, wheat, legumes, root crops, livestock and trees. MAIZE will benefit from MAIZE will also collaborate with other AFS CRPs in the development of framework for baselining and monitoring progress at farm and landscape levels. MAIZE will increasingly collaborate with other CRPs (and non CRP instititutions with scaling expertise) to develop and apply increasinly sophisticated business models for upscaling technologies.

3) MAIZE already collaborates with other AFS CRPs and PIM on the development and sharing of methods, tools and data in relation to foresight, impact assessment, gender, value chain/market analysis, and MELIA. In Phase-II, emphasis will be placed on stronger collaboration with CRP and non-CRP partners to develop and apply methods, tools and data for analysis of value addition in agri-food systems/value chains. joint analysis of complementarities and interactions in AFS (including maize and its by-products for animal feed) and advanced processing and postharvest technologies will be increasingly undertaken with colleagues in DCL, RTB and Livestock CRPs.

Agriculture for nutrition and health (A4NH)

Collaborative work with A4NH in MAIZE Phase-I has been focused on developing bio-fortified crops (provitamin A and kernel Zn enriched maize hybrids) and advocating for research products that decrease consumption of aflatoxin-contaminated maize, especially in Africa. CIMMYT and IITA will continue to support A4NH through their Harvest+ work. In Phase-II, MAIZE will continue to accelerate progress in developing nutritious crops and foods through exploiting the rich genetic diversity of maize. During Phase II, MAIZE will explore the feasibility and genetic variability for additional stacking of nutritional traits in maize varieties within A4NH. MAIZE will develop and produce nutrient enhanced germplasm, markers and breeding tools for maize micronutrients and develop increasinly nutrition-dense maize, which will be shared through MAIZE's global network of breeders and SME for commercialization of biofortified maize. In return, A4NH assist in identifying target areas and priority interventions and partners for nutrition and scale-up. During Phase-II, FP5 will develop stronger collaboration with A4NH and PIM for the adoption and dissemination of bio-fortified products, approaches and lessons to be learned on diet shifts, advocacy for better data capture and integration of value chain research into agri-food systems research. Several areas of iteration and complementarity have been identified with A4NH including food systems and understanding the dynamics of consumption and the differential roles in food systems for people by socio-economic status, age and gender, particularly among adolescent girls and women of reproductive age. There is a need for effective innovations with food suppliers to improve diets through maize AFS – requiring an enabling environment from regulators and policymakers.

Climate change (CCAFS)
MAIZE contributes to Climate Change (CCAFS) in a number of ways. Firstly, through improved foresight modeling, targeting (in conjunction with other AFS-CRPs, PIM), analysis of climate smart innovations (including weather index insurance; drought/heat tolerance; conservation agriculture). In Phase-I, modelling of future climate effects on production, together with synergies and trade-offs, to target adaptation domains with potential mitigation co-benefits has underpinned decision making in both MAIZE and CCAFS. In return, through its links with policy making bodies, CCAFS acts as a science-based advocate for policy changes to mitigate climate change. Increasngly, new abiotic and biotic stress-resilient improved MAIZE-derived cultivars will be evaluated within climate smart villages under heterogeneous production and socio-economic conditions. In return, CCAFS acts as faciitator, linking this germplasm to scaling-out partnerships. In Phase-II, MAIZE FP4 will work closely with CCAFS around research activities related to: a) participatory evaluation of MAIZE technologies and practices in climate smart villages (CSVs) and other sites where appropriate; b) improved resource use efficiency, particularly nitrogen and water, and impacts of GHG emissions; c) evaluation of the C sequestration potential of SI interventions, and; d) creation of minimum datasets for climate-smart technologies. Through CSVs and other CCAFS research, collaboration with important climate-related actors in both the public and private sectors will be strengthened. FP4 will also integrate with CCAFS in terms of data: (a) the generation of multi-criteria minimum datasets for maize-based systems and standardized methods and metrics to quantify climate smart agricultural technologies and practices over a range of scales; (b) to build a community of practice around climate resilient GxExM technologies and improved cropping system models that better characterize the effects of climate extremes on maize-based systems in terms of yield performance, resource use, GHG emissions, synergies and trade-offs. The GYGA spatial framework will provide a means to explicitly evaluate climate smart options in both current and future climates.

Policies and institutions (PIM)
Most of the collaboration between MAIZE and PIM is concentrated in FP1 and FP5. In Phase-I, MAIZE successfully collaborated with PIM in the co-development and sharing of methods, tools and data in relation to foresight, impact assessment, gender, value chain/market analysis through a strong community of practice. Phase-II, with the addition of FP5, MAIZE and PIM will further collaborate on

research to determine dietary pattterns, tools for better data capture and integration, and opportunities for value addition and scaling out.

Water, land, and ecosystems (WLE)

The collaboration between MAIZE and WLE is still at an early stage. To date, discussions have focused on how best to integrate the field and farm level knowledge on maize agronomy and systems analysis generated by MAIZE and the landscape level and beyond knowledge generated by WLE.

Genebank platform

Both FP2 and FP3 of MAIZE will align strongly with the Genebanks Platform. FP2 will focus on the Genotypic and phenotypic characterization of maize genebank accessions/genomic diversity and identification of novel variants for use by breeding programs. MAIZE will generate knowledge about genebank accessions, including definition of core sets to enhance use of genebank accessions. MAIZE FP2 will develop informatics tools to extract knowledge from Genebank data and to inform genebank decisions about gaps and duplications in collections. Ultimately, this will enhance use and impact of genebank accessions. Experience about intellectual property issues affecting the use of genetic resources will be generated and shared between MAIZE and the Genebank and Genetic Gains Platforms. The application of genetic engineering tools will be explored.

Genetic Gains Platform

MAIZE FP2 and FP3 will have strong linkages to the Genetic Gains Platform (GGP) and others. MAIZE FP2 and the Genetic Gains Platform will deploy tools developed by partners; for example, breeding program management software from the Integrated Breeding Platform and web-based visualization tools to interpret complex genomics and phenomics data developed by the James Hutton Institute. Interactions with MAIZE FP2-CoA2.1 and the Genetic Gains Platform will ensure that data management and GS prediction analysis pipelines result in useful and timely prediction reports to breeders. The GOBII project, a proposed component of the Genetic Gains Platform, is a showcase example of cooperation among these CRPs, involving five major crops. It is already generating interest from alternate crops, and the pioneering work done within GOBII is expected to benefit other non-focus crops within a ten year timeframe. MAIZE FP2 will also have strong linkages to the phenotyping and bioinformatics modules from the Genetic Gains Platform for inputs into high throughput/remote-sensing phenotypic data capture, storage, and analysis, and automated image analysis.

With regard to MAIZE FP3, all the six CoAs will be linked to the Genetic Gains Platform, MAIZE FP1 and FP2. MAIZE CoA 3.1 and 3.3 will provide promising maize germplasm for targeted environments and cropping systems to FP4, and will receive feedback on their performance through G × E × M analyses. Products from CoA 3.3 will form the core for developing novel technologies/processes/products through FP5. Some of the key tools developed by the Genetic Gains Platform for cross-cutting areas, such as phenotyping and breeding decision-making, will be validated and deployed in FP3. The FP3 team in turn will also help determine priorities to guide development of new tools in this platform.

Table 3.5: MAIZE Perspective on Site Integration in Phase-II

Countries	Phase-I and Extension	Possible integration In Phase-II	Lead center	Topics/projects	Integration under FP
			Sub-Saharan Africa		
Cameroon	Germplasm screening activity	RTB, integration of CIRAD's research	TBD (discussions among CRPs are ongoing)	Access to improved maize germplasm	FP3, FP4
DRC	Germplasm screening activity in the maize-growing provinces (through MAIZE)	RTB	TBD (discussions among CRPs are ongoing)	Access to improved maize germplasm	FP3
Ethiopia	Large portfolio of projects from several CRPs with a significant contribution from MAIZE	MAIZE, WHEAT, FTA, CCAFS, RTB, DCL, Livestock, PIM, WLE	MAIZE and/or CCAFS and/or Livestock	Adoption of improved maize varieties (see DTMA, NUME), Sustainable intensification (TAMASA, SIMLESA, FACASI, Africa RISING), improved targeting of SI intervention and integrated research on crop, tree, livestock systems	FP1, FP3, FP4 FP5
Ghana	Many IITA-led projects in relation to MAIZE, covering most Flagship Projects; includes Africa RISING, N2Africa	TBD	TBD	Access to improved maize germplasm and sustainable intensification	FP1, FP3, FP4, FP5
Kenya	Many CIMMYT and IITA led projects in Kenya under FP3, 4, 5	WLE, Livestock, FTA, RTB, CCAFS	MAIZE, FTA	Adoption of improved maize varieties (see DTMA, NUME), Sustainable intensification (SIMLESA, FACASI), improved targeting of SI intervention and integrated research on crop, tree, livestock systems	FP3, FP4, FP5

Malawi	MAIZE (SIMLESA, DTMA, DTMASS)	DCL (ICRISAT), WLE	MAIZE	Diversification, sustainable intensification (Africa RISING)	FP3, FP4, FP5
Mali	Africa RISING in southern Mali	DCL (ICRISAT), WLE, FTA, Livestock	DCL AFS	Diversification, intensification and risk in agro-ecologies where maize, sorghum co-exist	TBD
Mozambique	MAIZE (SIMLESA, USAID)	DCL (ICRISAT and CIAT), Livestock, RTB	MAIZE, RTB	Access to improved maize germplasm and sustainable intensification of maize-bean-livestock systems	FP4
Nigeria	Many IITA-led projects in relation to MAIZE, covering most flagship projects; good integration with DCL AFS	TBD	TBD	Access to improved maize germplasm and sustainable intensification of maize-bean-livestock systems. Value-addition. Technology targeting (TAMASA).	FP1, FP3, FP4 FP5
Rwanda	FTA, RTB, MAIZE	WLE, Livestock, WHEAT, DCL	RTB	Access to improved maize germplasm and sustainable intensification	FP3, FP4
Tanzania	MAIZE, RTB, FTA	WLE, Livestock, DCL, CCAFS, FTA	MAIZE or RTB	Access to improved maize germplasm and sustainable intensification (TAMASA, SIMLESA, FACASI). Value-addition. Technology targeting.	FP1, FP3, FP4 FP5
Uganda	MAIZE, RTB	FTA	TBD	Access to improved maize germplasm and sustainable intensification	FP1, FP3, FP4
Zambia	MAIZE, RTB	CCAFS, DCL, FTA	TBD (discussions among CRPs are ongoing)	Diversification and intensification (Africa RISING) and nutrient management (SIMLEZA)	FP1, FP3, FP4
Zimbabwe	MAIZE, DCL AFS	CCAFS	TBD (discussions among CRPs are ongoing)	Access to improved maize germplasm and sustainable intensification. Technology targeting.	FP1, FP3, FP4

Asia					
Bangladesh	MAIZE, RICE	WLE	RICE	Nutrient and water management, salinity management, crop diversification and improved cropping systems linked to markets, Mechanization	FP3, FP4
Cambodia	CIRAD MAIZE absent during Phase I.	CIRAD	TBD (discussions among CRPs are ongoing)	TBD	TBD
India	Large investment under MAIZE, WHEAT, RICE through CSISA in the IGPs. Good integration of CCAFS work in the IGPs with MAIZE and WHEAT. Livestock part of CSISA II but not in CSISA III. CIMMYT-led SRFSI project (ACIAR) mapped under CCAFS.	Develop further integration with WLE and DCL	MAIZE or RICE. Site integration already exists	Resource conserving technologies (water and nutrients), PPP, scaling of SI practices. Reduction of production risks. Conservation Agriculture. Better targeting of technical innovations. Covering both irrigated and rainfed farming systems.	FP1, FP3, FP4
Laos		CIRAD	TBD (discussions among CRPs are ongoing)	TBD (discussions among CRPs are ongoing)	
Nepal	MAIZE and WHEAT, GRSP. Two distinct agro-ecologies. Rainfed hills and irrigated Terai (IGP)	WLE, FTA, CCAFS	GRSP	Access to improved maize germplasm and sustainable intensification	FP3, FP4
Pakistan	MAIZE, WHEAT, GRSP, Livestock, WLE	Idem	WHEAT	Access to improved maize germplasm and sustainable intensification	FP3, FP4

Vietnam	FTA, GRSP MAIZE absent during Phase 1.	MAIZE, RICE	TBD (discussions among CRPs are ongoing)	Access to improved maize germplasm and sustainable intensification	FP3, FP4
			Latin America		
Dominican republic	No activity yet	CCAFS, DCL	MAIZE	Access to improved/adapted maize germplasm and sustainable intensification	FP3, FP4
Guatemala	USAID Buena Milpa project under MAIZE	WLE, DCL (CIAT)	MAIZE	Access to improved germplasm. Scaling of SI on-going work. Targeting of interventions	FP4
Haiti	On-going USAID project under MAIZE	DCL CIAT), WLE	TBD (discussions among CRPs are ongoing)	Access to improved germplasm. Resource conserving technologies (nutrient and soils). Production risk management. Development of viable seed systems	FP1, FP3, FP4
Mexico	MAIZE, WHEAT	DCL CIAT), Livestock	MAIZE	Access to improved germplasm. SI of maize-bean-livestock systems	FP1, FP3, FP4
Nicaragua	DCL AFS (CIAT)	MAIZE, Livestock, WLE	DCL	TBD (discussions among CRPs are ongoing)	FP4

Template 1: Overview of Inter-CRP Collaboration: What MAIZE provides and receive is presented as **Table 1.4**

Template 2a: MAIZE partnerships with other CRPs and Platforms (activities, mode, geographies and outputs sought).

Partner CRP	ACTIVITY AND COUNTRY(IES) IN WHICH THIS TAKES PLACE	ROLE OF MAIZE	ROLE OF COLLABORATING CRP/PLATFORM	COLLABORATION MODE (Complementary / Joint investment)	OUTPUTS / ADDED VALUE
AFS-CRP – RICE	Multi-commodity agri-food system analysis; sustainable intensification and diversification smallholder farmers Geography: tools – global; data – SSA, Asia, LAC	• To provide expertise and knowledge in maize agronomy and maize based systems. • Contribute inputs on mechanization. • Provide an integrative framework for multi-commodity systems including rice and maize. • Improved maize germplasm for sustainable intensification of rice-maize farming systems	Provide additional expertise and resources in system approaches to large on-going W3 projects (e.g., CSISA, SRFSI, API)	Joint investments	• Better targeting of technologies and their integration. • Scaling of innovations in rice-maize cropping systems. • Precision agriculture and approaches to increase input use efficiency • Systems approaches, technologies, methodologies; Helping ensure positive or neutral ecosystem impacts • Sharing expertise and knowledge on deploying novel tools for increasing genetic gains in stress-prone environments,
AFS-CRP – WHEAT	Multi-commodity agri-food system analysis; sustainable intensification and diversification smallholder farmers Geography: tools – global; data – SSA, Asia, LAC	To share scientific expertise from CIMMYT on all FP4 aspects	Sharing approaches, methodologies, sites	Joint investments	• Coherence of approaches between MAIZE and WHEAT by the lead institution (CIMMYT). • Economies of scale, including strategic partnership with advanced research institutions, and capacity development of partners. • Sharing expertise and knowledge on deploying novel tools for increasing genetic gains in stress-prone environments,

AFS-CRP – DCL	Multi-commodity agri-food system analysis; sustainable intensification and diversification smallholder farmers Geography: tools – global; data – SSA, South Asia, LAC	• To provide system expertise and methodological approaches for the intensification of maize-based systems which also rely on legume based technologies • Maize-specific expertise, data and studies • Systems expertise (multi-disciplinary, multi-scale, multi-commodity) • Co-development of methods and tools • Share expertise and approaches in innovation systems. • Appropriate scale mechanization	• Better access to promising legume germplasm and legume diversification options. • Sharing methodological approaches on systems research and genetic gains improvement.	Presently mainly through SIMLESA project.	• Integration of technical innovations in systems approaches. • Better understanding of trade-offs and synergies in smallholder maize-legume cropping systems • Enhanced agri-food systems analysis capability • Enhanced international public goods and relevance • Enhanced adoption and uptake of innovations • Shared approaches to processing and storage options.
AFS-CRP – RTB	Multi-commodity agri-food system analysis; sustainable intensification and diversification smallholder farmers Geography: tools – global; data – SSA (especially Ethiopia, Kenya, Zimbabwe, Zambia, Mozambique, DRC), South Asia, LAC ,...	• Maize-specific expertise, data and studies • Systems expertise (multi-disciplinary, multi-scale, multi-commodity) • Co-development of methods and tools • Sharing of expertise and approaches in innovation systems. • Appropriate scale mechanization	• Innovation approaches and system analysis • Co-development of methods and tools	Joint investment: Collaborative projects Complementary: AFS specific data and studies	• Scaling strategy and approaches for smallholder systems • Enhanced agri-food systems analysis capability • Enhanced international public goods and relevance • Enhanced adoption and uptake of innovations
AFS-CRP – FTA	Multi-commodity agri-food system analysis; sustainable intensification and diversification smallholder farmers Geography: FTA (presently in Ethiopia, Rwanda and to be outscaled to other SSA countries in Phase-II)	To provide expertise and knowledge in maize agronomy and maize based systems	Integration of commodities in a system approach	Joint investment, presently ACIAR W3 funding	• Integration of technical innovations in systems approaches. • Better understanding of trade-offs and synergies in smallholder systems

AFS-CRP – Livestock	Maize-Livestock farming system analysis; sustainable intensification and diversification smallholder farmers Geography: SSA, particularly Ethiopia, Kenya, and Zimbabwe; South Asia,	• To provide expertise and knowledge in maize agronomy and maize based systems. • Dual-purpose improved maize varieties (for grain and fodder) adapted to the target geographies. • Crop residue tradeoff in mixed systems (feed or mulch)	• Integration of commodities in multi-commodity/system approach. • Synergies and tradeoffs at farm and landscape levels in mixed crop-livestock systems	Joint investment through W3/bilateral funding	• Integration of technical innovations in systems approaches. • Better understanding of trade-offs and synergies in smallholder systems • Enhanced agri-food systems analysis capability • Enhanced international public goods and relevance • Enhanced adoption and uptake of innovations
A4NH	Food system analysis & impact assessment (bio-fortified crops) Geography: tools – global; data – SSA, Asia, LAC	• Maize-specific expertise, data and studies • Co-development of methods and tools	• Shared methods, tools and data • Cross-CRP learning/communities of practice	Joint investment: Methods and tool development; impact assessment (biofortified crops) Complementary: Maize specific data and studies	• Enhanced nutritional and food system analysis capability; • Enhanced international public goods and relevance • Joint capacity building interventions in the target geographies
CCAFS	Foresight and targeting; Climate smart agriculture analysis Geography: tools – global; data – SSA, Asia, LAC	• Maize-specific expertise, data and studies (including drought/heat tolerance; conservation agriculture) • Co-development of methods and tools (including weather index insurance) • Drought and heat tolerant maize as a main approach to climate change adaptation • Improved maize agronomy practices to contribute to CC adaptation and mitigation. • High quality agronomy data for maize-based systems. • Multi-commodity approaches.	• Shared methods, tools and data • Climate change data and expertise; cross-CRP learning/communities of practice • Provide adequate CC frame for SI of maize–based systems	Joint investment: Methods and tool development (incl weather index insurance) Complementary: Maize specific data and studies (including drought/heat tolerance; conservation agriculture); abiotic and biotic stress resilient maize germplasm	• Enhanced climate smart analysis capability • Enhanced international public goods and relevance • CC adaptation and mitigation technologies assessed and scaled. • Joint policy briefs / dialogues / workshops on climate-resilient agriculture

PIM	Foresight and targeting Geography: global	• Maize-specific expertise in crop modeling, bio-economic modeling, innovation pipeline, foresight and targeting • Co-development of methods and tools • Complementary maize specific scenario analysis and foresight and ex ante studies	• Facilitate access, maintain up-to-date and enhance IMPACT model • Co-apply IMPACT model to explore supply-demand analysis of whole agricultural sectors, and for ex-ante impact assessments of technology interventions in various commodities, including maize	Joint investment: IMPACT model Complementary: Complementary methods and tools; maize specific scenarios and studies	• Effectively managed IMPACT model and use capability • Enhanced international public goods and relevance • Enhanced foresight, targeting & priority setting
	Gender analysis; impact assessment; Value chain/market analysis; rural transformation Geography: tools – global; data – SSA, Asia, LAC	• Maize-specific expertise, studies and (panel) data • Co-development of methods and tools	• Shared methods, tools and data • Cross-CRP learning/communities of practice	Joint investment: Methods and tool development; communities of practice Complementary: Maize specific data and studies	
WLE	Global, methodological	Know-how on SI of maize-based systems. Investment through partnership on SI indicators and metrics at field/farm/landscape levels	Methodological support for landscape level research	Joint but to be further developed during Phase-II	Quality and relevance of MAIZE research at landscape scale. Indicators and metrics better serving M&E&L and SRF
Genebank platform	Global, methodological	• Genotypic and phenotypic characterization of genebank accessions • Informatics tools to extract knowledge from the data. • Experience on intellectual property issues affecting the use of genetic resources.	• Expert knowledge about genetic resources and scientific partnerships. • Intellectual property issues affecting the use of genetic resources.	Joint investments	• High-value maize germplam that can potentially increase the genetic diversity in MAIZE breeding programs, for traits of interest

Genetic gains platform	Global, methodological	Validation and deployment of novel tools / technologies / methodologies in MAIZE breeding pipelines	• Enabling tools for increasing genetic gains • Integrated Breeding Platform / Breeding Management System • Developing and implementing a shared high-throughput genotyping platforms that could support mainstreaming of genomic assisted breeding strategies across crops and institutions. • Leveraging phenotyping competencies and best practices	Complementary investments, besides bilateral funding (e.g., GOBII project)	Enhanced use of novel tools, technologies and best practices in breeding programs, leading to increased genetic gains
Big Data platform	Effective management and leveraging of big data. Geography: global	• To provide clear research questions at system level requiring innovative and 'state of the art' data management. • Sharing of biophysical and socio-economic, GIS and RS data sets • Co-development of methods and tools	• Develop and implement a unified approach among CRPs to the collection, management, access and analysis of large, complex, heterogeneous data sets. (biophysical and socio-economic) • Community of practice to share knowledge, experience, approaches and tools	Joint investments	• Effectively managed Big Data capability • Enhanced international public goods • Better analytical capabilities serving foresight and targeting of technological options. • Improved open-access to systems data. • Better decision support systems and their use in ICT systems. • Improved M&E&L framework through methods for SI indicator and metrics

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.

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
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/
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 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.
Cameroon **Placeholder until meting to be held March 16th**	No meeting for site integration has been yet held in Cameroon. However I had the opportunity to attend the DRC site integration meeting organized in DRC. In DRC I discussed extensively with Manning-Thomas, Nadia (CGIAR Consortium) who was facilitating this meeting in DRC. In consultation with other CGIAR Centres (IITA, CIFOR, Bioversity) we decided to organize the Cameroon meeting on 16 March 2016. The following institutions are expected to attend this meeting: IITA, CIFOR, Bioversity, ICRAF, IRAD, AVRDC, MINFOF, MINEF, Universities of Yaounde1, IBAYSUP, CRESA. Prior to this meeting, the CGIAR centers based in Cameroon were already working together in projects such as Sentinel Landscapes. ICRAF, CIFOR and Bioversity developed joint teams and worked together on institutional mapping of a landscape, socio-economic characterization and land degradation surveillance. For ICRAF as more most of research activities are covered by FTA, Scientists focussed their activities that are linked to CRP6.1, CRP6.2, CRP6.3, CRP6.4, and CRP6.5. Data collected from this research work were analysed and used for publications of scientific papers. With IITA, ICRAF and IRAD had also worked together for the implementation of Humid Tropics program. Overall, to date, the CRPS' joint initiative in Cameroon has created an approach involving several CGIAR centres (ICRAF, CIFOR, Bioversity), as well as other national partners (like IRAD- Cameroon's Institute of Agriculture for Development) to design partnership and identity research areas and priorities necessary for the development of the rural sector in Cameroon and other countries in the Congo Basin.

	When we meet on 16 March, we will identify research priorities and development a common program to address these.
DR Congo Nzola M. Mahungu (IITA)	National consultation workshop for the integration of CGIAR centers took place in Kinshasa (Democratic Republic of Congo- DRC), February 19th, 2016. Nine CG centers (AfricaRice, CIAT, CIFOR, CIMMYT, CIP, ICRAF, IFPRI, IITA and ILRI,) operating directly or indirectly through partners participated at this workshop. The event brought together more than 60 public-private partners from DRC including the DRC civil society. CRP representatives, NARS, donors and government officials. It was indicated at the workshop that the second phase of CRP's (2017-2025) presents three innovations as compared to the first one: well-integrated portfolio, aligned with national priorities, and coordinated and transparent interaction with local stakeholders and partners. Thus, the national consultation workshop constituted the first step of the integration process and aimed to engage partnership, find synergies and learn about national priorities. During the event, participants debated DRC development challenges and priorities via panel and group discussions.. Participants referred to examples of successful collaborations in DRC and strongly recommended a creation of a national R4D platform by IITA on behalf oc CG centers in consultation with the Institut National d'Etude et Recherche Agronomiques (INERA) as government representative, Federation of farmers Cooperative as civil society representative and the chair of donors community. Other themes identified by participants were to have forge a Common vision; to clearly define AR4D priorities; to aim at Impact at scale; and a strategy on Capacity development. Next step: the R4D platform coordinated by IITA will have its first meeting on 11 March 2012, to discuss amongst other issues: I. The role of the platform in DRC R4D agenda, its evolvement to a steering committee II. The mapping of CRPs present in DRC and refining/aligning CRP II to national priorities III. Explore possibilities of complementarities in sharing IITA and INERA infrastructures wherever feasible
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, DCL, 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 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.
Ghana Olufunke Cofie (IWMI)	Although not initially depicted as 'integration', CGIAR centres that are active in Ghana have been collaborating for a long time by sharing resources and working on different projects together. Since January 2016, nine Centres (AfricaRice, Bioversity, CIAT, CIP, IFPRI, IITA, ILRI, IWMI and WorldFish) and eight CRPs (A4NH, CCAFS, DCL, Maize, RICE, WLE, RTB, PIM) have been involved in the Ghana Site integration process. First, the Steering Committee (SC) was constituted by official nominations from the Centres/CRPS. Several virtual and face-to-face meetings were held prior to the national consultation workshop which took place from 2-3 March 2016 in Accra. Other preliminary activities carried out by the SC were: (i) mapping of Centre/CRP project locations, thematic focus, target commodities and partnerships in Ghana; (ii) Review of relevant national policy documents as well as donors' priorities for Ghana; and (iii) engagement with and sensitization of local partners on the Site Integration Process. From the mapping and review exercise, the SC identified potential thematic areas for CGIAR collaboration in Ghana. Two key national partners of the CGIAR in Ghana are the Ministry of Food and Agriculture (MoFA) and the Council for Scientific and Industrial Research (CSIR). These two institutions co-organized the National Consultation workshop with the Centres/CRPs. Over 60 people from different stakeholder categories participated in the event. The workshop revealed how the integrated efforts of the CGIAR Centres can actually complement national priorities and those of other partners, towards agricultural transformation in Ghana. Following MoFA's presentation on the national priorities for driving Ghana's Shared Growth and Development Objectives, the participants identified and discussed key themes that could be the CGIAR strategic focus in Ghana. The themes identified were consistent with the preliminary findings from the review done by the SC. The workshop participants also suggested ways of working effectively together (internal integration) and with local partners (external integration). The workshop further provided insight on tracking the progress and impact of the integrations as well as the coordination mechanism to sustain the Site Integration Process. Next steps are: (i) finalise the site integration plan with the information gathered during the workshop; (ii) engage in regular consultation and exchange with the national partners through their representation in the steering committee and (iii) sharing information at national platforms. The SC agreed that sharing of information, as well as collaboration in joint activities and resource mobilisation is paramount to strengthen our integration. Collaboration will commence on the identified themes and with a joint visit to the National Development Planning Commission of Ghana.
India	MAIZE FP3, FP5 and CoA 2.1 were flagged to be of high priority. Alignment with national priorities. In addition to the on going programmes the following points are identified:

	Stress resilient maize germplasm enhancement both for biotic and abiotic stresses. Abiotic: Drought, heat, water logging Biotic: Site specific priorities to be identified. However, BLSB and PFSR are emerging priorities. There is a need for conducting dedicated trials under rain fed conditions particularly in targeted areas such as Rajasthan, Gujarat, MP, Peninsular zone, Bihar, Orissa, HP, JK, Uttarakhand. Development of DH facility and implementation of DH technology for enhanced genetic improvement Trials under various CA and management regimes (G x E x M interaction) to identify suitable hybrids Value addition of existing hybrids (through QPM, dual purpose maize, etc.) for doubling the profitability to farmer Hub for data management which includes deployment and support for BMS Consider the rising importance of maize for food and industrial use (including specialty maize) in light of improving profitability Aflatoxin management needs to be considered. Creating community driers for farmer benefit in Eastern India. Mechanization of maize breeding. Opportunities for Integration SAU/ICAR/CIMMYT collaborative trials with common set of entries Sharing available research and phenotyping facilities with various MAIZE partners at MP, Gujarat, Rajasthan, Maharashtra, CIMMYT-Hyderabad, and BISA. Other facilities and partners in target areas across the country to be identified. Capacity building for DH, precision phenotyping, data management, genomics, etc.

Kenya	Opportunities for enhanced CGIAR – Kenya Partnership
	● Utilize a farming system approach in target areas
	● Link agriculture, income, nutrition and climate change
	● Sustainable intensification and soil health
	● BIG Data initiatives to support agriculture decision making
	● Capacity strengthening at MSc, PhD and on the job training
	    ● Adopt agroforestry interventions for climate change adaptation and mitigation
	    ● Adopt crop-tree systems for better integration and soil fertility management

	• Develop and adopt sound crop-livestock and small mechanization systems • Adopt farming system-nutrition-themed interventions CGIAR integration in Kenya • Sharing facilities at common test sites (benchmark sites, common IPs, stress screening facilities etc.) • Facilitate networking and continuity in research. • Adopt collaborative research projects with Kenya NARs. • Develop national Integrated data management systems (store, manage and share) data. • Integrate the 'soft' sciences and pay more attention to the impact of CG actions on gender, livelihoods, climate change, and environmental sustainability. • Provide holistic packages vs components to farmers.
Malawi	TBD
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 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.
Mozambique	TBD
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 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 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.
Niger	TBD
Nigeria	The Consultative Group on International Agricultural Research (CGIAR) conducts research on various issues through 15 centers distributed in different countries across the world. National research institutes and other development agencies also work on related aspects of agricultural value chains alongside the CGIAR initiatives. Due to lack of, or

	weak mechanisms to harmonize the operations of these multiple partners, there is a possibility for duplication of efforts and resource wastage especially where several institutions are conducting similar research in isolation in a given site. In order to address the above challenge, the CGIAR and development partners mandated the International Institute of Tropical Agriculture (IITA) to lead a process of integrating research activities and sites in Nigeria, one of the 20 selected countries for site integration in the world. Towards this effort, a national consultation workshop for Nigeria was held in Abuja Nigeria on 16th and 17th November 2015. The workshop focused on: Understanding Nigeria's agricultural research and development strategy; Mapping the CGIAR activities and sites in the country; Developing a common understanding of integration and key principles to be considered; Identifying the roles of various stakeholders in the integration process and; Developing a framework for integration. The main outcomes of the workshop were: • Elements of integration: Participants agreed that effective integration must entail pursuit of common goals, joint action plans, collaboration, inclusiveness, co-ownership and communication. • Integration principles: When selecting sites and issues, consideration must be given to opportunities for value addition on the collaboration and alignment with major issues. To effectively integrate work, there must be local ownership, institutional commitment at the highest level and open dialogue. • Harmonizing focus: There is need to harmonize Consortium Research Program (CRP) thematic focus with priority ARD challenges in Nigeria, while building synergies on the on-going major initiatives such as the agricultural transformation agenda for productivity and sustainability. • Operationalizing the integration: Implementation of an integrated approach requires the understanding of key challenges, guiding principles and specific steps on six important issues – project development, resource mobilization, partnerships, coordination, monitoring and evaluation, and communication. • Integration framework: A comprehensive integration plan must comprise stakeholder consultations to identify the issue/problem, sites and partners. It must also specify the steps for project development and implementation. • Lessons for future planning: The national consultation workshop in Nigeria offered important insights on the need for stakeholder inclusion; collaboration among government entities and CGIAR Centers; understanding national strategies and; scheduling of integration meetings to provide adequate time for discussions and synchronizing such meetings with government calendars to ensure effective government presence and participation so as to create local ownership of the outcomes.
Rwanda Kirimi Sindi (CIP)	The Rwanda CGIAR country collaboration and site integration process is coordinated by a committee of six individuals representing 4 centres. The Rwanda based CGIAR Centres are CIP, CIAT, IITA, and ICRAF. Each centre has one or two individuals as part of the steering committee. The centres have held 4 site integration meetings so far. One was with three main donors represented in Rwanda (USAID, EU, and DFID). The committee is working on mapping all on-going

	projects in Rwanda by the different centres and CRPS. This will be put on a map of Rwanda to assist all the centres understand areas where they is there is potential for synergy in working together. The map will assist the CG centres in communicating the contribution they are having to the donors and government policy makers and speak as one voice. The committee under the leadership of CIP will organized a CGIAR site integration workshop in Kigali on 29th March, 2016. This workshop will bring together an estimated 75 representative of donors, government agencies, other development organizations, civil societies, and financial institutions. There has been an already established forum R4D by Humid and Tropics that brings together all the CGIAR centres, policy makers, and other implementing partners in working together in an integrated manner. The site integration committee has resolved to build on this already on going forum and expand it further to achieve the CGIAR site integration goals. **Next steps:** • We will be setting up a full secretariat to assist in organising the workshop and all the invited participant will get invitation letters by 11th March, 2016. • Next review meeting will be on 18th March, 2016 to review the plans and progress for the workshop preparations • The main workshop meeting to be held on 29th, March 2016. This meeting will gather stakeholders views and then utilizing the recommendation to work on the site integration plan that will be finalized by end of April, 2016. • We will be posting all the minutes to the CG sites in the next two weeks.
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 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 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.

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 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.

3.8 Staffing of management team and flagship projects

Prasanna BODDUPALLI

MAIZE Director; Chair of MAIZE-Management Committee; FP3 Co-leader; CoA 3.2 Co-leader

Time commitment: 100%

Expertise

- As Director of Global Maize Program of CIMMYT, leading a multi-disciplinary team of 45+ scientists located in sub-Saharan Africa, Latin America and Asia, since March 2010; Technical oversight for CIMMYT and Chair/Member of Steering Committees for more than 10 bilateral projects, including DTMA/STMA, IMAS, WEMA, DH-Africa, HTMA, AAA, MasAgro-Maize, etc.
- Established the state-of-the-art maize doubled haploid (DH) facility at Kiboko (Kenya), in partnership with Kenya Agriculture & Livestock Research Organization (KALRO) in 2013; the facility offers maize DH line development service to the breeding programs of CIMMYT, IITA, NARES and SMEs in Africa.
- Since 2012, effectively coordinated the rapid response to the Maize Lethal Necrosis (MLN) in eastern Africa, including establishment of a centralized MLN Screening facility at KALRO-Naivasha (Kenya), in addition to breeding for MLN resistance, and MLN management, through extensive public-private partnerships.
- Formulated and successfully led several multi-institutional and multi-disciplinary projects on maize R4D in India, while serving the Indian Council of Agricultural Research (ICAR); served as AMBIONET (Asian Maize Biotechnology Network) Team Leader for India (1998-2005), and initiated research for the first time on molecular breeding for maize improvement in India.

Employment including current position

- 06/2015 to date: Director, CRP MAIZE; 06/2011 to date: Member of MAIZE Management Committee, and Leader for MAIZE Phase-I FP3 (Stress tolerant and nutritious maize) & FP4 (Strengthening maize seed systems).
- 03/2010 to date: Director, Global Maize Program, CIMMYT.
- 04/1991 to 03/2010: Served ICAR in various capacities, including as National Fellow & Leader of Maize Program, Indian Agricultural Research Institute, New Delhi, India (01/2005 to 03/2010); Maize Geneticist & Faculty Member, Division of Genetics, ICAR-IARI, New Delhi, India (04/1991 to 03/2010).

Education

- Ph.D. in Genetics, ICAR-Indian Agricultural Research Institute, India, 1991
- M.Sc. in Genetics, ICAR-Indian Agricultural Research Institute, India, 1987

Selected Recent Publications

Chaikam V, Martinez L, Melchinger A, Schipprack W, **Prasanna BM** (2016) Development and validation of red root marker-based haploid inducers in maize. *Crop Science* [doi: 10.2135/cropsci2015.10.0653].

Gowda M, Das B, Makumbi D, Babu R, Semagn KF; Mahuku G, Olsen MS, Bright JM, Beyene Y, **Prasanna BM** (2015) Genome-wide association and genomic prediction of resistance to maize lethal necrosis disease in tropical maize germplasm. *Theoretical and Applied Genetics* 128:1957–1968.

Nair S, Babu R, Magorokosho C, Mahuku G, Semagn K, Beyene Y, Das B, Makumbi D, Kumar L, Olsen M, **Prasanna BM** (2015) Fine mapping of *Msv1*, a major QTL for resistance to Maize Streak Virus leads to development of production markers for breeding pipelines. *Theoretical and Applied Genetics* 128: 839-1854.

Shiferaw B, Tesfaye K, Kassie M, Abate T, **Prasanna BM**, Menkir A (2014) Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: technological, institutional and policy options. *Weather and Climate Extremes* 3: 67-79.

Cairns JE, Hellin J, Sonder K, , Araus JL, MacRobert J, **Prasanna BM** (2013) Adapting maize to climate change in sub-Saharan Africa. *Food Security* 5: 345-360.

Prasanna BM, Chaikam V, Mahuku G (2012) *Doubled Haploid Technology in Maize Breeding: Theory and Practice.* Mexico D.F.: CIMMYT. 50 pp.

Olaf ERENSTEIN

MAIZE-Management Committee Member & FP1 Co-leader

Time commitment: 50%

Expertise

- Program director of a team of 30+ internationally recruited scientists located in sub-Saharan Africa, Latin America and Asia. The team's research-for-development (R4D) aims to help prioritize, target, understand and enhance wheat and maize interventions for greatest impact and social inclusiveness.
- Since 2013 involved in the CRP's Management Committee.
- Research has focused on R&D implications based on agricultural system and innovation analysis in developing countries, particularly in cereal based systems (maize, wheat, rice).

Employment including current position

- 2013 – to date: Director Socio-economics Program, CIMMYT, Mexico (initially Ethiopia)
- 2009-2012: Senior Ag-economist, CIMMYT, Ethiopia
- 2004-2009: Agro-economist, CIMMYT, India
- 2000-2004: Production economist, Africa Rice Centre (WARDA/ADRAO), Côte d'Ivoire/Mali

Education

- Ph.D. Agricultural Economics, Wageningen University, the Netherlands, 1999
- M.Sc. Agricultural Economics & M.Sc. Tropical Crop Science, Wageningen Ag. University (NL), 1990

Selected Recent Peer-reviewed Publications

Erenstein, O, Gérard, B., and Tittonell, P. (eds.) 2015. Special Issue: Biomass use trade-offs in cereal cropping systems: Lessons and implications from the developing world. Agricultural Systems 134: 1-128.

Krishna, V.V., **Erenstein, O**., Sadashivappa, P., Vivek, B.S. 2014. Potential Economic Impact of Biofortified Maize in the Indian Poultry Sector. International Food and Agribusiness Management Review 17: 109-138.

Kassie, G.T., **Erenstein, O**., Mwangi, W., MacRobert, J., Setimela, P. & Shiferaw, B. (2013). Political and economic features of the maize seed industry in southern Africa. Agrekon, 52(2), 104-127.

Grings, E., **Erenstein, O**., Blümmel, M. (Eds). 2013 Special Issue: Dual-purpose maize. Field Crops Research, 153, 1-112.

Erenstein, O., Sayre, K., Wall, P., Hellin, J., Dixon, J. 2012. Conservation agriculture in maize and wheat based systems in the (sub)tropics: Lessons from adaptation initiatives in South Asia, Mexico and Southern Africa. Journal of Sustainable Agriculture 36(2): 180-206.

Tahirou ABDOULAYE

FP1 Co-leader, CoA 1.4 and 5.4 Co-leader

Time commitment: 50%

Expertise

- Have been involved in evaluation and impact assessment of several projects mainly in West Africa. Research work covers a wide range of rural economic issues including seed systems, farm-level efficiency and also technology evaluation and transfer. More recent research focus on post-harvest losses, innovation systems and value chains and how these can help increase technology uptake by small farmers.
- Led the socioeconomic component of Drought Tolerant Maize for Africa (DTMA) project (CIMMYT-IITA) in West Africa since 2009.
- Coordinator of the Purdue Improved Crop Storage (PICS) project (Sub grant) aimed at promoting hermetic grain storage in West Africa.
- Currently project leader for the PICS3 project working Nigeria and Ghana. This latest phase of the project has reached 1,500 villages in Nigeria and another 1000 villages in Ghana with hermetic storage technology focusing on maize.
- Principal investigator of the Cassava Monitoring Survey (CMS) project aimed at documenting use of improved cassava varieties in Nigeria with the use of fingerprinting for identification.

Employment

- 2007-present Project coordinator and Impact economist, IITA, Nigeria
- 2006-2007 Research fellow with JIRCAS at the Sahelian center of ICRISAT, Niamey
- 2004-2006 Economist, INRAN, Niger
- 1997-2004 Graduate Research assistant and Professional research associate, Purdue University, USA.
- 1994-1995 Graduate research assistant, Purdue University USA
- 1989-1994 Economist at INRAN, Niamey, Niger

Education

- 2002 PhD, Agricultural Economics, Purdue University, USA
- 1995 MSc, Agricultural Economics, Purdue University, USA

Selected Recent Peer-reviewed Publications

Bola Amoke Awotide, Arega D. Alene, **Tahirou Abdoulaye** and Victor M. Manyong, 2015. Impact of agricultural technology adoption on asset ownership: the case of improved cassava varieties in Nigeria. Food Sec. (2015) 7:1239–1258

Abdoulaye T., Abass A., Maziya-Dixon B., Tarawali G., Okechukwu R., Rusike J., Alene A., Manyong V. and Ayedun B, 2014. Awareness and use of improved cassava varieties and processing Technologies. Journal of Development and Agricultural Economics, 6(2), 67- 75.

Bokar Moussa, **Tahirou Abdoulaye**, Ousmane Coulibaly, Dieudonné Baributsa, J. Lowenberg-Deboer, 2014. Adoption of on-farm hermetic storage for cowpea in West and Central Africa in 2012. Journal of Stored Products Research, 58: 77-86.

Dieudonné Baributsa, **Tahirou Abdoulaye**, Jess Lowenberg-DeBoer, Clémentine Dabiré, Bokar Moussa, Ousmane Coulibaly, Ibrahim Baoua. 2014. Market building for post-harvest technology through large-scale extension efforts, Journal of Stored Products Research, 58: 59-66.

Genti Kostandini, Roberto La Rovere, **Tahirou Abdoulaye**. 2013. Potential impacts of increasing average yields and reducing maize yield variability in Africa. Food Policy, 43: 213–226.

Justice Akpene Tambo and **Tahirou Abdoulaye**. 2013. Smallholder farmers' perceptions of and adaptations to climate change in the Nigerian savanna" Regional Environmental Change 13: 375-388.

Kevin PIXLEY

MAIZE-Management Committee Member & FP2 Co-leader

Time commitment: 50%

Expertise

- As Director of Genetic Resources Program of CIMMYT, Provide strategic and administrative leadership for a team of scientists to conserve, and to apply a wide range of genetic and bioinformatics tools to effectively use, genetic diversity of maize and wheat.
- As Associate Professor of Agronomy at the University of Wisconsin: Teach undergraduate and graduate students in agronomy and the College of Agriculture and Life Sciences. Lead the oat breeding program with emphasis on cultivar development while developing opportunities for graduate student research projects
- As Associate Director & Maize Breeder, Maize Program, CIMMYT: develop the research agenda and strategies for CIMMYT Global Maize Program's Projects in Asia and Latin America, and on nutritionally enhanced maize.
- Maize Crop Leader, HarvestPlus Challenge Program (June 2003-2012): Coordinate and lead efforts of a global network of scientists seeking to enhance nutritional value of maize, with particular attention to provitamins A. Lead a maize breeding program to develop maize with enhanced nutritional value for provitamin A and zinc.
- Developed and provided disease resistant inbred lines currently used by private and public sector programs in Africa. Partnered with biotechnologist to investigate use of marker-assisted selection for MSV resistance. Led research guiding students to investigate inheritance and methodology for weevil resistance breeding in maize.
- Published 50 research papers on genetics, breeding and nutrition in refereed international journals of repute.
- Supervised as major advisor 6 PhD, 6 M.Sc (or M.Phil.) and 12 B.Sc. students in plant breeding.

Employment including current position

- 07/2011 to date: Director, Genetic Resources Program, CIMMYT. Co-leader of CRP MAIZE FP2. Project Leader of MasAgro Biodiversidad.
- 09/2009 to 06/2001: Associate Professor of Agronomy, University of Wisconsin, Madison, WI, USA.
- 01/1990 to 09/2009: Maize Breeder, CIMMYT. Held various positions including Program Director, Associate Program Director, Team Leader and Regional Representative for CIMMYT in Zimbabwe/Southern Africa.

Education

- Ph.D. in Plant Breeding, Iowa State University, 1990
- M.Sc. in Crop Physiology, University of Florida, 1985

Selected Recent Publications

Gannon, B., C. Kaliwile, S.A. Arscott, S. Schmaelzle, J. Chileshe, N. Kalungwana, M. Mosonda, **K. Pixley**, C. Masi and S.A. Tanumihardjo. 2014. Biofortified orange maize is as efficacious as a vitamin A supplement in Zambian children even in the presence of high liver reserves of vitamin A: a community-based, randomized placebo-controlled trial. Am. J. Clin. Nutr. 100:1541-50.

Suwarno, W.B., **K.V. Pixley**, N. Palacios-Rojas, S.M. Kaeppler and R. Babu. 2014. Formation of heterotic groups and understanding genetic effects in a provitamin A biofortified maize breeding program. Crop Sci. 54:14-24.

Kandianis, C.B., R. Stevens, W. Liu, N. Palacios, K. Montgomery, **K. Pixley**, W.S. White and T. Rocheford. 2013. Genetic architecture controlling variation in grain carotenoid composition and concentrations in two maize populations. Theor. Appl. Genet. 126:2879-2895.

Babu, R., N. Palacios Rojas, S. Gao, J. Yan and K. Pixley. 2013. Validation of the effects of molecular marker polymorphisms in LcyE and CrtRB1 on provitamin A concentrations for 26 tropical maize populations. Theor. Appl. Gen. 126:389-399.

Pixley, K.V., N. Palacios-Rojas and R.P. Glahn. 2011. The usefulness of iron bioavailability as a target trait for breeding maize (Zea mays L.) with enhanced nutritional value. Field Crops Res. 123:153-160.

Warburton, M.L., P. Setimela, J. Franco, H. Cordova, **K. Pixley**, M. Banziger, S. Dreisigacker, C. Bedoya and J. MacRobert. 2010. Toward a cost-effective fingerprinting methodology to distinguish maize open pollinated varieties. Crop Sci. 50:467-477.

Abebe MENKIR

MAIZE-Management Committee Member; FP2 & FP3 Co-leader

Time commitment: 75%

Expertise

- Maize breeder-geneticist at IITA since 1996.
- Team leader for maize improvement research at IITA since 2001.
- Collaborated with the national agricultural research systems, advanced research institutes, private seed companies, NGOs and CBOs for many years
- Member of the Research Committee of a regional maize network for eight years and as an elected coordinator of the IITA multidisciplinary project on maize-grain legume production systems for three years
- One of the principal investigators of 24 successful projects
- Supervised/guided 15 PhD and 11 MSc students
- Co-editor of 3 books and author or co-author of 137 journal articles, 20 edited book chapters, and 4 monographs
- Received 2015 Crop Science of America Fellow and other awards for his contributions to maize improvement research and product delivery

Education:

- PhD in Plant breeding, Kansas State University, USA in 1993
- MSc in Plant breeding, University of Manitoba, Canada in 1984

Selected Recent Publications

Adebayo, M. A., **Menkir, A.** 2015. Combining ability of adapted and exotic drought-tolerant maize inbred lines under full irrigation and rainfed conditions in Nigeria. Journal of Crop Improvement 29:117-130.

Menkir, A., Rocheford, T., Maziya-Dixon, B., Tanumihardjo, S. 2015. Exploiting natural variation in exotic germplasm for increasing provitamin-A carotenoids in tropical maize. Euphytica 205: 203-217.

Menkir, A., Gedil, M., Tanumihardjo, S. A., Adepoju, A. and Bossey, B. 2014. Carotenoid accumulation and agronomic performanca of maize hybrids involving parental combinations from different marker-based groups. Food Chemistry 148:131-137.

Brown, R., **Menkir, A**., Chen, Z., Bhatnagar, D., Yu, J., Yao, H., Cleveland, T. 2013. Breeding aflatoxin-resistant maize lines using recent advances in technologies - a review. Food Additives and Contaminants: Part A. 30(8):1382-1391.

Abebe Menkir, Dan Makumbi, and Jorge Franco. 2012. Assessment of reaction patterns of hybrids to *Striga hermonthica* (Del.) Benth under artificial infestation in Kenya and Nigeria. Crop Science 52:2528–2537.

Bruno GERARD

MAIZE-Management Committee Member; FP4 Co-leader

Time commitment: 50%

Expertise

- Sustainable Intensification Flagship leader of MAIZE Phase-I
- Research leadership in CIMMYT: team of 42 internationally recruited scientists
- Coordination of multi-center research under CGIAR system-wide initiative (SLP)
- Research interests in geospatial topics, land use, soil fertility and resource management at farm and landscape levels, multi-disciplinary approaches

Employment including current position

- September 2011 – Present: Director, Sustainable Intensification Program, International Maize and Wheat Improvement Center (CIMMYT), Mexico
- September 2008 - August 2011: System-wide Livestock (SLP) Program coordinator, International Livestock Research Institute (ILRI), Ethiopia
- September 2005 - August 2008: Visiting Scientist seconded from ICRISAT to Université Catholique de Louvain, Belgium
- January 2000 - August 2005: Principal Scientist International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niger

Education

- Ph.D. from the Plant Nutrition department at the University of Hohenheim (2000)
- MSc in Irrigation Engineering, Utah State University, USA (1990)

Selected Recent Peer-reviewed publications:

Akponikpè, P.B.I., Minet, J., **Gérard, B**., Defourny, P., Bielders, C.L., 2011. Spatial fields' dispersion as a farmer strategy to reduce agro-climatic risk at the household level in pearl millet-based systems in the Sahel: A modeling perspective. Agric. For. Meteorol. 151: 215–227.

Bielders, C.L., **Gérard, B**., 2015. Millet response to microdose fertilization in south–western Niger: Effect of antecedent fertility management and environmental factors. Field Crops Res. 171: 165–175.

Mekasha, A., **Gérard, B**., Tesfaye, K., Nigatu, L., Duncan, A.J., 2014. Inter-connection between land use/land cover change and herders'/farmers' livestock feed resource management strategies: A case study from three Ethiopian eco-environments. Agric. Ecosyst. Environ. 188: 150–162.

Powlson, D.S., Stirling, C.M., Jat, M.L., **Gérard, B.G**., Palm, C.A., Sanchez, P.A., Cassman, K.G., 2014. Limited potential of no-till agriculture for climate change mitigation. Nature Climate Change 4: 678–683.

Tittonell, P., **Gérard, B**., Erenstein, O., 2015. Tradeoffs around crop residue biomass in smallholder crop-livestock systems–What's next? Agric. Syst. 134: 119–128.

Valbuena, D., Erenstein, O., Tui, S.H.-K., Abdoulaye, T., Claessens, L., Duncan, A.J., **Gérard, B**., Rufino, M.C., Teufel, N., Rooyen, A. van, Wijk, M.T. van, 2012. Conservation Agriculture in mixed crop–livestock systems: Scoping crop residue trade-offs in Sub-Saharan Africa and South Asia. Field Crops Res. 175–184.

Vanlauwe, B., Wendt, J., Giller, K.E., Corbeels, M., **Gérard, B**., Nolte, C., 2014. A fourth principle is required to define Conservation Agriculture in sub-Saharan Africa: The appropriate use of fertilizer to enhance crop productivity. Field Crops Res. 155: 10–13.

David CHIKOYE

MAIZE-Management Committee Member; CoA 4.3 Co-leader

Time commitment: 20%

Expertise

- David's professional background is research on weed management in the tropics.
- His main research interests include assessing the response of weed seedbanks to control options and promoting the uptake of improved weed, crop and natural resource management options by farmers
- David has trained many postgraduate students and has contributed to authoring over 100 refereed journal articles and conference abstracts or proceedings.

Employment including current position

- Present: Director of the Regional Hub for southern Africa and Plant Production and Health Management at the International Institute of Tropical Agriculture (IITA, Nigeria)
- Postdoctoral fellow at the University of Guelph and lecturer at the University of Zambia

Education

- Ph.D. from the University of Guelph, Canada.
- MSc from the University of Manitoba, Canada
- BSc from the University of Zambia, Zambia

Selected Recent Publications

Chikoye, D., Ekeleme, F., Lum, A.F., Udensi, U.E. 2014. Competition between *Imperata cylindrica* and maize in the forest savannah transition zone of Nigeria. Weed Research, 59:285-292.

Fontem, L.A., Chikoye, D. 2012. Efficacy of herbicide formulations for weed control in maize in a humid tropical environment. Journal of Food Agriculture and Environment, 10(3&4):1572-1574.

Chikoye, D., Fontem, L.A., Menkir, A. 2011. Seed coating herbicide tolerant maize hybrids with imazapyr for *Striga hermonthica* (Del.) Benth control in the West African savanna. Journal of Food Agriculture and Environment, 9(1):416-421.

Menkir, A., **Chikoye, D.** and Fontem Lum, A. 2010. Incorporating an herbicide resistance gene into tropical maize with inherent polygenic resistance to control *Striga hermonthica* (Del.) Benth. Plant Breeding, 129(4):385-392.

Bernard VANLAUWE

FP4 Co-leader

Time commitment: 25%

Expertise

- Joined IITA in Kenya in March 2012 to lead the Central Africa hub and the Natural Resource Management research area. In this capacity, also has an oversight role in the Humidtropics, the Water, Land, and Ecosystems, and the CCAFS CGIAR Research Programs. In 2016, started engaging in the MAIZE CRP.
- Prior to this recent appointment, Bernard was the leader of the Integrated Soil Fertility Management (ISFM) program of the Tropical Soil Biology and Fertility research area of CIAT (TSBF-CIAT). He joined CIAT-TSBF in 2001 and led the development, adaptation, and dissemination of best ISFM options in various agro-ecological zones in sub-Saharan Africa.
- In September 2010, the obtained a Visiting Professor position at the Swedish Agricultural University in Uppsala in the Soils and Environment Department. Before, he worked at IITA in Nigeria (1991 – 2000) and the Catholic University of Leuven, Belgium (1989-1991), focusing on unraveling the mechanisms underlying nutrient and soil organic matter dynamics in tropical agro-ecosystems. In that context, he obtained his PhD in 1996 in Applied Biological Sciences.
- Published over 150 papers in scientific journals and over 160 in other forms and has (co-) supervised over 40 PhD and over 60 MSc students.

Employment including current position

- 2012 – today: Director, Central Africa and Natural Resource Management, International Institute of Tropical Agriculture (IITA), Nairobi, Kenya
- 2010 – today: Guest Professor, Sveriges Lantbruksuniversitet (Swedisch Agricultural University), Sweden
- 2003 – 2012: Senior Scientist and Principal Scientist, Tropical Soil Biology and Fertility Institute of the International Centre for Tropical Agriculture (TSBF-CIAT), Nairobi, Kenya
- 2001 – 2003: Integrated Soil Fertility Management Officer, Tropical Soil Biology and Fertility Programme (TSBF) of UNESO, Nairobi, Kenya
- 1991 – 2001: Junior Expert, Associate Expert, and Associate Scientist, IITA, Ibadan, Nigeria
- 1989-1991: Research Associate, Catholic University of Leuven, Belgium

Education

- PhD, Applied Biological Sciences, Katholieke Universiteit Leuven, Belgium, 1996

Selected Recent Publications

Vanlauwe B, Wendt J, Giller KE, Corbeels M, Gerard B, Nolte C, 2014, A fourth principle is required to define conservation agriculture in sub-Saharan Africa: the appropriate use of fertilizer to enhance crop productivity. Field Crops Research 155: 10-13.

Vanlauwe B, Coyne D, Gockowski J, Hauser S, Huising J, Masso C, Nziguheba G, Van Asten P 2014 Sustainable intensification and the smallholder African farmer Current Opinion in Environmental Sustainability 8: 15-22.

Vanlauwe B, K Descheemaeker, K E Giller, J Huising, R Merckx, G Nziguheba, J Wendt, and S Zingore 2015 Integrated Soil Fertility Management in sub-Saharan Africa: Unravelling local adaptation. Soil 1: 491-508.

Vanlauwe B, Six J, Sanginga N, Adesina, AA 2015 Soil fertility declines at the base of rural poverty in sub-Saharan Africa. Nature Plants 1: 1.

Ronner E, A.C. Franke, **B. Vanlauwe**, M. Dianda, E. Edeh, B. Ukem, A. Bala, J. van Heerwaarden, K.E. Giller 2016 Understanding variability in soybean yield and response to P-fertilizer and rhizobium inoculants on farmers' fields in northern Nigeria. Field Crop Research 186: 133-145.

Giller KE, Andersson JA, Corbeels M, Kirkegaard J, Mortensen D, Erenstein O, and **Vanlauwe B**. 2015. Beyond Conservation Agriculture. Frontiers in Plant Science 6: 1-14.

Vincenzo FOGLIANO

CoA 5.2 Co-leader

Time commitment: 20%

Expertise

- Fields of expertise include food design, thermal treatment, and food bioactives. During his professional career, Vincenzo has had the opportunity to investigate many aspects related to food processing, human nutrition and medical science related to bioactive food compounds. He has worked on the design of functional foods containing dietary fiber, proteins and phytochemicals from different sources in collaboration with many food industries.
- Vincenzo investigated chemical analytical and physiological aspects of the Maillard Reaction with the consequent formation of beneficial and detrimental bioactive products. He also developed an original research line connecting food science and phytochemicals, and their health effects, particularly inflammation and cancer.
- Vincenzo has acted as a consulting expert for some of the main Italian and international food companies. He was coordinator of FP7 EU projects, COST action and strategic national cluster Italian projects, and was a partner in several EU projects since 1998 (FP4). He was president of the International Maillard Reaction Society up to 2012, and member of the advisory board of ILSI Europe as well as of the editorial board of leading food science journals.
- Vencenzo guided 14 Ph.D. students, some of whom now occupy leading positions in academia and the food industry, and is presently supervising 18 Ph.D. students. Authored more than 250 papers published in peer-reviewed international journals with 6000 citations and an h-index of 46. He is cited in the ISI Thompson list of the World's Highly Cited Scientists (www.highlycited.com). Food science with background in chemistry and biochemistry.

Employment including current position

- Professor of Functional Food at the Master degree in Food and Health. Chairman of the degree in Food and Health from 2006 to 2008.
- Professor of Food Chemistry at the Master of Science in Food Science and Technology and the Master of Science in Food and Health
- Director of CRIAcq the center of Aquaculture of the University of Naples "Federico II"
- Full Professor and Chair of the Food Quality and Design Group University Wageningen

Education

- PhD in Food Science, Corvinus University of Budapest
- Master of Science in Chemistry at the University of Rome "La Sapienza".

Selected Recent Peer-reviewed publications

Vitaglione P, Napolitano A, **Fogliano V.** 2008. Cereal dietary fibre as natural functional ingredient to deliver phenolic compounds into the gut. Trends in Food Science and Technology 19: 451-463.

Gokmen V., Serpen A., **Fogliano V.** 2009. Direct measurement of the total antioxidant capacity of foods: the 'QUENCHER' approach. Trends in Food Science and Technology 20: 278-288.

Morales FJ, Somoza V., **Fogliano V.** 2012. Physiological Relevance of Dietary Melanoidins. Amino Acid Journal, Amino Acids 42: 1097-1090.

Troise AD, **Fogliano V.** 2013. Reactants encapsulation and Maillard Reaction. Trends in Food Science & Technology 33: 63–74.

Buono S, Langellotti AL, Martello A, Rinna F, **Fogliano V.** 2014. Functional ingredients from microalgae. Food Funct. 5: 1669–1685.

Anita LINNEMANN

FP5 Co-leader, CoA 5.2 Co-leader

Time commitment: 20%

Expertise

- Anita's expertise is to develop food technological solutions as a means to enhance nutrition security in developing countries, in particular at the bottom-of-the-pyramid in sub-Saharan Africa. For this purpose she applies a consumer-oriented perspective in combination with local food resources and tailor-made food technological practices. Furthermore, she takes the entire food production chain into account to ensure that the food system operates as effective and efficient as possible.
- Anita's work in education and research is characterized by an inter- and transdisciplinary approach and the integration of natural and social sciences. To date, 12 PhD students have graduated under her supervision.

Employment

- Since 1995: Scientific staff member at the Food Quality and Design group of Wageningen University, the Netherlands

Education

- 1994: PhD degree in Tropical Crop Science, Wageningen University, the Netherlands
- 1985: A double MSc degree in Tropical Crop Science and Food Technology, Wageningen University, the Netherlands

Selected Publications

Carvajal-Larenas, F.E.; M. Koziol; **A.R. Linnemann**; M.J.R. Nout and M.A.J.S. van Boekel, 2015. Consumer liking, purchase intent, and willingness to pay for Lupinus mutabilis Sweet in relation to debittering treatments. Food Quality and Preference 40 (part A): 221-229.

Chadare, F.J.; **A.R. Linnemann**; J.D. Hounhouigan; M.J.R. Nout and M.A.J.S. van Boekel, 2009. Baobab food products: a review on their composition and nutritional value. Critical Reviews in Food Science and Nutrition 49(3): 254-274.

Dahiya, P.K.; **A.R. Linnemann**; M.J.R. Nout, M.A.J.S. van Boekel, N.K. Khetarpaul and R.B. Grewal, 2014. Consumption habits and innovation potential of mung bean foods in Hisar District of Haryana State, India. Ecology of Food and Nutrition 53 (2): 171-192.

Hounhouigan, M.H.; P.T.M. Ingenbleek; I.A. Lans; H.C.M. van Trijp and **A.R. Linnemann**, 2014. The adaptability of marketing systems to interventions in developing countries: evidence from the pineapple system in Benin. Journal of Public Policy & Marketing 33 (2): 159-172.

Linnemann, A.R.; E.M.T. Hendrix; R.K. Apaiah and M.A.J.S. van Boekel, 2015. Food chain design using multi criteria decision making, an approach to complex design issues. NJAS Wageningen Journal of Life Sciences 72-73: 13 - 21.

Madode, Y.E.; M.J.R. Nout; E.J. Bakker; **A.R. Linnemann**; D.J. Hounhouigan and M.A.J.S. van Boekel, 2013. Enhancing the digestibility of cowpea (Vigna unguiculata) by traditional processing and fermentation. Food Science and Technology = Lebensmittel-Wissenschaft und Technologie 54 (1): 186-193.

Mpofu, A.; **A.R. Linnemann**; W. Sybesma; R. Kort; M.J.R. Nout and E.J. Smid, 2014. Development of a locally sustainable functional food based on mutandabota, a traditional food in southern Africa. Journal of Dairy Science 97 (5): 2591 - 2599.

Bussie MAZIYA-DIXON

FP5 Co-leader, CoA 3.3, 5.1, 5.2, and 5.3 Co-leader

Time commitment: 50%

Expertise

- As Leader of the Agriculture for Nutrition CRP of IITA, coordinating a multi-disciplinary team of scientists located in West, East, Central, and Southern Africa, since January 2012; Head, Food and Nutrition Sciences Laboratory, and Senior Scientist responsible for research in food technology and nutrition
- Developed and/or contributed to project proposals for research on maize quality, processing and utilization
- As Head of the Food and Nutrition Sciences Laboratory, supervise all laboratory research activities on maize quality and utilization and laboratory staff including budgeting, personnel issues, and procurement of laboratory chemicals and equipment
- Collaborated with national research institutes, non-governmental organizations, and community based groups to increase awareness on maize postharvest research and technologies developed at IITA.
- Conducted the first food consumption and nutrition national survey in Nigeria and other countries in SSA to assess food security, nutritional status, micronutrient deficiencies and nutrient intakes
- Worked with small and medium-scale processing industries on product development, food safety, and environmental hygiene
- Managed and coordinated four special projects. All involve a variety of development partners, colleagues from national and international institutions with specialization in range of different disciplines
- Co-supervised with University partners 10 MSc and 15 PhD degree-related researches in food science/technology at IITA
- Published more than 90 research papers on food quality, processing, and nutrition in international journals, and (co)authored 18 books/ technical manuals.

Employment including current position

- 2012 to Present: Leader, CRP on Agriculture for Nutrition and Health, IITA
- 2013 to Present: Senior Scientist, IITA
- 2000 to 2012: Scientist, Crop Utilization Specialist, IITA

Education

- Ph. D in Food Science, 1992, Kansas State University

Selected Recent Publications

Alamu, O. E., **Maziya-Dixon, B**., Olaofe, O., Menkir, A. 2015. Varietal and harvesting time effects on physical characteristics and sensory properties of roasted fresh yellow maize hybrids. IOSR Journal of Applied Chemistry (IOSR-JAC) 8(2): 55-63.

De Moura, F. F., Moursi, M., Lubowa, A., Ha, B., Boy, E., Oguntona, B. E., Sanusi, R., **Maziya-Dixon. B.** 2015. Cassava intake and vitamin A status among women and preschool children in Akwa-Ibom, Nigeria. PLoS ONE. 10(6) (e0129436):1-14.

Akinola, A. A., **Maziya-Dixon, B**., Ayedun, B., Abdoulaye, T. 2014. Economics of maize, soybean and cowpea processing in the northern regions of Ghana. Journal of Food, Agriculture & Environment 12(2):252–258.

Day, R.S., Douglass, D.L., and **Maziya-Dixon, B.** 2008. Developing a Nigerian-Specific Food and Nutrient Coding Database Journal of Food Composition and Analysis 21: S109-S114.

Natalia PALACIOS ROJAS

FP5 Co-leader, CoA 3.3, 5.1 and 5.2 Co-leader

Time commitment: 50%

Expertise

- Main area of work is the development of maize germplasm with high nutritional quality, including high quality protein maize, high zinc and high provitamin A maize. This includes assessing the nutritional quality of food products and phenotyping of genetic diversity for the nutritional, end-use and culinary quality of maize.
- Served as principal investigator and leader of Harvest plus maize biofortification at CIMMYT for the last 5 years.
- Established and maintains the state-of-the-art maize nutritional quality laboratory at CIMMYT
- Published more than 40 research papers on maize nutritional breeding and plant biochemistry in international journals of repute (more than 3050 citations), besides (co)authoring 7 books chapters and more than 10 magazines and brochures of science.
- Served as (co)-supervisor of 11 Ph.D. and 14 M.Sc. students

Employment including current position

- 07/2013 to date: Senior scientist- Maize nutritional quality specialist, Head of maize quality laboratory, Global Maize program, CIMMYT
- 10/2008 to 06/2013: Scientist- Maize nutritional quality specialist, Head of maize quality laboratory, Global Maize program, CIMMYT
- 01/2007 to 09/2008: Associate scientist, Head of maize quality laboratory, Global Maize program, CIMMYT
- 01/2005 to 12/2006: Post-doctoral scientist Maize quality, Global Maize program, CIMMYT
- 09/2001 to 12/2004: Post-doctoral scientist Max Plank Institute of Molecular Plant physiology, Postdam-Germany

Education

- Ph.D. in Plant Biochemistry, University of East Anglia-John Innes Centre, England, 2000

Selected Recent Publications

Obata, T., Witt, S., Lisec, J., **Palacios-Rojas, N**., Florez-Sarasa, I., Yousfi, S., Araus, J.L., Cairns, J., Fernie, A. Metabolite profile of maize leaves in drought, heat and combined stress field trials reveals the relationship between metabolism and grain yield. (2015). Plant physiology 169: 2665-2683

Chomba, E., Wescott, C., Wescott, J., Mpabalwani, E., Krebs, N., Patinkin, Z., **Palacios-Rojas, N**., Hambidge, M. (2015). Zinc Absorption from Biofortified Maize Meets the Requirements of Young Rural Zambian Children. J. of Nutrition 145 (3): 514-9.

Heying, E., Tanumihardjo, J., Vasic, V., Cook, M., **Palacios-Rojas, N**., Tanumihardjo, S. (2014) Biofortified orange maize enhances β-Cryptoxanthin concentrations in egg yolks of laying hens better than tangerine peel fortificant. J. of Agriculture and Food Chemistry 62: 11892-11900.

Miranda A, Vázquez-Carrillo G, García-Lara S, San Vicente F, Torres JL, Ortiz-Islas S, Salinas-Moreno Y and **Palacios-Rojas N.** (2013). Influence of genotype and environmental adaptation into the maize grain quality traits for nixtamalization. CyTA–J. Food 11:54-61

Babu, R., **Palacios-Rojas, N**., Gao, S., Yan, J., Pixley, K. (2012). Validation of the effects of molecular marker polymorphisms in LcyE and CrtRB1 on provitamin A concentrations for 26 tropical maize populations. Theor. Appl. Genet. DOI 10.1007/s00122-012-1987-3.

Yan, J., Kandianis, C. B., Harjes, C. E., Bai, L., Kim, E., Yang, X., Skinner, D., Fu, Z., Mitchell, S., Li, Q., Salas-Fernandez, M., Zaharieva, M., Babu, R., Fu, Y., **Palacios, N**., Li, J., DellaPenna, D., Brutnell, T., Buckler, E., Warburton, M., Rocherford, T. (2010). Rare genetic variation at *Zea mays crtRB1* increases beta-carotene in maize grain. Nature Genetics, 42(4): 322-327.

Gideon KRUSEMAN

CoA 1.1 Co-leader

Time commitment: 50%

Expertise

- As an ex-ante and foresight specialist, leading this research with a multi-disciplinary team of scientists located in sub-Saharan Africa, Latin America and Asia, since August 2015
- Expert in quantitative economic and bio-economic modeling of complex systems at farm household, community, value chain, national and global levels, using econometric, simulation and mathematical programming techniques..
- Expert in quantitative and qualitative ex-ante policy analysis
- Expert in ex-post impact assessment, monitoring and evaluation

Employment including current position

- 08/2015 to date: Ex-ante and foresight specialist at CIMMYT
- 01/2016 to date: Focal point Big Data at CIMMYT.
- 03/2015 to 08/2016 Consultant Big Data
- 03/2006 to 03/2015: Lead on environmental economic modelling, at LEI Wageningen, ex-ante and ex-post impact evaluation of programs, projects and policies in Netherlands, EU, Tunisia, Egypt and Bangladesh
- 03/2004 to 03/2006: Senior Research fellow at the Institute of Environmental studies in Amsterdam involved in environmental modelling, research on the poverty environment nexus, environmental policy in Ntherlands, EU, Tunisia, Kenya, Ethiopia and Pakistan
- 09/2003-03/2004: Consultant for IFPRI for East African highlands project; consultant for ICCO conserning monitoring and evaluation
- 04/1992-09/2003: worked in different capacities in Wageningen University and DLO research institutes on research related to food security and sustainable land use and research on climate change. Research related to Netherlands, EU, Mali, Costa Rica, Ethiopia and China
- 03/1989 to 04/1992 associate expert for the Andean outreach project of CIAT's bean program covering Peru, Ecuador and Bolivia.

Education

- Ph.D. in Development Economics, Wageningen University, Netherlands, 2000

Selected Recent Publications

Gebrezgabher, S., **G. Kruseman**; M.P Meuwissen, D. Lakner, A.G Oude Lansink (2015) Factors influencing adoption of manure separation technology in the Netherlands. Journal of Environmental Management 150: 1-8.

Hagos, F.; Yawez, E.; Yohannes, M.; Mulugeta, A.; Abraha, G.G.; Abreha, Z.; **Kruseman, G**.; Linderhof, V.G.M. (2013) Small scale water harvesting and household poverty in Northern Ethiopia. in: Nature's Wealth: The Economics of Ecosystem Services and Poverty, Papyrakis, E., Bouma, J., Brouwer, R., Beukering, P.J.H. van (editors) - Cambridge : Cambridge University Press, pp. 265 - 282

Kabubo-Mariara, J.; Linderhof, V.G.M.; **Kruseman, G**.; Atieno, R. (2013) Tenure security and ecosystem service provisioning in Kenya. in: Nature's Wealth: The Economics of Ecosystem Services and Poverty, Papyrakis, E., Bouma, J., Brouwer, R., Beukering, P.J.H. van (editors), Cambridge: Cambridge University Press, pp. . 356 - 372

Kruseman, G. and L. Pelligrini (2013) Institutions and forest management in the Swat region of Pakistan. in: Nature's Wealth: The Economics of Ecosystem Services and Poverty, Papyrakis, E., Bouma, J., Brouwer, R., Beukering, P.J.H. van. (editors) - Cambridge: Cambridge University Press, pp. 234 -258

Woltjer, G.B.; Bezlepkina, I.; Leeuwen, M.G.A. van; Helming, J.F.M.; Bunte, F.H.J.; Buisman, F.C.; Luesink, H.H.; **Kruseman, G**.; Polman, N.B.P.; Veen, H.B. van der; Verwaart, T. (2011) The agricultural world in equations: an overview of the main models at LEI Den Haag : LEI, onderdeel van Wageningen UR, (LEI-Memorandum 11-151

Sika DOFONSOU GBEGBELEGBE

CoA 1.1 Co-leader

Time commitment: 50%

Expertise

- Leader of IITA's strategic foresight research program
- Conducting ex-ante evaluation of improved agricultural technologies related to IITA's mandate crops
- Improving bio-economic models used in ex ante impact assessment studies

Employment including current position

- Scientist, Social Science Dept, IITA, (June 2015 to now)
- Associate Scientist, Socio-economics Program, CIMMYT (Jan 2011 to June 2015)
- Post-doctoral fellow, ReSAKSS, ILRI (Jan 2008 – Jan 2011)

Education

- PhD, 2008, Agricultural Economics (international development), Purdue University, USA
- MS, 2002, Agricultural Economics and Business, University of Guelph, Canada

Selected Recent Peer-reviewed publications:

Robinson, S.; Mason-D'Croz, D.; Islam, S.; Cenacchi, N.; Creamer, B.; Gueneau, A.; Hareau, G.; Kleinwechter, U.; Mottaleb, K.; Nedumaran, S.; Robertson, R.; Rosegrant, M.W.; **Sika, G**.; Sulser, T.B.; Wiebe, K. 2015. Climate change adaptation in agriculture: Ex ante analysis of promising and alternative crop technologies using DSSAT and IMPACT. IFPRI Discussion Paper. no.01469. 73 p

Kindie Tesfaye, **Sika Gbegbelegbe**, Jill E. Cairns, Bekele Shiferaw, BM Prasanna, Kai Sonder, Kenneth J. Boote, Dan Makumbi, Richard Robertson, 2015. Bioeconomic impact of climate change on maize production in sub-Saharan Africa and its implications for food security. International Journal of Climate Change Strategies and Management.

Sika Gbegbelegbe, Uran Chung, Bekele Shiferaw, Siwa Msangi, Kindie Tesfaye, 2014. Quantifying the impact of weather extremes on global food security: A spatial bio-economic approach; Weather and Climate Extremes

Uran Chung, **Sika Gbegbelegbe**, Bekele Shiferaw, Richard Robertson, Jin I. Yun, Kindie Tesfaye, Gerrit Hoogenboom, Kai Sonder, 2014. Modeling the effect of a heat wave on maize production in the USA and its implications on food security in the developing world; Weather and Climate Extremes

Gbègbèlègbè D. S., Lowenberg-DeBoer, J., Adeoti R., Lusk, J., Coulibaly O, 2015. The Estimated Ex Ante Economic Impact of Bt Cowpea in Niger, Benin and Northern Nigeria. Agricultural Economics;

Stirling, C.; Hellin, J.; Cairns, J.; Silverblatt-Buser, E.; Tefera, T.; Ngugi, H.; **Gbegbelegbe, S**.; Tesfaye, K.; Chung, U.; Sonder, K.; Cox, R. A.; Verhulst, N.; Govaerts, B.; Alderman, P.; Reynolds, M. 2014. Shaping sustainable intensive production systems: improved crops and cropping systems in the developing world; Book: Climate change impact and adaptation in agricultural systems

Paswel MARENYA

CoA 1.2 Co-leader

Time commitment: 100%

Expertise

- Agricultural development, policy and technology adoption on maize based smallholder systems of East and Southern Africa.
- Analysis of pathways and impacts of technology adoption among smallholder maize farmers within the framework of sustainable intensification.
- Lead a multicounty project on Identifying Socioeconomic Constraints to, and Incentives for, Faster Technology Adoption: Pathways to Sustainable Intensification in Eastern and Southern Africa (Adoption Pathways).
- Lead the socioeconomics component of a four-year, five-country project on Sustainable Intensification of Maize Legume Systems in East and Southern Africa (SIMLESA).

Employment including current position:

- June 2013 – present: Economist (Technology Adoption and Impacts), International Maize and Wheat Improvement Center (CIMMYT), Addis Ababa.
- March 2010 – May 2013: Post-Doctoral Research Fellow, International Food Policy Research Institute (IFPRI), Washington D.C.
- March 2002 - March 2010: Lecturer, Department of Agricultural Economics, University of Nairobi, Kenya.

Education

- 2008, PhD, Natural Resources Policy and Management, Cornell University, Ithaca, NY, USA.
- 2005, MS, Applied Economics and Management, Cornell University, Ithaca, NY, USA.

Selected Recent Peer-reviewed Publications

Marenya, P, Kassie, M., Tostao E. (2015). Fertilizer use on individually and jointly managed crop plots in Mozambique, Journal of Gender, Agriculture and Food Security, 1(2): 62-83.

Marenya, P., Smith, V.H. and Nkonya E., (2014). Relative Preferences for Soil Conservation Incentives among Smallholder Farmers: Evidence from Malawi. American Journal of Agricultural Economics, 96(3): 690-210.

Marenya, P.P., E. Nkonya, W. Xiong, J. Deustua Rossel and K. Edward (2012) Which would work better for improved soil fertility management in sub-Saharan Africa: Fertilizer Subsidies or Carbon Credits? Agricultural Systems 110: 162-172.

Marenya, P.P., Barrett, C.B. (2009). State-conditional fertilizer yield response on western Kenyan farms. American Journal of Agricultural Economics 91: 991-1006.

Marenya P.P., Barrett, C.B., (2009) Soil quality and fertilizer use among smallholder farmers in Western Kenya. Agricultural Economics, 40(5): 561-572.

Shiferaw FELEKE

CoA 1.2 Co-leader

Time commitment: 50%

Expertise

- Agricultural Policy analysis
- Assessment of impact of technologies
- Track technologies contributions towards key performance indicators such as poverty and food security

Employment including current position

- 2014 - Present: Impact Economist International Institute of Tropical Agriculture (IITA)
- 2007- 2013: Research Associate at the Centre for Tobacco Grower Research

Education

- 2006, PhD, Agricultural Economics, University of Florida, USA.
- 2002, MS, Agricultural Economics, University of Florida, USA.

Selected Recent Peer-reviewed publications:

Tiller, K. **Feleke, S.** and Starnes, J. 2013. “Federal Excise Tax Increase and Its Effects on U.S. Tobacco Production” Empirical Economics, 44 (2): 701-717.

Tiller, K., **Feleke, S**. and Starnes, J. 2010. “Exit among Burley Tobacco Growers after the End of the Federal Tobacco Program” Journal of Agricultural and Applied Economics 42(2):161–175.

Tiller, K., **Feleke, S.** and Starnes, J. 2010. “A discrete-time Hazard Analysis of the Exit of Burley Tobacco Growers in Tennessee, North Carolina and Virginia” Agricultural Economics, 41(5): 397–408.

Feleke, S and Kilmer, R. 2009 “Japanese Market for Imported Fruit Juices” International Food and Agribusiness Management Review 12(4): 1-28.

Lone BADSTUE

CoA 1.3 Co-leader

Time commitment: 50%

Expertise

- Rural Development Sociologist with special focus on gender and social heterogeneity, crop genetic resources improvement and seed systems, knowledge processes, local livelihoods and farmer decision making processes.
- Badstue has over 15 years of experience working with international development issues. She has broad experience working with different types of social actors and multi-disciplinary teams on issues related to rural development processes, including social relations and gender, seed systems and crop genetic resources, technology diffusion, natural resource management and collective action, as well as mainstreaming of gender in institutional procedures and project portfolios. She has long-term experience in several countries of Latin America and in Tunisia and Kenya, and short-term assignments in a number of countries in Sub-Saharan Africa and Asia.
- Badstue is currently Strategic Leader for Gender research at CIMMYT, and chairs the Executive Committee of GENNOVATE, a collaborative research initiative on Gender Norms, Agency and Innovation in Agriculture and Natural Resource Management involving 11 CRPs.

Employment including current position

- October 2011 till present, Strategic Leader for Gender Research, International Maize and Wheat Improvement Center (CIMMYT), Mexico.
- March 2010 – September 2011, Gender and Advocacy Specialist, Helen Keller International (HKI), Kenya.
- October 2007 – February 2010, Socio-Economic and Gender Specialist, African Water Facility (AWF), African Development Bank.
- October 2000 – May 2006, Associate Scientist, International Maize and Wheat Improvement Center (CIMMYT), Mexico.

Education

- PhD Rural Development Sociology, Wageningen University, The Netherlands, 2006.
- MA Social Anthropology, University of Copenhagen, Denmark, 2000.

Amare TEGBARU

CoA 1.3 Co-leader

Time commitment: 50%

Expertise

- Social Anthropology, Gender and rural development
- IITA Gender Specialist and Gender Unit Head (current position)
- Maize Gender Focal Point
- Humid Tropics Gender Research Coordinator

Employment

- 1989-1991 Associate Professional Officer (APO), FAO, Thailand
- 1991 -1991 Rural Sociology advisor, FAO, Bhutan
- 1992 – 1998 University Lecturer & Examiner, Stockholm University, Sweden
- 1998 – 2000 University Lecturer & Examiner, Falun University College, Dalarna, Sweden
- 2000-2005 Senior Socio-economic Adviser, National Agriculture and Livestock Extension Program, Sida, Kenya
- 2005-2007 Agriculture Technology Development and Transfer (ATDT) project Coordinator, CIAT, Rwanda
- 2007-2009 Promoting Sustainable Agriculture in Borno (PROSAB) project coordinator and specialist in Participatory Gender Research
- 2010-2012. IITA Country Representative in Liberia and Gender Specialsit
- 2013- to date. IITA Gender Specialsit and Gender Unit Head, IITA Eastern Agfrica Regional Hub, Tanzania

Education

- PhD. 1998, Social Anthropology, Stockholm University, Sweden
- MSc. 1987, Social Anthropology and Development Studies, Stockholm University, Sweden

Selected Recent Publications

Tegbaru, A. et al. (2016) Gender empowerment outcome as an unforeseen consequence of Health & Nutrition project: the case of the MIRACLE Project. (In Press).

Tegbaru, A., John Fitz Simons, Holger Kirscht and Per Hillbur (2015) Resolving the Gender Empowerment Equation in agricultural research: A systems approach. Journal of Food, Agriculture & Environment 13(3&4):131-139.

Christine Okali, Mike Loevensohn and **Amare Tegbaru (**2014) Interpreting the agricultural transformation agenda – women's roles in seed systems. FAO Discussion Paper, Institute of Development Studies, UK.

Tegbaru, A. (2014) Gender Master Plan. N2Africa Phase II - Putting nitrogen fixation to work for smallholder farmers in Africa. IITA, Nigeria & Wageningen University.

Tegbaru Amare, Holger Kirscht and Eva Rathgeber (2013). Humidtropics Gender Strategy. Humidtropics System Research. IITA. CGIAR.

Jon HELLIN

CoA 1.4 Co-leader

Time commitment: 60%

Expertise

- Jon Hellin has 25 years of experience in agricultural research and rural development (farmers' access to markets, land management, and climate change adaptation and mitigation) including 12 years' field work in Latin America, East Africa, South Asia and the Caribbean.
- He has authored and co-authored two books and over 80 articles (including 50 in peer-reviewed journals).
- His current research interests include making markets work for the poor; and index insurance and farmers' uptake of climate-smart agricultural technologies
- From 2010 - 2014, he led CIMMYT's socio-economics team in the "Sustainable Modernization of Traditional Agriculture" (MasAgro) initiative in Mexico. He also contributed to the MasAgro proposal and subsequent strategic direction of the initiative.
- From 2009 – 2010 he was the interim director of CIMMYT's Socio-economics program while also serving on CIMMYT's Senior Management Committee.
- Since joining CIMMYT in 2005, Jon has contributed to successful proposal writing for projects supported by the Bill and Melinda Gates Foundation, USAID, SDC, European Union and DFiD

Employment

- 2005 – present Poverty and Value Chain Specialist, International Maize and Wheat Improvement Centre (CIMMYT), Mexico
- 2002-2005 International Team Leader, Markets and Livelihoods Programme, ITDG (now called Practical Action), UK
- 2000-2002 Independent consultant
- 1994-1999 Senior Scientific Officer, Natural Resources Institute (NRI), UK but based in Honduras

Education

- 1999 Ph.D. in Geography, Geography Department, Oxford Brookes University, UK
- 1989 MSc. Forestry and its Relation to Land Use. University of Oxford, UK
- 1987 BA Hons. Modern History University of Oxford, UK

Selected Recent Publications

Hellin, J., Krishna, V.V., Erenstein, O. and Boeber, C. 2015. India's Poultry Revolution: Implications for its Sustenance and the Global Poultry Trade. International Food and Agribusiness Management Review Volume 18, Special Issue.

Hellin, J., Bellon, M.R. and Hearne, S. 2014. Maize Landraces and Adaptation to Climate Change in Mexico. Journal of Crop Improvement 28:4, 484-501.

Shiferaw B., **Hellin, J.** and Muricho, G. 2011. Improving Market Access and Agricultural Productivity Growth in Smallholder Agriculture in Africa: What Roles for Producer Organizations and Collective Action Institutions? Food Security 3(4), 475-489, DOI: 10.1007/s12571-011-0153-0.

Donnet, L. and **Hellin, J.** 2011. Los Productores Frente a los Cambios de la Demanda en las Cadenas de Trigo en México y Argentina. Revista Mexicana de Economía Agrícola y de los Recursos Naturales 4(2) pp. 39-48.

Bellon, M.R., Hodson, D. and **Hellin, J.** 2011. Assessing the Vulnerability of Traditional Maize Seed Systems in Mexico to Climate Change. Proceedings of the National Academy of Sciences 108 (33): 13432–13437.

Kate DREHER

CoA 2.1 Co-leader

Time commitment: 60%

Expertise

- As a Germplasm Data Coordinator at CIMMYT since 2013, helps to coordinate efforts to implement institutional databases and tools for storing and utilizing maize and wheat phenotypic, genotypic, and genealogical data.
- Collaborates with members of the CIMMYT Knowledge Management Unit, Sustainable Intensification, and Socio-Economics Programs who focus on the management of agronomic and socio-economic data.
- Serves as a CIMMYT representative to the CGIAR Data Management Task Force and the Wheat Information System Expert Working Group, leads the CGIAR Dataverse Community of Practice, and contributes to the further development of CIMMYT Open Access policies, resources, and implementation plans in conjunction with other CGIAR centers
- At the Carnegie Institution for Science (2007-2013) worked on biological database curation for The Arabidopsis Information Resource (TAIR, www.arabidopsis.org) and the Plant Metabolic Network (www.plantcyc.org) and helped release databases focused on plant metabolism in over 15 species.
- Contributed to 12 articles published in peer-reviewed journals and one book chapter.
- Mentored 8 students at the Carnegie Institution for Science and 6 at the University of California, Davis, and served as a Teaching Assistant for 3 classes at the University of California, Davis.

Employment including current position

- 12/2013 to date: Germplasm Data Coordinator, CIMMYT, México
- 10/2007 to 11/2013: Biocurator, Carnegie Institution for Science, United States of America
- 03/2007 to 10/2007, Molecular Biology Consultant, CIMMYT, México

Education

- Ph.D. in Plant Biology , University of California, Davis, United States of America, 2007
- B.A. in Biology and Economics, Williams College, United States of America, 1999

Selected Recent Publications

Kim T, **Dreher K**, Nilo-Poyanco R, Lee I, Fiehn O, Lange BM, Nikolau BJ, Sumner L, Welti R, Wurtele ES, Rhee SY. (2015) Patterns of metabolite changes identified from large-scale gene perturbations in Arabidopsis using a genome-scale metabolic network. Plant Physiology. 167(4):1685-98.

Dreher K. (2014) Putting the Plant Metabolic Network pathway databases to work: going offline to gain new capabilities. Methods Mol. Biol. 1083:151-71.

Lamesch P, Berardini TZ, Li D, Swarbreck D, Wilks C, Sasidharan R, Muller R, **Dreher K**, Alexander DL, Garcia-Hernandez M, Karthikeyan AS, Lee CH, Nelson WD, Ploetz L, Singh S, Wensel A, Huala E. (2012). The Arabidopsis Information Resource (TAIR): improved gene annotation and new tools. Nucleic Acids Research. 40(Database issue):D1202-10.

Zhang P., **Dreher K**., Karthikeyan A., Chi A., Pujar A., Caspi R., Karp P., Kirkup V., Latendresse M., Lee C., Mueller L.A., Muller R., and Rhee SY (2010). Creation of a genome-wide metabolic pathway database for Populus trichocarpa using a new approach for reconstruction and curation of metabolic pathways for plants. Plant Physiology. 153(4):1479-1491.

Trushar SHAH

CoA 2.1 Co-leader

Time commitment: 20%

Expertise

- Crop informatics – data management and analysis
- Breeding Management System – database and tools for breeding
- Software development for decision support tools - developed tools for Marker Assisted Backcrossing
- Bioinformatics applications – Analysis of WGRS and GBS data with application to crop breeding

Employment including current position

- Jan 2015 to present: Integrated Breeding Hub Manager, IITA, Kenya
- Oct 2009-Nov 2014: Bioinformatics Scientist, ICRISAT, India
- Jul 2007 – Oct 2009: Bioinformatics Specialist, CIMMYT, Mexico

Education

- 1997 MSc (Distinction) – Molecular Modelling and Bioinformatics, University of London, UK
- 1996 BSc (Hons) – Biochemistry, Molecular Biology and Biotechnology, University of Bristol, UK

Selected Recent Peer-reviewed publications

Varshney RK, Chen W, Li Y, Bharti AK, Saxena RK, Schlueter JA, Donoghue MTA, Azam S, Fan G, Whaley AM, Farmer AD, Sheridan J, Iwata A, Tuteja R, Penmetsa RV, Wu W, Upadhyaya HD, Yang SP, **Shah T**, Saxena KB, Michael T, McCombie WR, Yang B, Zhang G, Yang H, Wang J, Spillane C, Cook DR, May GD, Xu X and Jackson SA. (2011) Draft genome sequence of pigeonpea (Cajanus cajan), an orphan legume crop of resource-poor farmers. Nature Biotechnology doi:10.1038/nbt. 2022.

Wen W, Araus J, **Shah T**, Cairns J, Mahuku G, Banziger M, Torres J, Sanchez C And Yan J. (2011) Molecular Characterization of a Diverse Maize Inbred Line Collection and its Potential Utilization for Stress Tolerance Improvement. Crop Science 51:2569-2581.

Morris GP, Ramu P, Deshpande SP, Hash CT, **Shah T**, Upadhyaya HD, Riera-Lizarazu O, Brown PJ, Acharya CB, Mitchell SE, Harriman J, Glaubitz JC, Buckler ES, Kresovich S (2012) Population genomic and genome-wide association studies of agroclimatic traits in sorghum. Proc. National Acad. Sci. USA.

Shutu X, Dalong Z, Ye C, Yi Z, **Shah T**, Ali F, Qing L, Zhigang L, Weidong W, Jiansheng L, Xiaohong Y, Jianbing Y (2012) Dissecting tocopherols content in maize (*Zea mays* L.), using two segregating populations and high-density single nucleotide polymorphism markers. BMC Plant Biology 12:201.

Azam S, Rathore A, **Shah TM**, Telluri M, Amindala B, Ruperao P, Katta M a VSK, Varshney RK. (2014) An Integrated SNP Mining and Utilization (ISMU) Pipeline for Next Generation Sequencing Data. PLoS One 9: e101754.

Doddamani D, Katta MA, Khan AW, Agarwal G, **Shah TM**, Varshney RK. (2014) CicArMiSatDB: the chickpea microsatellite database. BMC Bioinformatics 15: 212.

Mike OLSEN

CoA 2.2 Co-leader

Time commitment: 50%

Expertise

- Fourteen years private sector experience in conventional and molecular maize breeding as part of Syngenta and Monsanto North America breeding teams. Recognized as Monsanto Fellow.
- Two years public sector experience leading the molecular breeding team of the CIMMYT Global Maize Program and providing strategic direction for upstream research efforts.
- Project lead for Improved Maize for African Soils (IMAS), a multi-institutional public-private partnership to develop maize varieties with improved performance under low fertility conditions common in Sub-Saharan Africa.
- CIMMYT Principal Investigator for the Genomics and Open source Breeding and Informatics Initiative (GOBII), a partnership between Cornell University, ICRISAT, IRRI, and CIMMYT to enable routine use of genomic data in applied CGIAR breeding programs through integration of appropriate infrastructure, databases, analysis pipelines, and user interfaces.
- Co-inventor of 25 commercially utilized maize inbred lines and 13 hybrid varieties with US patents issued between 2009 and 2015.

Employment including current position

- 01/2013 to date: Trait Pipeline and Upstream Research Coordinator, Global Maize Program, CIMMYT.
- 06/2008 to 01/2013: Maize Discovery Breeder, Monsanto Company, Minnesota, USA.
- 06/2003 to 06/2008: Maize Line Development Breeder, Monsanto Company, Minnesota, USA.
- 06/2002 to 06/2003: Maize Output Trait Breeder, Monsanto Company, Iowa, USA.
- 06/1999 to 06/2002: Maize Output Trait Breeder, Wilson Genetics (a Syngenta and Land O' Lakes joint venture), Iowa, USA.

Education

- Ph.D., M.Sc. Plant Breeding and Genetics, University of Minnesota, USA, 1999.

Selected Recent Publications

Beyene Y, Semagn K, Mugo S, Tarekegne A, Babu R, Meisel B, Sehabiague P, Makumbi D, Magorokosho C, Oikeh S, Gakunga J, Vargas M, **Olsen M**, Prasanna BM, Banziger M, Crossa J. 2014. Genetic gains in grain yield through genomic selection in eight bi-parental maize populations under drought stress. Crop Science 55, 154-163.

Gowda M, Das B, Makumbi D, Babu R, Seman K, Mahuku G, **Olsen MS**, Bright JM, Beyene Y, Prasanna BM. 2015. Genome-wide association and genomic prediction of resistance to maize lethal necrosis disease in tropical maize germplasm. Theoretical and Applied Genetics DOI 10.1007/s00122-015-2559-0

Nair SK, Babu R, Magorokosho C, Mahuku G, Semagn K, Beyene Y, Das B, Makumbi D, Kumar PL, **Olsen M**, Prasanna B. 2015. Fine mapping of Msv1, a major QTL for resistance to Maize Streak Virus leads to development of production markers for breeding pipelines. Theoretical and Applied Genetics DOI 10.1007/s00122-015-2551-8

Semagn K, Beyene Y, Babu R, Nair S, Gowda M, Das B, Tarekegne A, Mugo S, Mahuku G, Worku M, Warburton ML, **Olsen M**, Prasanna M. 2015. Quantitative trait loci mapping and molecular breeding for developing stress resilient maize for sub-Saharan Africa. Crop Science 55, 1-11.

Zhang X, Pérez-Rodriguez, Semagn K, Beyene Y, Babu R, López-Cruz MA, San Vicente F, **Olsen M**, Buckler E, Jannick J-L, Prasanna BM, Crossa J. 2014. Genomic prediction in biparental tropical maize populations in water-stressed and well-watered environments using low-density and GBS SNPs. Heredity doi:10.1038/hdy.2014.99

Melaku GEDIL

CoA 2.1 & 2.2 Co-leader

Time commitment: 50%

Expertise

- As the Head of Bioscience Center manages a biotechnology laboratory with a user of up to 80 personnel including scientists, technicians, grad students with major tasks of procurement of equipment and lab consumables, promotion, training, financial management, genotyping services, personnel management and communication.
- Broad background in plant breeding, statistical genetics, molecular biology, and bioinformatics for developing and applying an efficient and effective molecular breeding program for pest and disease resistance, quality traits, and abiotic stresses such as drought.
- Genomics and modern breeding approaches such as marker-assisted recurrent selection (MARS), genome wide association study (GWAS), genome selection, linkage/QTL mapping, comparative genomics and bioinformatics.
- Proficient with state-of-the-art lab techniques including DNA sequencing, gene cloning and library screening, variety of PCR techniques including quantitative real-time PCR.

Employment including current position

- 2007 to date, Molecular breeder & Head of Bioscience (since 2010), IITA Ibadan, Nigeria
- 2006 to 2007, SAIC-Frederick NCI-NIH, Maryland, USA
- 2002 to 2006 Georgetown University, Washington DC, USA
- 1999 to 2001, Postdoctoral fellow, molecular genetics, IITA, Nigeria

Education

- Ph.D., Crop Science, Oregon State University, Corvallis, Oregon, Jan, 1999.
- M.Sc., Biotechnology/Bioinformatics (May 2005). Georgetown University, Washington DC.

Selected Recent Publications

Badu-Apraku, B., **Gedil, M**., Annor, B., Talabi, A. O., Oyekunle, M., Akinwale, R. O., Fakorede, M. A. B.,Fasanmade, T. Y., Akaogu, I. A. 2015. Heterotic responses among crosses of IITA and CIMMYT early white maize inbred lines under multiple stress environments (Euphytica, Online First)

Badu-Apraku et al. (2015). Grouping of Early Maturing Quality Protein Maize Inbreds based on SNP markers and Combining Ability under Multiple Stress Environments. Field Crops Research (in print)

Menkir, A., **Gedil, M**., Tanumihardjo, S. A., Adepoju, A., Bossey, B. 2014 Carotenoid accumulation and agronomic performanca of maize hybrids involving parental combinations from different marker-based groups Food Chemistry, 148, 131 - 137.

Azmach, G., **Gedil, M**., Menkir, A., & Spillane, C. (2013). Marker-trait association analysis of functional gene markers for provitamin a levels across diverse tropical yellow maize inbred lines. BMC Plant Biology, 13(227), 1— 16.

Adeyemo, O., Menkir, A., **Gedil, M.** and Omidiji, O. 2011. Carotenoid and molecular marker-based diversity assessment in tropical yellow endosperm maize inbred lines. Journal of Food, Agriculture and Environment 9(3):383-392.

Sarah HEARNE

CoA 2.3 Co-leader

Time commitment: 100%

Expertise

- Assessment of the genomic and phenotypic diversity of the CIMMYT genebank collection of maize and other publically accessible maize genetic resources. GWAS for high priority traits using landrace panels. Selection sweep evaluation for key abiotic, biotic and anthropogenic characteristics of maize landraces. Development of new analytical approaches to explore and understand maize genetic diversity.
- Modelling training population formation, selection techniques and breeding methods for GS advancement to optimize landrace based pre-breeding approaches for oligo and polygenic traits. Pre-breeding using genomic selection and forward breeding.
- Works with bioinformaticians and programmers to develop integrated systems and specific tools for genetic research, breeding application and knowledge dissemination.
- Leadership, oversight, coordination, planning and monitoring of activities within the maize and informatics components of the SeeD initiative.
- Fundraising and research strategy development.

Employment

- 2011 to present: Senior scientist, molecular geneticist and pre-breeder at CIMMYT, Mexico.
- 2008 to 2011: Scientist at; IITA Ibadan & IITA, Nairobi. Plant Molecular Geneticist/Physiologist
- 2005 to 2008: Scientist at; IITA, Nairobi. Plant Molecular Geneticist/Physiologist.
- 2001 to 2003: Postdoctoral Fellow at CIMMYT Mexico. Molecular Geneticist / Physiologist.

Education

- Ph.D. 2001, The University of Sheffield, UK.
- B.Sc. (Hons) 1997 Applied Plant Science. First class. The University of Manchester, UK.

Selected Recent Publications

Gorjanc, G., Jenko, J., **Hearne, S.J**., Hickey, J.M. (2016) Initiating maize pre-breeding programs using genomic selection to harness polygenic variation from landrace populations. BMC Genomics, 17, DOI:10.1186/s12864-015-2345-z

Adebayo, M.A., Menkir, A., Blay, E., Gracen, V., Danquah, E., **Hearne, S.** (2014) Genetic analysis of drought tolerance in adapted × exotic crosses of maize inbred lines under managed stress conditions. Euphytica, 196: 261-270.

Semagn, K., Babu, R., **Hearne, S**., Olsen, M. (2014) Single nucleotide polymorphism genotyping using Kompetitive Allele Specific PCR (KASP): Overview of the technology and its application in crop improvement. Mol. Breeding, 33: 1-14.

Swarts K., Li H., Alberto Romero Navarro J., An D., Romay M.C., Hearne S., Acharya C., Glaubitz J.C., Mitchell S., Elshire R.J., Buckler E.S., Bradbury P.J. (2014) Novel methods to optimize genotypic imputation for low-coverage, next-generation sequence data in crop plants. Plant Genome, 7(3).

Mir, C., Zerjal, T., Combes, V., Dumas, F., Madur, D., Bedoya, C., Dreisigacker, S., Franco, J., Grudloyma, P., Hao, P.X., **Hearne, S**., Jampatong, C., Laloë, D., Muthamia, Z., Nguyen, T., Prasanna, B.M., Taba, S., Xie, C.X., Yunus, M., Zhang, S., Warburton, M.L., Charcosset, A. (2013) Out of America: Tracing the genetic footprints of the global diffusion of maize. TAG, 126: 2671-2682.

Muchero, W., Diop, N.N., Bhat, P.R., Fenton, R.D., Wanamaker, S., Pottorff, M., **Hearne, S**., Cisse, N., Fatokun, C., Ehlers, J.D., Roberts, P.A., Close, T.J. (2009) A consensus genetic map of cowpea [*Vigna unguiculata* (L) Walp.] and synteny based on EST-derived SNPs. PNAS, 106 (43): 18159-18164.

Terence MOLNAR

CoA 2.4 Co-leader

Time commitment: 20%

Expertise

- Management of large-scale multi-location biotic and abiotic stress trials of maize genetic resources that include public-private collaborations and collaborations with NARS partners in Mexico. Currently evaluating 1300 testcrosses with landrace germplasm for drought tolerance in 5 locations and evaluating 900 BC1 individuals for tolerance to tar spot disease complex.
- In 2015 led effort in selecting and evaluating 1000 maize landrace accessions for tolerance to the component viruses of the MLN disease complex. Breeding populations with best 20 landraces currently being developed.
- In 2015 began development of a rapid-cycle nursery system in Mexico that allows 3 cycles in 13 to 15 months (depending on germplasm maturity).
- From 2002 – 2013 led and managed commercial maize breeding programs for DuPont-Pioneer in France and the US. Inbred lines developed in the breeding programs have been parents in at least 9 commercial hybrids registered in EU member countries and at least 3 Pioneer brand commercial hybrids currently being sold in the US central Corn Belt.
- Led the effort for developing the DuPont-Pioneer strategy for breeding with and testing of double-haploids for Maritime and Continental Europe evaluation zones and coordinated the initial implementation of large scale double-haploid breeding in the region.
- Extensive experience in using marker-assisted selection and genomic selection in a maize breeding program including the application of markers for incorporating novel exotic haplotypes into existing elite germplasm. This was accomplished for 1) incorporating elite late maturity US germplasm into elite northern Europe early germplasm and, 2) incorporating elite Brazilian and Mexican tropical germplasm into elite US Corn Belt germplasm.

Employment

- 2013 – present: Senior Research Scientist, Genetic Resource Program, CIMMYT – El Batán, México
- 2011 – 2013: Research Scientist – Maize Breeder, DuPont–Pioneer, Champaign, IL, USA
- 2002 – 2010: Research Scientist – Maize Breeder, DuPont–Pioneer, Pacé, France

Education

- 2002: PhD. Crop ScienceNorth Carolina State University, Raleigh, NC, USA
- 1998: M.S. Crop Science, North Carolina State University, Raleigh, NC, USA

Publications

Prioul, J.L., C. Thévenot and **T. Molnar** (eds). 2011. Advances in Maize. Essential Reviews in Experimental Biology. Vol.2. Society for Experimental Biology.

Robertson-Hoyt, L.A., J. Betrán, G.A. Payne, D.G. White, T. Isakeit, C.M. Maragos, **T.L. Molnar**, and J B. Holland. 2007. Relationships among resistances to Fusarium and Aspergillus ear rots and contamination by Fumonisin and Aflatoxin in maize. Phytopathology 97: 311-317.

Robertson, L.A., M.P. Jines, PJ Balint-Kurti, C.E. Kleinschmidt, D.G. White, G.A. Payne, C.M. Maragos, **T.L. Molnar**, and J.B. Holland. 2006. QTL mapping for Fusarium ear rot and fumonisin contamination resistance in two populations of maize. Crop Science 46: 1734-1743.

Balint-Kurti, M.D. Krakowsky, M.P. Jines, L.A. Robertson, R.K. Baesman, **T.L. Molnar**, M.M. Goodman, and J.B. Holland. 2006. Identification of quantitative trait loci for resistance to southern leaf blight of maize. Phytopathology 96:1067-1071.

Felix SAN VICENTE

CoA 3.1 (Latin America) Co-leader

Time commitment: 30%

Expertise

- As maize breeder/geneticist has spent more than 30 years developing and adapting breeding methods for increasing genetic gains in tropical maize.
- As maize breeding coordinator for Latin America at CIMMYT, leading a multi-disciplinary team of scientists located in Mexico, since January 2011; Project leader for MasAgro-Maize, 2012-2014.
- Since 2010, working with partners in Latin America, has developed 15 hybrids and 8 open pollinated varieties (OPVs) which are grown commercially on about 500,000 ha in 10 countries of Latin America.
- Proposed and released 14 Tropical CIMMYT Maize Lines (CMLs), which are elite germplasm used as parents of maize hybrids in at least 25 different countries worldwide.
- Published more than 35 research papers on maize genetics and breeding in international journals of repute, besides (co)authoring 5 technical manuals and 2 book chapters.
- As a Faculty Member at Universidad Central de Venezuela, guided 2 Ph.D. and 5 M.Sc. students, and received Best Research Paper Award.

Employment including current position

- 01/2014 to date: Principal Scientist, Maize Breeder Lowland Tropics and Maize Breeding Lead Latin America, CIMMYT-Mexico. Flagship Project 3, CoA 3.1 (Latin America) Lead.
- 01/2010 to 12/2013: Senior Scientist, Maize Breeder Lowland Tropics and Maize Breeding Lead Latin America, CIMMYT-Mexico.
- 01/1998 to 12/2009: Served Venezuelan National Institute of Agricultural Research (INIA) in various capacities, including as Principal Scientist & Leader of Maize Program, Venezuela (01/2000 to 12/2009); Maize Breeder, National Cereals Program, INIA, Venezuela (01/1998 to 12/1999).
- 01/1998 to 12/2009. Faculty Member College of Agriculture, Advanced Plant Breeding and Quantitative Genetics, Universidad Central de Venezuela, Venezuela.
- 01/1995 to 12/1997: Postdoctoral fellow. Lowland Tropical Maize Subprogram, CIMMYT- Mexico.
- 11/1982 to 12/1987 and 06/1992 to 12/1994: Scientist and Maize Breeder, National Cereals Program, INIA, Venezuela.

Education

- Ph.D. in Plant Breeding, Iowa State University, USA, 1992

Selected Recent Publications

Cairns JE, Sonder K, Zaidi PH, Verhulst N, Mahuku G, Babu R, Nair SK, Das B, Govaerts B, Vinayan MT, Rashid Z, Noor JJ, Devi P, San Vicente F, Prasanna BM. (2012). Maize Production in a Changing Climate: Impacts, Adaptation, and Mitigation Strategies. In: Donald Sparks (ed.), Advances in Agronomy, 114: 1-58.

Kebede Z, Burgueño J, San Vicente F, Cairns JE, Das B, Makumbi D, Magorokosho C, Windhausen VS, Melchinger AE, Atlin GN (2013). Effectiveness of selection at CIMMYT's main maize breeding sites in Mexico for performance at sites in Africa and vice versa. Plant Breeding DOI:10.1111/pbr.12063.

Miranda A, Vásquez-Carrillo G, García-Lara S, San Vicente F, Torres JL, Ortiz-Islas S, Salinas-Moreno Y, Palacios-Rojas N (2013). Influence of genotype and environmental adaptation into the maize grain quality traits for nixtamalization, CyTA. Journal of Food DOI:10.1080/19476337.2013.763862.

Trachsel S, San Vicente FM, Suarez EA, Rodriguez CS, Atlin GN (2015). Effects of planting density and nitrogen fertilization level on grain yield and harvest index in seven modern tropical maize hybrids (Zea mays L.). Journal of Agricultural Science doi:10.1017/S0021859615000696.

Jill CAIRNS

CoA 3.1 (Africa) Co-leader

Time commitment: 40%

Expertise

- Quantified genetic gains within the maize breeding pipeline in eastern and southern Africa, providing the baseline for measuring future success of the maize breeding pipeline through the addition of new tools and techniques.
- Prioritized climate change research needs for maize systems in Eastern and Southern Africa and led efforts to incorporate heat stress tolerance into CIMMYT maize breeding programs. New hybrids which yield up to five times more than commercial varieties under heat stress are now available for commercialization.
- Established remote sensing capacity within the national maize breeding program of Zimbabwe. Facilitating linkages between advanced research institutes and national research programs.
- Identification of key drought tolerant donors for maize breeding. Through the systematic screening the best inbred lines within the CIMMYT and IITA breeding programs allowed the identification of the most donor tolerant lines. The publication and promotion of these results has resulted in these lines being widely incorporated into international and national breeding programs in sub-Saharan Africa, Mexico and Asia.
- Published more than 40 research papers and book chapters on maize and rice, with over 900 citations.

Employment including current position

- 02/2013 to date: Senior scientist, Global Maize Program, CIMMYT, Zimbabwe.
- 07/2009 to 01/2013: Scientist, Global Maize Program, CIMMYT
- 03/2006 to 06/2009: International Research Fellow, IRRI
- 06/2003 to 02/2006: Postdoctoral Fellow, IRRI.

Education

- Ph.D. in Plant Science, University of Aberdeen, UK, 2003

Selected Recent Publications

Tesfaye K, Gbegbelegbe S, **Cairns JE**, Shiferaw B, Prasanna BM, Boote KJ, Sonder K, Makumbi D, Robertson R (2015) Maize systems under climate change in sub-Saharan Africa: Potential impacts on production and food security. International Journal of Climate Change Strategies and Management 7, 247 – 271.

Zaman‐Allah M, Vergara O, Araus JL, Tarekegne A, Magorokosho C, Zarco‐Tejada PJ, Hornero A, Albà AH, Das B, Craufurd P, Olsen M, Prasanna BM, **Cairns J** (2015) Unmanned aerial platform‐based multi‐spectral imaging for field phenotyping of maize. Plant Methods 11:35

Araus JL, **Cairns JE** (2014) Field high-throughput phenotyping: the new crop breeding frontier. Trends in Plant Sci. 19: 52-61.

Cairns, J.E., J. Hellin, K. Sonder, J.L. Araus, J.F. MacRobert, C. Thierfelder, and B.M. Prasanna (2013) Adapting maize production to climate change in sub-Saharan Africa. Food Sec. 5: 345-360

Cairns, J.E., J. Crossa, P.H. Zaidi, P. Grudloyma, C. Sanchez, J.L. Araus, S. Thaitad, D. Makumbi, C. Magorokosho, M. Bänziger, A. Menkir, S. Hearne, and G.N. Atlin (2013) Identification of drought, heat, and combined drought and heat tolerant donors in maize. Crop Sci. 53: 1335-1346.

Cairns JE, Sanchez C, Vargas M, Ordoñez RA, Araus JL (2012) Maize ideotypes associated with grain yield in different water regimes. Journal of Integrative Plant Biology 54, 107-120.

Bindiganavile S. VIVEK

CoA 3.1 (Asia) Co-leader

Time commitment: 60%

Expertise

- Contributions to maize germplasm improvement figure in the release and commercialization of numerous maize open-pollinated varieties and hybrids in sub-Saharan Africa. Eleven maize inbred lines have been released as CIMMYT Maize Lines (CMLs).
- Coordinated the Affordable, Accessible, Asian (AAA) Drought Tolerant Maize Project, a partnership with national partners, Syngenta and other private seed partners for development and deployment of affordable drought tolerant maize hybrids. This effort has led to the identification of several hybrids which are on the verge of being commercialized.
- Capacity building effort has led to the training of several maize researchers and technicians in maize breeding, experimental design and informatics. Formal capacity building effort has led to the supervision of 9 Master’s and 5 Ph.D. students through various Universities.
- Contributions to maize research information management has led to the development of software used by many maize breeders at CIMMYT, public institutions and private seed companies.
- Research findings are published in over 25 refereed journal articles and as two practical manuals.
- Lead the formation of the International Maize Improvement Consortium for Asia – a consortium of over 40 seed companies formed in an effort to better engage the private seed industry of Asia to enable a focused development and deployment of high-yielding and stress tolerant maize hybrids for markets in South and South-East Asia.

Employment including current position

- 01/2015 to date: Maize Breeder and Principal Scientist, Global Maize Program, CIMMYT; Leader for MAIZE FP3 CoA 3.1 (Asia)
- 9/1997 to 12/2014: Various scientist positions at CIMMYT

Education

- Ph.D. in Plant Breeding and Plant Genetics, University of Wisconsin-Madison, USA, 1997

Selected Publications

Wegary D, **Vivek BS**, Labuschagne MT (2014). Combining Ability of Certain Agronomic Traits in Quality Protein Maize under Stress and Nonstress Environments in Eastern and Southern Africa. Crop Science 54(3):1004-1014.

Lobell DB, Banziger M, Magorokosho C, **Vivek B** (2011) Nonlinear heat effects on African maize as evidenced by historical yield trials. Nature Climate Change 1:42-45

Wegary D, Labuschagne M, **Vivek BS** (2011) Effect of Low Soil Nitrogen Fertility on Protein Quality and Endosperm Modification of Quality Protein Maize (Zea mays L.). Field Crops Res 121:408-415

Vivek BS, Krivanek AF, Palacios-Rojas N, Twumasi-Afriyie S, Diallo AO (2008) Breeding Quality Protein Maize (QPM): Protocols for Developing QPM Cultivars. Mexico, D.F.: CIMMYT

Vivek BS, Kasango J, Chisoro S, Magorokosho C (2007) Fieldbook: Software For Managing A Maize Breeding Program: A Cookbook For Handling Field Experiments, Data, Stocks and Pedigree Information CIMMYT

Lava KUMAR

CoA 3.2 Co-leader

Time commitment: 25%

Expertise

- Leading strategies to control emerging and remerging diseases in sub-Saharan Africa, such as maize lethal necrosis, banana bunchy top, cassava viruses, and also facilitating phytosanitary strategy of genebanks, advocacy on strengthening phytosanitary capacity and prevention of disease spread through germplasm.
- Part of the MAIZE team; and involved in the characterization of maize germplasm for maize streak virus resistance, phenotyping breeding lines and understanding genetics and molecular mechanisms of resistance. I am also Cluster leader on Banana virus (RTB) and coordinating GH theme in the Genebank Platform.
- Led, several multidisciplinary and multi-country projects. For example plant health component of seed yam of YIIFSWA project funded by the BMGF, which contributed to establishment of clean planting materials of popular landraces, disease mapping and epidemiology, development of QMP and certification system, capacity development in yam virus diagnostics and seed health management.
- Initiated BBTV Alliance in 2009 (www.bbtvalliance.org) as a continent wide strategy to combat bunchy top disease spread in Africa. Developed sensitive and robust diagnostic tools for the detection of emerging pathogens including Maize chlorotic mottle virus responsible for MLN.
- Authored/co-authored more than 80 peer reviewed journal articles, 10 book chapters and edited books/proceedings. Also co-supervised 6 PhD students, and organized nearly 20 training courses on virus disease diagnosis and control.

Employment including current position

- 01/08/10 to present: Head, Germplasm Health Unit / Virologist: IITA, Nigeria
- 01/08/07 to 31/07/10: Virologist (West & Central Africa): IITA, Nigeria
- 01/01/05 to 30/05/07: Scientist – Virology: ICRISAT, India
- 31/12/04 to 01/09/99: Special Project Scientist (Virology): ICRISAT, India

Education

- PhD Virology, Sri Venkateswara University, Tirupati, India, 2000
- MSc Virology, Sri Venkateswara University, Tirupati, India, 1995

Selected Recent Peer-reviewed publications

Mahuku, G., Lockhart, B.E.L., Wanjala, B., Jones, M.W., Kimunye, N.J., Stewart, L.R., Cassone, B.J., Sevgan, S., Nyasani, J.O., Kusia, E., **Kumar, P.L**., Niblett, C.L., Kiggundu, A., Asea, A., Pappu, H.R., Wangai, A., Prasanna, B.M., and Redinbaugh, M.G. 2015. Maize lethal necrosis, an emerging threat to maize-based food security in sub-Saharan Africa. Phytopathology 105: 956-965.

Sudha Nair, K., Babu, R., Magorokosho, C., Mahuku, G., Semagn, K., Beyene, Y., Das, B., Makumbi, D., **Kumar, P.L**., Olsen, M., and Prasanna, B.M. 2015. Fine mapping of Msv1, a major QTL for resistance to Maize streak virus leads to development of production markers for breeding pipelines. Theoretical and Applied Genetics 1839 - 1854.

Lukanda, M., Owati, A., Ogunsanya, P., Valimunzigha, K., Katsonga, K., Ndemere, H. and **Kumar P.L**. 2014. First Report of Maize chlorotic mottle virus Infecting Maize in the Democratic Republic of the Congo. Plant Disease 98 (10): 1448

Kumar, P.L., Selvarajan, R., Iskra-Caruana, M-L., Chabannes, M. and Hanna, R. 2015. Biology, etiology and control of virus diseases of banana and plantain. Advances in Virus Research 91: 229-269.

Silva, G., Bömer, M., Nkere, C., **Kumar, P.L.** and Seal, S.E. 2015. Rapid and specific detection of Yam mosaic virus by reverse-transcription recombinase polymerase amplification. Journal of Virological Methods 222: 138-144.

P.H. ZAIDI

CoA 3.4 Co-leader

Time commitment: 30%

Expertise

- As Senior Maize Physiologist at CIMMYT-Asia, leading a multi-disciplinary and multi-institutional, including both public and private sector, projects on development and deployment of abiotic stress resilient maize suitable for Asian tropics.
- As project leader further strengthened the collaborative research activities of CIMMYT-Asia with Asian NARS, both public and private sector partners, including a strong abiotic stress breeding and phenotyping network in the region.
- Developed/fine-tuned screening methods and phenotyping protocols for major abiotic stresses, including drought, water-logging and heat stress. Published harmonized field phenotyping protocols for precision phenotyping of key abiotic stresses in tropics.
- Developed and shared new generation of stress-resilient maize germplasm, including multi-parent populations, inbred lines, released stress-resilient elite traits donor as CIMMYT Maize Lines (CML), including CML 562 – CML 565, and developed new elite stress-resilient hybrids that area licensed to partners in the Asian region for deployment and scale-out.

Employment including current position

- 10/2010 to date: Senior Scientist – Asia Regional Maize Program, International Maize & Wheat Improvement Center (CIMMYT).
- 12/2007 to 09/2010: Scientist – Asia Regional Maize Program, International Maize & Wheat Improvement Center (CIMMYT).
- 11/2006 to 11/2007: Senior Scientist (Maize Physiologist and Leader, Abiotic Stress Breeding, All-India Coordinated Maize Program), Directorate of Maize Research, ICAR, New Delhi, India.
- 11/1997 to 10/2006, Scientist (Maize Physiologist and Leader, Abiotic Stress Breeding, All-India Coordinated Maize Program), Directorate of Maize Research, ICAR, New Delhi, India.

Education

- Ph.D. in Crop Physiology, N.D. University of Agricultural Sciences and Technology, Faizabad, India, 1994
- One year course in Executive General Management (EGM) from Indian Institute of Management (IIM), Bangalore, India, 2007.

Selected Recent Peer-reviewed publications:

Zaidi P.H., Z. Rashid, MT Vinayan, GD Almeida, RK Phagna, R Babu (2015). QTL Mapping of Agronomic Waterlogging Tolerance Using Recombinant Inbred Lines Derived from Tropical Maize (Zea mays L). Germplasm. PLOS ONE | DOI:10.1371/journal.pone.0124350

Kleinknecht, K.; J. Möhring, K.P. Singh, **P.H. Zaidi**, G.N. Atlin and H.P. Piepho (2013). Comparison of the performance of best linear unbiased estimation and best linear unbiased prediction of genotype effects from zoned Indian maize Data. Crop Science, 53(4):1384-1391.

Cairns JE, Crossa J, **Zaidi PH**, Grudloyma P, Sanchez C, Araus JL, Makumbi D, Magorokosho C, Bänziger M, Menkir A, Hearne S, Atlin GN. (2013). Identification of drought, heat and combined drought and heat tolerance donors in maize (Zea mays L.). Crop Science 53, 1335-1346.

Zaidi, PH, Zerka Rashid, M.T. Vinayan and T. Anil Babu (2012). Pre-germination anaerobic stress tolerance in tropical maize (Zea mays L.). Aust. J. Crop Sci.: 6(12):1703-1711.

Cairns, J.E., K. Sonder, **P.H. Zaidi**, N. Verhulst, G. Mahuku, R. Babu, S.K. Nair, B. Das, B. Govaerts,M.T. Vinayan, Z. Rashid, J.J. Noor, P. Devi, F. San Vicente and B.M. Prasanna. 2012. Maize Production in a Changing Climate: Impacts, Adaptation and Mitigation Strategies. Advances in Agronomy. 114: 1-58.

Tsedeke ABATE

CoA 3.5 & 3.6 (Africa) Co-leader

Time commitment: 50%

Expertise

- Project Leader of the Stress Tolerant Maize for Africa (STMA); he is also leader of Maize Seed Systems for Africa, based at CIMMYT-Nairobi.
- Prior to joining CIMMYT in 2012, Tsedeke led the Tropical Legumes II (TL II) project jointly implemented by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Center for Tropical Agriculture (CIAT), and the International Institute of Tropical Agriculture (IITA), in Africa and South Asia.
- Tsedeke is best known for his passion for putting agricultural knowledge into practical use – scaling-up and scaling-out improved technologies to impact the lives and livelihoods of smallholder farmers. Tsedeke has widely published on African agriculture.
- Formerly Director General of the Ethiopian Institute of Agricultural Research (EIAR)

Education

- BS in agriculture (high honors, 1977) from University of Florida, Gainesville, Florida, USA
- MS in Entomology/Agriculture (1979) from University of Florida, USA
- PhD in biological sciences (1990) from Simon Fraser University, Vancouver, Canada.

Selected Publications

Abate T. Shiferaw B, Menkir A, Wegary D, Kebede Y, Tesfaye K, Kassie M, Bogale G, Tadesse B, Keno T. 2015. Factors that transformed maize agriculture in Ethiopia. Food Sec. 7:965-981 (DOI: 10.1007/s12571-015-0488-z)

Fisher M; **Abate T**; Lunduka R; Asnake W; Alemayehu Y; Madulu RB. 2015. Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. Climatic Change.

Abate T. 2012 – 2015: DT Maize, a quarterly bulletin of the DTMA project: www.dtma.cimmyt.org

Abate T; Shiferaw B; Gebeyehu S; Amsalu B; Negash K; Assefa K; Eshete M; Aliye S; Hagmann J. 2011. A systems and partnership approach to agricultural research for development: Lessons from Ethiopia. Outlook on Agriculture 40(3): 213-220.

Abate T. 2006. Successes with Value Chain: Proceedings of the International Conference on Scaling up and Scaling out Agricultural Technologies in Ethiopia, 9-11 May 2006. EIAR, Addis Ababa, 275 pp.

Baffour BADU-APRAKU

CoA 3.5 & 3.6 (Africa) Co-leader

Time commitment: 25%

Expertise

- As the leader of the Ghana National Maize Program and Joint Coordinator of the Ghana-CIDA Grains Development Project (GGDP) from 1987 to 1992 a QPM laboratory for the screening of maize genotypes for high lysine content was established in Ghana and used to develop the QPM variety, Obatanpa GH which was released, and widely adopted in Ghana, Benin, Togo, Mali, Senegal, Cameroon, Côte d'Ivoire, Burkina Faso, Nigeria, Chad, Guinea, Uganda, Malawi, Swaziland, Zimbabwe, Mozambique, South Africa, and Ethiopia.
- Through his maize breeding program at IITA since 1992, several Striga-resistant and drought-tolerant early and extra-early populations have been developed and are serving as valuable sources of varieties and inbred lines for breeders of the sub-region. Over the years, many early and extra-early Striga, drought and low soil nitrogen-tolerant varieties and, more recently, hybrids have been developed in his program, formally released, and widely adopted by farmers in the sub-region.
- Baffour has also conducted research to improve maize selection and evaluation procedures including breeding for resistance to multiple stresses, identification of indirect selection criteria, and grouping of evaluation sites into mega-environments using GGE biplot analysis of genotype × trait interaction and factor analysis of repeatability estimates.
- His most recent achievement includes the development of Striga-resistant and low soil nitrogen-tolerant extra-early varieties and hybrids with genes for tolerance to drought at the flowering and grain-filling periods. He led a group of scientists to develop a heterotic grouping method, designated HGCMAT.

Employment including current position

- 2007 to date: Maize Breeder, IITA, Ibadan, Nigeria
- 1992-2006: Coordinator of WECAMAN, and Maize Breeder, IITA
- 1986-1992: Leader of the National Maize Program of Ghana and Joint Coordinator of the Ghana-CIDa Grains Development Project

Education

- MSc in Genetics and Plant Breeding, University of Guelph, Ontario, Canada
- Ph.D. in Genetics and Plant Breeding, Cornell University, Ithaca, New York, USA.

Selected Publications

Badu-Apraku, B., M.A.B. Fakorede , M. Oyekunle, G.C. Yallou, K. Obeng-Antwi, A. Haruna, I.S. Usman and R.O. Akinwale. 2015. Gains in grain yield of early maize cultivars developed during three breeding eras under multiple environments. Crop Sci. 55:527–539. Do:10.2135/cropsci 2013.11.0783.

Badu-Apraku, B., M.A.B. Fakorede, M. Gedil, A.O. Talabi, B. Annor, M. Oyekunle, R.O. Akinwale, T. Y. Fasanmade, M. Aderounmu.. 2015. Heterotic responses among crosses of IITA and CIMMYT early white maize inbred lines under multiple stress environments. Euphytica (DOI 10.1007/s10681-015-1506-0).

Badu-Apraku, B., M.A.B. Fakorede, M. Oyekunle, R.O. Akinwale. 2015. Genetic gains in grain yield under nitrogen stress following three decades of breeding for drought tolerance and Striga resistance in early maturing maize. Journal of Agric. Sci. (doi:10.1017/S0021859615000593).

Badu-Apraku, B. and Fakorede, M. Breeding early and extra-early maize for resistance to biotic and abiotic stresses in sub-Saharan Africa, Plant Breeding Reviews, volume 37, pages 115-199, chapter 3, John Wiley & Sons, Inc, 2013.

Badu-Apraku, B., M.A. B. Fakorede, Menkir and Sanogo. 2012. Conduct and Management of maize field trials. IITA, Ibadan, Nigeria. 59 pp. ISBN978-978-8444-02-2.

Sadananda AJANAHALLI

CoA 3.5 & 3.6 Co-leader (Asia)

Time commitment: 50%

Expertise

- Has 36 years of agricultural research and seed industry experience.
- As CIMMYT Maize Seed Systems Specialist in Asia, supporting institutions of national agricultural research systems and SME enterprises in deployment of maize hybrids to the farming communities in the tropical Asian region.
- Worked in private sector seed industry and companies like NFCL, Advanta, Emergent Genetics, Monsanto & Vibha seeds, at various capacities and roles in research & technology management, supporting commercial objectives of the business
- Worked in Indian Agricultural Research Institute (IARI), New Delhi for 16 years, as rice geneticist and contributed in development of 7 CVRC notified varieties & hybrids and was recognized by Government of India for development of basmati rice cultivars in India.
- Established Rice Breeding & Genetics Research Center (RBGRC), Aduthurai, India, as a shuttle breeding facility for rice breeding.

Employment including current position

- 05/2013 to date: Seed System Specialist for South Asia; Project lead –International Maize Improvement Consortia – Asia (IMIC-Asia) and Seed System lead, Nepal Seed and Fertilizer project.
- 06/1995 to 05/2014: Research & Technology Lead in various seed companies like NFCL, Advanta, Emergent Genetics, Monsanto & Vibha seeds.
- 07/1979 to 05/1995: Served in Indian Agricultural Research Institute (IARI), New Delhi in various capacities as rice geneticist & breeder.

Education

- Ph.D. in Genetics, ICAR-Indian Agricultural Research Institute, India, 1980
- Rockefeller Post-doctoral Fellow at University of Georgia, USA, 1991-1993
- Diploma In Business Management from IGNOU, New Delhi & Cornell University, USA

Selected Publications

Sadananda AR, BS Vivek and PH Zaidi. International Maize Improvement Consortium (IMIC) in Asia: Partnership with seed partners for Client Oriented product development & delivery: 2014. 12th Asian Maize Conference & expert consultation on Maize for Food, Feed, Nutrition and Environmental Security, Bangkok, Thailand, Oct 30-Nov 1, 2014.231-237

Prasanna BM, BS Vivek, **AR Sadananda**, Daniel Jeffers, PH Zaidi, Christian Boeber, Olaf Erenstein, Raman Babu, Sudha K Nair, Bruno Gerard, ML Jat, Natalia Palacios and Kevin Pixley (Ed): 2014. Book of Extended summaries, 12th Asian Maize Conference & expert consultation on Maize for Food, Feed, Nutrition and Environmental Security, Bangkok, Thailand, Oct 30-Nov 1, 2014. Pp 483

Gopalakrishna KS, Waters DLE, Katiyar SK, **Sadananda AR**, Vaddadi S, Henry RJ. 2012. Genome-wide DNA polymorphisms in elite indica rice inbreds discovered by whole-genome sequencing. Plant Biotechnology Journal DOI: 10.1111/j.1467-7652.2011.00676.x.

Siddiq E. A., Singh V. P., Zaman F. U., **Sadananda A. R.**, Abraham M. J., Hari Prasad A. S., Anju Mahendru, Natrajan U. S., Nagarajan M., Atwal S. S., Sinha S. N., Chopra N. K., Seth Rakesh, Mahapatra T., Prabhu K. V. and Singh A. K. 2009. Development of high yielding Basmati quality rice varieties. Indian Farming, 59(1): 13-17.

Arturo SILVA HINOJOSA

CoA 3.5 & 3.6 (Latin America) Co-leader

Time commitment: 50%

Expertise

- Leader of the IMIC-LA platform for the regional maize seed industry, public sector researchers, and CIMMYT for improving smallholder maize productivity through improvement and dissemination of high yielding, stress-tolerant, and nutritionally-enhanced hybrids for the Latin American tropics/subtropics, especially in Mexico under the MasAgro Project.
- Established an overall product and marketing strategy for the Africa region, working closely with the business units and leveraging market and economic data for increased efficiency in addressing market needs, while aligning with the ACEA and Africa regional leadership teams on risk and opportunity assessments, resource allocation and decision-making processes.
- Defined the strategies and tactics of the Corn & Sorghum Seed Business, aligned with the Strategic intent of Syngenta in order to reach a significant presence within the corn & sorghum seed market in Mexico creating better and complete offers plus solutions for the grower. Establish the strategic plans of the corn & sorghum seed business in Mexico to deliver profitable growth…
- Developed an integrated Latin America North supply plan that meets demand requirements within defined cost targets. Lead seed sales forecasting processes and analyze to match supply with demand. Coordinate, follow up and update the Production Plan for commercial seeds by crop, brand, and hybrid in order to cover the product requirements of customers as well as the general market.
- Supplied planning and demand forecasting of Corn, Soybeans, Sorghum, Sunflower and Alfalfa sold in Argentina, Bolivia and Uruguay. Responsible for the update, projection and report of the Supply and Demand Information. Development & implementation of a CRM & Sales Information System for dealer performance evaluation.

Employment including current position

- Leader of the IMIC-Latin America at CIMMYT, Mexico (2014 – till date)
- Senior Manager, Marketing and Product Strategy for Africa at Pioneer Hi-Bred (2012-2014)
- Mexico Seeds Manager at Syngenta (2007 – 2011)
- LAN Commercial Seed Planning & Allocations Manager at Monsanto (2002 – 2006)
- Product Manager Southern Cone at Pioneer Hi-Bred (1999 – 2001)
- Sales Manager at ProGenetic SA de CV (1994 – 1998)

Education

- MBA Instituto de Empresa Business School. Madrid, Spain, 2002

Santiago LOPEZ-RIADURA

CoA 4.1 Co-leader

Time commitment: 20%

Expertise

- Systems analysis, modeling and scenario assessment of agricultural systems at different scales
- Multi-criteria and sustainability assessment of farming systems
- Participatory research on systems analysis and co-innovation
- Leadership of work packages in interdisciplinary projects

Employment including current position

- September 2012 – Present: Scientist Sustainable Intensification Program CIMMYT, International Maize and Wheat Improvement Center (CIMMYT), Mexico
- December 2007 – August 2012: Scientist at Joint Research Unit "Innovation and Development in Agriculture and Food" (UMR INNOVATION) of the Institut National de la Recherche Agronomique (INRA), Montpellier, France
- December 2005 – November 2007: Post-doc at the Joint Research Unit Soil, Agro- and Hydro-systems, spatialization (UMR SAS) of the Institut National de la Recherche Agronomique (INRA), Rennes, France

Education

- Ph.D. in Production Ecology and Resource Conservation from Wageningen University (WUR), the Netherlands (2005)
- MSc in Sustainable Agriculture, Wye College, University of London, UK (1997)

Selected Recent Peer-reviewed publications

Frelat R, **Lopez-Ridaura S,** Giller KE, Herrero M, Douxchamps S, Djurfeldt AA, Erenstein O, Henderson B, Kassie M, Paul BK, Rigolot C, Ritzema RS, Rodriguez D, van Asten PJ, & van Wijk MT. 2016. Drivers of household food availability in sub-Saharan Africa based on big data from small farms. PNAS, 113 (2): 458-63

Delmotte, S., Barbier, JM., Mouret, JC, Le Page, C., Wery, J., Chauvelon, P., Sandoz, A., **Lopez-Ridaura, S.** 2016. Participatory integrated assessment of scenarios for organic farming at different scales in Camargue, France, Agricultural Systems, 143: 147-158.

Dogliotti, S., Rodriguez, D., **Lopez Ridaura, S.** ; Tittonell, P. ; Rossing, W. A. (2014) Designing sustainable agricultural production systems for a changing world: methods and applications. Agricultural Systems: 1-2.

Delmotte, S., **Lopez-Ridaura, S**., Barbier, J.-M. & Wery, J. (2013) Prospective and participatory integrated assessment of agricultural systems from farm to regional scales: Comparison of three modeling approaches. Journal of Environmental Management, 129, 493-502.

Lopez-Ridaura, S., van der Werf, H., Paillat, J.M. and le Bris, B. (2009) Environmental evaluation of transfer and treatment of excess pig slurry by Life Cycle Assessment. Journal of Environmental Management 90 (2) : 1296-1304.

Lopez-Ridaura, S., van Keulen, H., van Ittersum, M. K. and Leffelaar, P.A. (2005) Multiscale methodological framework to derive indicators for sustainability evaluation of peasant natural resource management systems. Environment, Development and Sustainability 7: 51-69

Bram GOVAERTS

CoA 4.1 (Latin America) Co-leader

Time commitment: 15%

Expertise

- Leading and developing the strategy for Sustainable Intensification in Latin America
- Leading the Mexico based Conservation Agriculture and Agronomy Program (a total of 150 staff, students and consultants)
- Manage the strategic research on conservation agriculture (CA) based on long-term trials and develop the network of partners for excellence in science around those trials
- Leading the MasAgro project in Mexico (yearly budget of 20 million USD)
- Integration of the value chain including recommendations for policy makers at different government levels in Central America
- Development of innovation networks in Central America
- International Peer-Reviewed Journal Publications: >65 - H-index = 20 - Books and Book chapters: 20

Employment including current position

- 2015-Date Strategy Lead Sustainable Intensification in Latin America, CIMMYT.
- 2012-2015 Associate Director of the Global Conservation Agriculture Program, CIMMYT.
- 2012 Senior Scientist Maize and Wheat based Cropping Systems Management, CIMMYT.
- 2009-2011 Scientist Maize and Wheat based Cropping Systems Management, CIMMYT.
- 2008-2009 Associate Scientist Maize and Wheat based Cropping Systems Management, CIMMYT.
- 2007-2008 Post-doctoral Fellow, Maize and Wheat based Cropping Systems Management, CIMMYT.
- 2003-2007 Research Associate with the Katholieke Universiteit Leuven

Education

- 2007 PhD Bioscience Engineering – Soil science
- 2003 MSc Bioscience Engineering – Soil conservation – Tropical agriculture

Selected Recent Publications

Govaerts, B., Sayre, K. D., Deckers, J., 2005. Stable high yields with zero tillage and permanent bed planting? Field Crops Research 94: 33-42

Govaerts, B., Verhulst, N., Castellanos-Navarrete, A., Sayre, K.D., Dixon, J. and Dendooven, L. (2009) Conservation agriculture and soil carbon sequestration; between myth and farmer reality. Critical Reviews in Plant Science 28(3): 97–122.

Dendooven, L., Gutiérrez-Oliva, V.F., Patiño-Zúñiga, L., Ramírez-Villanueva, D.A., Verhulst N., Luna-Guido M., Marsch, R., Montes-Molina, J., Gutiérrez-Miceli, F.A., Vásquez-Murrieta, S., **Govaerts, B**., 2012. Greenhouse gas emissions under conservation agriculture compared to traditional cultivation of maize in the central highlands of Mexico. Science of the Total Environment 431: 237–244.

Herrera, J.M., Verhulst, N., Trethowan, R.M., Stamp, P., **Govaerts, B**., 2013. Insights into genotype × tillage interaction effects on the grain yield of wheat and maize. Crop Science 53: 1845–1859

Turmel, M.-S., Speratti, A., Baudron, F., Verhulst, N., **Govaerts, B**., 2015. Crop residue management and soil health: A systems analysis. Agricultural Systems 134: 6-16.

Jens A. ANDERSSON

CoA 4.2 Co-leader

Time commitment: 30%

Expertise

- Anthropology of development in Africa
- Development and implementation of on-farm research methodologies, focusing on multi-scale analyses, farmer decision-making and technology integration (adoption);
- Coordination of innovation research and external support to innovation approaches in CRP MAIZE

Employment

- 2012-current Innovation scientist, CIMMYT (working globally), The Netherlands
- Evaluating and redesigning innovation approaches for the co-development and increased adoption of sustainable agricultural practices in CIMMYT's operational areas; Research on technology adoption and impact; Evaluating context-specific technical and economic knowledge needs for farmers, as well as socio-economic and institutional constraints to technology adoption; Supporting cross-regional learning in innovation methods and approaches in agricultural development.
- 2005-2011 Research coordinator, southern Africa, Wageningen University, The Netherlands
- Research programme: 'Competing Claims on Natural Resources: Overcoming mismatches in resource use through a multi-scale perspective'.
- 2004-2006 Postdoc Research Fellow, University of Amsterdam.
- Project: 'Liberalization and changing migration in southern Africa: Migrants, traders and the sociology of economic life in Mzimba district, Malawi.'

Education

- 2002 PhD (cum laude), Social Sciences, Wageningen University
- 1993 MSc (cum laude), Sociology of Rural Development, Wageningen University

Recent publications

Cheesman, S., **Andersson, J.A.** and Frossard, E. (2016) Do closing knowledge gaps, close yield gaps? The Journal of Agricultural Science 6 (forthcoming).

Glover, D., Sumberg, J. and **Andersson, J.A**. (2016) The adoption problem; or why we still understand so little about technological change in African agriculture. Outlook on Agriculture 45(1) (forthcoming).

Giller, K.E, **Andersson, J.A**., Corbeels, M., Kirkegaard, J.A., Mortensen, D., Erenstein, O. and Vanlauwe, B. (2015) Beyond conservation agriculture. Frontiers in Plant Science 6(870).

Farnworth, C.R., **Andersson, J.A**., Misiko, M., Baudron, F., Badstue L., and Stirling, C.M. (2015) Gender and Conservation Agriculture in East and Southern Africa: Towards a Research Agenda. International Journal of Agricultural Sustainability 14 (2):142-165.

Andersson, J.A. and D'Souza, S. (2014) From adoption claims to understanding farmers and contexts: A literature review of Conservation Agriculture (CA) adoption among smallholder farmers in southern Africa. Agriculture, Ecosystems and Environment 187: 116–132.

Baudron, F., **Andersson, J.A**., Corbeels, M. and Giller, K.E. (2012) Failing to Yield? Ploughs, conservation agriculture and the problem of agricultural intensification: An example from the Zambezi Valley, Zimbabwe. Journal of Development Studies 48(3): 393–412.

Andersson, J.A. and Giller, K.E. (2012) On heretics and God's blanket salesmen: Contested claims for Conservation Agriculture and the politics of its promotion in African smallholder farming. In: Sumberg, J. and Thompson, J. (eds.). Contested Agronomy: Agricultural Research in a Changing World. London: Routledge, pp. 22–46.

Alpha YAYA KAMARA

CoA 4.2 Co-leader

Time commitment: 35%

Expertise

- Alpha Kamara is a Systems Agronomist and a Senior Scientist working at the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. He heads the IITA station in Kano, Nigeria and coordinates the Consortium Research Program on Water, Land, and Ecosystems.
- Alpha has extensive experience spanning over 20 years, in the fields of agronomy, soil fertility management, seed systems development, crop science, natural resource management, stress physiology and farmer participatory evaluation of technologies, which enabled him to initiate, design and efficiently implement research and development-oriented project activities in SSA.
- He has led and is currently coordinating and managing several research for development oriented projects that are meant to improve rural livelihoods in sub-Saharan Africa.
- Alpha has contributed to many grant-winning proposals at IITA with a combined value of over 30 million US dollars. He has published over 70 journal articles, 20 articles in books of Abstracts and over 20 papers in conference proceedings in the areas of natural resource management, soil fertility, weed and crop management and crop physiology.

Employment

- March 2007- To date. Savanna Systems Agronomist, International Institute of Tropical Agriculture
- January 2004- February 2007. Project and Systems Agronomist, Promoting Sustainable Agriculture in Borno, project (PROSAB), International Institute of Tropical Agriculture, Ibadan, Nigeria
- April 2002- December 2003. Systems Agronomist, Drought-tolerant maize project, International Institute of Tropical Agriculture
- September 2011- To-date, Coordinator: Consortium Research Program 5 (CRP5). Water, Land, and Ecosystems
- March 2007- To-date: Taskforce leader, Sudan Savanna taskforce of the Kano-Katsina Maradi-PLS of the sub-Saharan African Challenge program, International Institute of Tropical Agriculture

Education

- PhD. 1998, Agronomy and Natural Resource Management, University of Kassel, Germany
- M.Sc 1993, Agronomy, Christian Albrecht's University of Kiel, Germany

Selected Recent Peer-reviewed Publications

Kamara A. Y., Sylvester U. Ewansiha, Abdullahi I. Tofa, and Steve Boahen (2014). Agronomic response of soybean to plant population in the Guinea Savannas of Nigeria. Agronomy Journal 106:1051-1059,

Kamara A. Y., Friday Ekeleme, Jibrin M. Jibrin, Gbessay Tarawali, and Ibrahim Tofa. (2014), Assessment of level, extent and factors influencing Striga infestation of cereals and cowpea in a Sudan Savanna ecology of northern Nigeria. Agriculture, Ecosystems and Environment 188 (111–121

Kamara A.Y, S. U Ewansiha, and A. Menkir (2013). Assessment of Nitrogen Uptake and Utilization in Drought Tolerant and Striga Resistant Tropical Maize Varieties. Archives of Agronomy and Soil Science ; http://dx.doi.org/10.1080/03650340.2013.783204

Kamara A. Y., Sylvester U. Ewansiha, Hakeem A. Ajeigbe and Lucky O. Omoigui (2012). Response of old and new cowpea varieties to insecticide spray regimes in the Sudan savanna of Nigeria. Archives of Phytopathology and Plant Protection, 1–12

Kamara, A.Y, S. U Ewansiha, and A. Menkir, A. I Tofa. (2012) Agronomic response of drought-tolerant and Striga-resistant maize cultivars to nitrogen fertilization in the Nigerian Guinea savannas. Maydica, 57: 114-120.

Stephen K. BOAHEN

CoA 4.3 Co-leader

Time commitment: 25%

Expertise

- Leads a multi-disciplinary team in developing sustainable intensification of maize-based systems through participatory research and extension in Southern Africa.
- Coordinated and managed several multi-institutional and multi-disciplinary projects and currently leading a multi-million dollar USAID public-private partnership scaling up project on common beans, cowpea, groundnut, pigeon pea, soybean and sesame in Mozambique
- Established legume research program and developed improved crop management strategies for legume-based cropping systems with a focus on identifying the physiological and management constraints to agronomic performance; development of sustainable soil fertility management through nitrogen fixation, P application and cropping systems
- Developed seed systems to increase private-sector involvement and improve the effectiveness of community engagement to increase seed sales and uptake of improved soybean and cowpea varieties among smallholder farmers
- Published more than 20 articles in refereed journals and over 15 papers in conference proceedings
- Co-supervised 8 M.Sc. and 4 Ph.D. students.

Employment including current position

- Systems Agronomist: 2007 – Present, International Institute of Tropical Agriculture (IITA), Numpula, Mozambique.
- Research Agronomist: 2003 – 2007, Delta Research and Extension Center, Mississippi State University, Stoneville, MS. USA
- Research Associate: 2001 – 2003, Department of Plant and Animal Sciences, Nova Scotia Agricultural College, Truro, NS Canada.

Education

- Ph.D., Agronomy/Plant Physiology, 2000, University of Saskatchewan, Saskatoon, SK, Canada
- M. Sc., Agronomy, 1995, University of Helsinki, Finland

Selected Publications:

Gyogluu, C., **Boahen, S.K.** and Dakora, F.D. 2016. Response of promiscuous-nodulating soybean (*Glycine max* L. Merr.) genotypes to *Bradyrhizobium* inoculation at three field sites in Mozambique. Symbiosis:DOI 10.1007/s13199-015-0376-5

Kamara, A.Y., Ewansiha, S.U., **Boahen, S.K**. and Tofa, A.I. 2014. Agronomic response of soybean varieties to plant population in the Guinea Savannas of Nigeria. Agron. J. 106:1051–1059.

Kumar, P. L., Sharma, K., **Boahen, S.K.**, Tefera, H., Tamo, M. 2011. First report of soybean witches'-broom disease caused by Group 16SrII phytoplasma in soybean in Malawi and Mozambique. Plant Disease 95(4) 492–495.

Zhang, L., and **Kyei-Boahen, S.** 2011. Effects of spring post-planting flooding on early soybean production in Mississippi. Online. Crop Management doi:10.1094/CM-2011-0722-01-RS.

Zhang, L., J. Zhang, S. **Kyei-Boahen** and M. Zhang 2010. Simulation and prediction of soybean growth and development under field conditions. American-Eurasian J. Agric. & Environ. Sci., 7 (4): 374-385.

L. Zhang and **S. Boahen** 2010. Evaluation of critical shattering time of early-maturity soybeans under early soybean production system. Agric. Biol. J. N. Am., 1(4): 440-447.

Timothy J. KRUPNIK

CoA 4.3 Co-leader

Time commitment: 15%

Expertise

- Since joining CIMMYT, Timothy has led and managed multi-million dollar USAID and EU research for development programs. He currently manages a portfolio of applied and multidisciplinary research efforts in tropical maize, wheat, and rice systems agronomy, farming systems analysis, scale-appropriate farm machinery, and the integration of environmental and development goals in agricultural production.
- Timothy's research in South Asia has actively involved hundreds farmers the implementation and management their own adaptive experimental trials and farming system analyses.
- Prior to CIMMYT, Timothy was affiliated with AfricaRice and partnered with the FAO to conduct on-farm, participatory action research on water saving rice cropping systems, and detailed studies of nutrient balances and water productivity, as well as crop-weed competition under water saving irrigation.
- Timothy has conducted research and has consulting experience in Senegal, India, Madagascar, Bangladesh, Haiti, Ethiopia, and Kenya. He has authored of 21 peer-reviewed papers, one book, and several technical reports and invited presentations, in addition to the development of a number of award winning extension materials including seven farmer-to-farmer educational videos now translated into six languages with documented viewership of over 110,000 farmers and millions of television viewers in South Asia.
- In collaboration with partners, his science into scaling efforts have resulted in over 41,000 farmers utilizing resource conserving and resilient crop management practices on 17,000 hectares in South Asia.

Employment including current position

- CIMMYT: Scientist (August 2014 – Present)
- CIMMYT: Associate Scientist (June 2013 – July 2014)
- CIMMYT: Post Doctorial Fellow (July 2011 – April 2013)

Education

- Ph.D. in Environmental Studies (Concentration in Agroecology). University of California, Santa Cruz, 2011.
- MSc. International Agricultural Development. University of California, Davis, 2014.

Selected Recent Publications

Akter, S., **Krupnik, T.J.**, Khanam, F., Rossi, F.J. 2016.The influence of gender and product design on farmers' preferences for weather-indexed crop insurance. In Press: Global Environmental Change.

Krupnik, T.J., Ahmed, Z.U., Timsina, J., Yasmin, S., Hossain, F., Mamun, A. and A. McDonald. 2015. Untangling crop management and environmental influences on wheat yield variability in Bangladesh: An application non-parametric approaches. Agricultural Systems. 139: 166–179.

Aravindakshan S., Rossi, F., and **T.J. Krupnik**. 2015. What does benchmarking of wheat farmers practicing conservation tillage in the eastern Indo-Gangetic Plains tell us about energy use efficiency? An application of slack-based Data Envelopment Analysis. Energy. 90: 483–493

Krupnik, T.J., Ahmed, Z.U., Timsina, J., Shahjahan, Md., Kurishi, A.S.M.A., Rahman, S. Miah, A.A., Gathala, M.K., and A. McDonald. 2015. Forgoing the fallow in Bangladesh's stress-prone coastal deltaic environments: Effect of sowing date, nitrogen, and genotype on wheat yield in farmers' fields. Field Crops Research. 170: 1–7.

Krupnik, T.J., Santos Valle, S., Hossain, I., Gathala, M.K., Justice, S., Gathala, M.K. and A. McDonald. 2013. Made in Bangladesh: Scale-appropriate machinery for agricultural resource conservation. International Maize and Wheat Improvement Center. Mexico, D.F.

Krupnik, T.J., Shennan, C. and J. Rodenburg. 2012. Yield, water productivity and nutrient balances under the System of Rice Intensification and Recommended Management Practices in the Sahel. Field Crops Research. 130: 155–167.

David KAHAN

CoA 4.4 Leader

Time commitment: 15%

Expertise

- Agribusiness development
- Business modelling
- Innovation Systems
- Agricultural extension
- Farm business management
- Farm economics
- Natural resource management
- Marketing and value chain development

Employment including current position

- Nov. 2013–Present, Agribusiness/ Scaling up Specialist, CIMMYT, International Maize and Wheat Improvement Centre, Addis Ababa, Ethiopia
- 2012 –2013, Principal Officer, Agricultural Innovation and Extension, FAO Rome, Italy
- 2010 –2012, Senior Officer, Agribusiness and Agro-enterprise Development, FAO, Regional Office for Asia and the Pacific, Bangkok, ThailanD
- 2001 –2010, Senior Officer, Agribusiness and Agro-enterprise Development, FAO, Rome, Italy
- 1996-2001 FAO, Chief Technical Adviser, Myanmar.

Education

- Ph.D. Rural Development, University of Reading, UK (1982)
- M.Sc. Farm Management, University of Reading, UK (1976)
- M.A Agricultural Economics, University of Wisconsin, USA (1976)

Selected Recent Publications

Baudron F., **David Kahan** (2015) Re-examining appropriate mechanization in Eastern and Southern Africa: two-wheel tractors, conservation agriculture and private sector involvement, Food Security.

Kahan D. et.al. Agricultural mechanization and small scale agriculture: case study evidence from Eastern and Southern Africa (recently submitted).

Kahan D. et al. (2016) Business models for scaling-up 2WT technologies among smallholder farmers: theoretical underpinnings and empirical observations (recently submitted).

Kahan D. 2013. Market-oriented advisory services in Asia – a review and lessons learned. FAO, Regional Office for Asia and the Pacific.

FAO. 2014. The State of Food and Agriculture: Innovation in family farming (led the writing team).

Kahan D. 2007. Business services in support of farm enterprise development. AGS Occasional Paper, 16, FAO.

William J. COLLINGS

CoA 4.4 Co-leader

Time commitment: 15%

Expertise

- 35 years of Experience primarily in South Asia as a manager, technical specialist and designer of a range of agriculture, resource management, aquaculture/fisheries horticulture and related programs
- Most of his recent work involves the design and management of large multi-sectorial agriculture programs that focus on market based agriculture and include mechanization and livestock, aimed at poor rural smallholders
- He has significant experience in market based value chain approaches, livelihoods and income generating activities in sustainable agriculture, horticulture, aquaculture, livestock and micro-irrigation programs.
- He has significant experience as a manager of large programs working with host governments, multilateral and bilateral donors and the private sector. Apart from national governments, those agencies include the Asian Development Bank, World Bank, the European Community, USAID, CARE, DANIDA, DFID, GIZ, Bill & Melinda Gates Foundations, SAVE the Children, BRAC and others.
- He established Bangladesh's Tropical Forest Conservation Foundation-based on a debt equity swap. He has designed and managed rural credit programs with both NGOs and commercial banks.

Employment including current position:

- December 2014 – Present: Project Leader/COP, CIMMYT, USAID funded CSISA Mechanization and Irrigation Program and Country Coordinator for the regional Gates/USAID Funded CSISA III program and Project Leader for the Bangladesh SIIL Program.
- March 2013- October 2014: COP, Winrock International, USAID KISAN Project. Nepal.
- Managing and administrating USAID's largest Feed the Future initiative in Nepal. This integrated agriculture and nutrition project operates in the western districts of Nepal
- Oct. 2009 – Dec 2012: Regional Director-South Asia, WorldFish Center, Bangladesh Office Responsible for all WorldFish research and program activities in the South Asia region.

Education:

- 1973, BSc in Biology and Chemistry, Jacksonville University, Jacksonville Florida
- 1980, MSc from the Auburn University School of Agriculture, Auburn Alabama

Hugo DE GROOTE

CoA 5.3 & 5.4 Co-leader

Time commitment: 100%

Expertise

- Economic analysis and impact assessment of new maize and wheat technologies
- Farmer participatory evaluation of stress tolerant maize; participatory testing and impact assessment of herbicide resistant maize and other strategies to control striga;
- Economic analysis, impact assessment and consumer acceptance of nutritionally enhanced maize (quality protein maize and maize biofortified with vitamin A);
- Analysis of seed systems and regulatory systems in the region;
- Analysis of market information systems, market chains and efficiency of input markets in reaching the poor;
- Project coordinator/principal investigator (impact of quality protein maize, zinc agronomic fortification, climate smart technology dissemination) or leader of the socioeconomic component (VA maize, grain storage, insect resistant maize, and others).

Employment including current position:

- Agricultural Economist/Scientist (from 1999), Senior Scientist (from 2004), Principal Scientist (from 2009), International Maize and Wheat Improvement Center (CIMMYT), Kenya
- Project Coordinator, Biological Control and Biodiversity (1998-1999), Agricultural Economist (1997-1999), International Institute of Tropical Agriculture (IITA), Benin.
- Agricultural Economist, Royal Institute for the Tropics, Amsterdam, January 1994-February 1997:
- Post-Doctoral Research Fellow, International Food Policy Research Institute (IFPRI), Washington D.C., November 1992-November 1993.

Education:

- 1992, PhD, University of Wisconsin-Madison, US, Agricultural Economics.
- 1981, MSc, Ghent State University, Belgium, Agriculture.

Selected Recent Peer-reviewed Publications

De Groote H., F. Oloo, S. Tongruksawattana, B. Das. 2016. Community-survey based assessment of the geographic distribution and impact of maize lethal necrosis (MLN) disease in Kenya. Crop Protection 82: 30–35.

De Groote H., C. Narrod, S. Kimenju, C. Bett, R. Scott, M. Tiongco and Z. Gitonga. 2016. Measuring rural consumers' willingness to pay for quality labels using experimental auctions: the case of aflatoxin free maize in Kenya. Agricultural Economics 47 (2016) 33-45.

De Groote, H., Chege, C.K., Tomlins, K., Gunaratna, N.S., 2014. Combining experimental auctions with a modified home-use test to assess rural consumers' acceptance of quality protein maize, a biofortified crop. Food Quality and Preference 38, 1-13.

De Groote, H., G. Dema, G. Sonda, and Z.M. Gitonga. 2013. Maize for food and feed in East Africa– the farmers' perspective. Field Crops Research 153, 22–36.

De Groote, H., S. Kimenju, P. Likhayo, F. Kanampiu a, T. Tefera, and J. Hellin. 2013. Effectiveness of hermetic systems in controlling maize storage pests in Kenya. Journal of Stored Products Research 53, 27-36.

Gitonga, Z.M., **Hugo De Groote**, Kassie Menale and Tadele Tefera. 2013. Measuring the impact of metal silos on household maize storage and food security in Kenya using propensity score matching. Food Policy 43:44-55.

De Groote, H., Overholt, W.A., Ouma, J.O., Wanyama, J., 2011. Assessing the potential economic impact of Bacillus thuringiensis (Bt) maize in Kenya. African Journal of Biotechnology 10 (23), 4741-4751.

Michelle GUERTIN

Monitoring & Evaluation Specialist

Time commitment: 50%

Expertise

- Michelle has worked on developing policies and programs, implementing complex national regulatory programs and international negotiations, and monitoring and evaluating programs and policies.
- She has managed multidisciplinary teams for over 10 years and led DFATD's Development Evaluation Directorate as Interim Director for prolonged periods.
- She has represented Canada at several multilateral forums, including the OECD Development Assistance Committee (DAC) and the Multilateral Organization Performance Assessment Network (MOPAN).

Employment including current position

- 2014 to present - Senior Monitoring, Evaluation and Learning Specialist
- 2002 – 2014 - Senior Evaluation Manager Government of Canada
- 2004 – 2008 – Manager – Innovative Partnership Programme, ILRI, Kenya.
- 2003-2004 – Consultant ESAE-FAO, Italy.

Education

- PhD Agricultural and Environmental Sciences at McGill University, Canada.
- MSc. Environmental Sciences at Université de Sherbrooke, Canada.

Selected Recent Publications

- Department of Foreign Affairs, Trade and Development. (2015) Synthesis Report – Summative Evaluation of Canada's Afghanistan Development Program.
- **Guertin, M**., Gaffney, S., Prakash, V., Melanson, J. (2014) Comparative Study of MOPAN and EvalNet Approaches to Assessing Multilateral Organization's Development Effectiveness. Internal Government of Canada, OECD and MOPAN paper. Presented at the DAC Development Evaluation Network and the MOPAN Steering Committee.
- Department of Foreign Affairs, Trade and Development. (2014) Synthesis Report - Bolivia Country Program Evaluation - 2005-2010.
- Canadian International Development Agency. (2013) Development Effectiveness Review of the Asian Development Bank. Canadian International Development Agency. (2012) Development Effectiveness Review of the World Health Organization.

Stephen MUGO

Cross-Cutting – Enhancing local capacities

Time commitment: 25%

Expertise

- Maize Breeder, and Leader of WEMA Project for CIMMYT.
- Has led several bilateral and multilateral maize improvement projects.
- Guided 6 Ph.D. and 10 M.Sc. students.
- Published more than 60 research papers in peer-reviewed journals, 20 book chapters and working papers and technical manuals.

Employment including current position

- 2008 to present - Principal Scientist and Maize Breeder in CIMMYT's Global Maize Program & Project Leader, WEMA-CIMMYT.
- 2004 –2008 Project Leader of the Water Efficient Maize For Africa (WEMA) project
- 2001 – 2003 Project Leader of Strengthening Seed Systems project in Kenya and Uganda
- 1999 – 2004 Project Leader the Insect Resistant Maize for Africa (IRMA) project

Selected Recent Publications

Mwimali M, Derera J, **Mugo S**, Tongoona P. 2015. Response to S1 recurrent selection for resistance to two stem borers, *Busseola fusca* and *Chilo partellus*, in two tropical maize populations. Euphytica. DOI 10.1007/s10681-015-1496-y.

Makumbi D., A. Diallo, F. Kanampiu, **S. Mugo**, and H. Karaya. 2014. Agronomic Performance and Genotype x Environment Interaction of Herbicide-Resistant Maize Varieties in Eastern Africa. Crop Science 55: 540-555.

Beyene, Y., K. Semagn, **S. Mugo**, A. Tarekegne, R. Babu, B. Meisel et al. 2014. Genetic gains in grain yield through genomic selection in eight bi-parental maize populations under drought stress. Crop Sci. 55:154-163.

Tefera T., G. Demissie, S. Mugo, Y. Beyene. 2013. Yield and agronomic performance of maize hybrids resistant to the maize weevil Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae). Crop Protection 46 (2013) 94-99.

Mugo S., S. Gichuki, M. Mwimali, C. Taracha, and H. Macharia. 2011. Experiences with the biosafety regulatory system in Kenya during the introduction, testing and development of Bt maize. African Journal of Biotechnology 10: 4682-4693.

David WATSON

MAIZE Program Manager

Time commitment: 100%

Expertise

- Program and research management; guiding and managing demand-driven agricultural research and agricultural and rural development interventions.
- The transformation and commercialization of agrarian systems (both developed countries and developing countries).
- Sustainable agriculture and rural development education, training and extension.
- Rural, agricultural and agri-environmental policy development.

Employment including current position

- 2012 to present - Program Manager for MAIZE CRP, CIMMYT, Mexico.
- 2008 – 2012 – Director, Project Development and Management, IITA, Nigeria.
- 2004 – 2008 – Manager – Innovative Partnership Programme, ILRI, Kenya.
- 2003-2004 – Consultant ESAE-FAO, Italy.

Education

- 1998 – Ph.D. Human Geography, University of Hull, UK.
- 1993 – MSc. Environmental Policy and Management. University of Hull, UK.

Selected Recent Peer-reviewed publications:

Watson, D.J. (ed). (Chapters in press). Achieving sustainable cultivation of maize. Volume 1: From improved varieties to local applications. Burleigh Dodds Science Publishing.

Watson, D.J. (ed). (Chapters in press). Achieving sustainable cultivation of maize. Volume 2: Cultivation techniques, pest and disease control. Burleigh Dodds Science Publishing.

James, B.D., Bramel, P., Witte, E., Asiedu, R., **Watson, D**., and Okechuku, R. (2011). Expanding the application of cassava value chain technologies through UPoCA Project. African Journal of Root and Tuber Crops, 9: 38.

IARSAF (International Association of Research Scholars and Fellows) (2010). Climate Change, Cropping Systems and Coping Strategies in Impact of Climate Change on Food Security in sub-Saharan Africa. Proceedings of the 13th Annual Lecture/Symposium of the International Association of Research Scholars and Fellows. IITA, Ibadan, Nigeria, 25th February, 2010.

Watson, D.J. and Van Binsbergen, J. (2008) Livestock Market Access and Opportunities in Turkana, Kenya. Research Report 3. International Livestock Research Institute (ILRI), Nairobi, Kenya. ISBN 92–9146–208–X.

Watson, D.J. (2008) Community farmer field school animal health facilitators: Hybridizing private animal healthcare and capacity building in remote pastoralist areas. Research Report 14. ILRI (International Livestock Research Institute), Nairobi, Kenya. 70 pp. ISBN 92–9146–227–6.

Watson, D.J. and Van Binsbergen, J. (2008) Livelihood Diversification Opportunities for Pastoralists in Turkana, Kenya. Research Report 5. International Livestock Research Institute (ILRI), Nairobi, Kenya. ISBN 92–9146–210–1.

3.9 Open Access and Open Data Management

Open Access and Open Data planning, according to the CGIAR Open Access and Data Management Policy ("CG OADMP"), is driven by the target date for implementing Policy mandates by the end of 2018. By then, full Open Access and Open Data should be a reality (CG OADMP has been effective as of October 2, 2013).

Key challenges are:

- Culture change: Since scientists are compelled by the CG OADMP to make their information products immediately, irrevocably, unrestrictedly and freely accessible online, they may face a challenge on how adapting to the current and future requirements. This challenge is also closely related to the following.
- Availability and commitment of resources for implementing Open Access and Open Data. Adequate investments are required for proper compliance with the CG OADMP. Cost drivers are:
    - Implementation, maintenance and improvement of suitable repositories, including hardware infrastructure as well as staff costs for development, maintenance and population. [CG OADMP § 4.1.2]
    - Implementation, maintenance and improvement of interoperability, including the cost of properly tagging all the information products with metadata based on controlled vocabularies. [CG OADMP § 4.1.3]
    - Data storage, format conversion and adequate preservation for future use, including costs related to storage volumes, backup storage and disaster recovery plans. [CG OADMP § 4.1.4]
    - Copyright and Open Licenses, which include the royalties paid for publishing articles under the Gold or Green Open Access ways. [CG OADMP § 4.1.5]
    - Incentives and professional expertise in all areas of Open Access and Data Management. [CG OADMP § 4.1.6]
    - Translation of key documents and other media into pertinent languages. [CG OADMP § 4.1.7]

Planning and implementation

To comply with the CG OADMP, CRP-Management will consider the following issues during project planning and implementation:

- Allocation of staff and material resources for proper implementation, maintenance and improvement of suitable repositories and tools, implementation of interoperability (including metadata tagging), data curation and data quality control, data storage, license management (including royalties for Gold and Green Open Access publishing), counseling on information product management, and translation. [CG OADMP § 4.1.2 to § 4.1.7]
- Properly designing and putting in place coordination mechanisms among participating centers and/or units for ensuring proper Open Access and Open Data implementation. [CG OADMP § 2]
- Establishing and implementing procedures and workflows for meeting the deadlines for making information products Open Access, according to the CG OADMP. [CG OADMP § 4.2]

Brief Data Management Plan

- Expected information product types
  MAIZE expects to produce the following types of information products: Annual reports, books and monographs, brochures, databases, datasets, factsheets/flyers, financial management documents, financial statements, guidelines and manuals, gray literature, journal articles, newsletter/bulletins, non-conventional literature, photographs, posters, presentations, proceedings, reports, reprints, research highlights, research plans, research reports, software, special publications, speeches and presentations, technical bulletins, theses, trip reports, videos/film.

- Formats
  Currently most of the information products are natively created in digital formats, so that these can be immediately stored in proper repositories for "into perpetuity" archiving. Nevertheless, MAIZE will make a special effort to transform relevant legacy information products into digital formats, as a way to preserve institutional knowledge. Moreover, MAIZE will do its best to archive its information products in commonly used and highly compatible digital file formats, such as PDF, CSV, JPG, MP4, etc.

- Storage and preservation of information products
  Currently MAIZE uses the following state-of-the-art digital repositories:
    - CIMMYT Institutional Multimedia Publications Repository
    - CIMMYT Institutional Research Data and Software Repository

  These repositories ensure not only preservation and backup but openness of research outputs via FAIR principles as well. Since the partner center/institutions may not have such repositories in place, it will be necessary to implement similar ones for preserving FAIR principles CRP-wide as well as the center's independence.

- Licensing
  CIMMYT already has different licenses for all its publicly available information products. Those licenses have been approved by its Legal Unit and are shown to the users of the repositories before they can download any information product. Since the partner center has not fully implemented a licensing system, it will be necessary to cover all information products coherently CRP-wide.

- Procedures, workflows and embargo periods
  All procedures, workflows and embargo periods regarding information products must observe the regulations given in the CG OADMP. CRP MAIZE will review procedures, workflows and embargo period(s) currently in place at both centers and will adapt them to comply with the CG OADMP if necessary.

Technical considerations

Information products stored in the repositories cited in the DMP can be found by search engines, and their contents indexed via standard protocols. Those state-of-the-art repositories provide syntactic and semantic interoperability by means of widely used international standards such as OAI-PMH, Agrovoc and Dublin Core; they are hosted in first-class cloud servers so the content is properly backed-up and archived "into perpetuity". The partner center has not implemented such kinds of interoperable repositories, so this should be one of the priority actions to be taken. The repositories currently used in MAIZE are summarized below (**Table 3.9**).

Table 3.9: MAIZE-related information product repositories

Name	Repository Technology	URL	FAIR compliant?
CIMMYT Institutional Multimedia Publications Repository	DSpace	http://repository.cimmyt.org/	Yes
CIMMYT Institutional Research Data and Software Repository	Dataverse	http://data.cimmyt.org/	Yes
IITA Knowledge	Non-specific	http://www.iita.org/knowledge	No

Technical Operations

Given the above considerations, personnel and infrastructures will be allocated to ensure proper development of the following routine and on-demand operations:

- Implementation of suitable repositories and tools (on demand). [CG OADMP § 4.1.2]
- Maintenance and improvement of suitable repositories and tools (routine). [CG OADMP § 4.1.2]
- Implementation of interoperability (on demand). [CG OADMP § 4.1.3]
- Maintenance and improvement of interoperability (routine). [CG OADMP § 4.1.3]
- Implementation of hardware infrastructure, storage volumes, backup storage, and disaster recovery plans (on demand). [CG OADMP § 4.1.4]
- Maintenance and improvement of hardware infrastructure, storage volumes, backup storage, and disaster recovery plans (routine). [CG OADMP § 4.1.4]
- Translation of key documents and other media into pertinent languages (on-demand). [CG OADMP § 4.1.7]
- Data curation, metadata tagging, and data quality control (routine). [CG OADMP § 4.1.3 and § 4.1.4]
- Periodic evidence-based review of the implementation of relevant regulations in force (routine). [CG OADMP § 5]
- Continuous coordination among participating centers to ensure proper Open Access and Open Data implementation (routine). [CG OADMP § 2]
- Training activities covering relevant topics to ensure proper staff knowledge and engagement to accomplishing envisaged Open Access and Open Data objectives (on demand).

Coordination and decision-making

The CIMMYT Knowledge Management, Data Management, Geographic Information Systems and Intellectual Property working group, which holds periodic meetings regarding Open Access and Open Data Management activities, should be extended to include relevant equivalent staff from the partner center, as well as the CRP Program Manager and other relevant staff, in order to jointly define workflows, procedures and governance recommendations that should be followed CRP-wide.

Narrative for required resources (e.g., human and financial)

Besides existing resources (material and human), **Table 3.10** shows additional resources forecasted for MAIZE OA/OD activities (see Uplift budget).

Table 3.10: Additional OA/OD budget proposed for MAIZE Phase-II.

MAIZE Phase-II		
Amount	**Resource**	**Average estimated extra cost per year**
1	Locally Recruited Staff for data curation, data quality assurance prior to final publication, metadata tagging, data storage, coordination with other centers and units and implementation of procedures and workflows related to information product management.	USD 48,700
0.5	Locally Recruited Staff for license management, data storage, counseling on information product management and coordination with other centers and units, shared by both Maize and Wheat CRPs.	USD 17,000
0.5	Locally Recruited Staff for the design, development and implementation of training, shared by both Maize and Wheat CRPs.	USD 17,000
N/A	Server rental and maintenance, storage volumes, backup storage and server disaster recovery set-up	USD 26,000
N/A	Implementation of suitable publicly accessible repositories (outsourcing).	USD 4,000
N/A	Implementation of a FAIR Integrated Library Management System (outsourcing).	USD 2,500
N/A	Maintenance of repositories and Information Library Management Systems.	USD 6,000
N/A	Improvement of suitable publicly accessible repositories, mainly regarding interoperability and dissemination features and channels/pipelines (outsourcing).	USD 50,000
N/A	Translation of key documents and other media into pertinent languages	USD 20,000
N/A	Training materials and fees (books, fees for attending courses, etc.)	USD 15,000
N/A	Fees for publishing in Open Access (see tables below)	USD 292,662
Total average estimated extra cost per year		**USD 498,862**

Total estimated extra cost for 2017-2022 for MAIZE = USD 2,993,172

Table 3.11 shows estimates for MAIZE publishing fees in Open Access, based on the assumption that all articles published in 2015 have been published as Gold Open Access. A 15% annual increase is added to compensate for increments both in scientific production and publishers' prices.

Table 3.11: OA publishing costs for CIMMYT and IITA

CRP MAIZE– Estimated costs for publishing in Open Access		
Year	**Cost (CIMMYT)**	**Cost CIMMYT and IITA (CRP)**
2015	USD 95,145	USD 158,575 (60%-40%)
2016	USD 104,660	USD 174,433 (60%-40%)
2017	USD 120,359	USD 200,598 (60%-40%)
2018	USD 138,413	USD 230,688 (60%-40%)
2019	USD 159,174	USD 265,290 (60%-40%)
2020	USD 183,050	USD 305,083 (60%-40%)
2021	USD 210,507	USD 350,845 (60%-40%)
2022	USD 242,083	USD 403,472 (60%-40%)
Total cost estimate 2017-2022	USD 1,053,586	**USD 1,755,976** (60%-40%)
Average annual cost estimate 2017-2022	USD 175,598	**USD 292,662** (60%-40%)

Explanatory note for the above tables
The "total average estimated extra cost per year" in **Table 3.10** is the result of dividing by 6 (2017 to 2022) the "total estimated extra cost for 2017-2022 for MAIZE" (2,993,172 / 6 = 498,862).
The numbers shown in **Table 3.11** were calculated as follows:

1. The cost for year 2015 is the hypothetical cost of having published all 2015 CIMMYT CRP MAIZE publications in Gold Open Access.
2. The cost for year 2016 is the result of applying a 15% increase to the cost for 2015. The cost for year 2017 is the result of applying a 15% increase to the cost for year 2016 and so on.
3. The "total cost estimate 2017-2022" is the sum of costs from 2017 to 2022: 120,359 + 138,413 + 159,174 + 183,050 + 210,507 + 242,083 = 1,053,586.
4. The "average annual cost estimate" is the result of dividing by 6 (2017 to 2022) the "total cost estimate 2017-2022" (1,053,586 / 6 = 175,598).

We assume that CIMMYT will contribute 60% and IITA 40% of all publications produced in MAIZE Phase-II; these include co-authors in these publications from other partner institutions. For example, since USD 138,413 was estimated for CIMMYT Open Access publications for 2018, this means that IITA Open Access publications for 2018 would amount to USD 92,275. The total cost for Open Access publications for the whole CRP for 2018 would be USD 230,688.

3.10: Intellectual Asset Management

I. Relevance of Intellectual Asset (IA) management for CRPs

All MAIZE participants (the Lead and the Participating Center(s), as well as other partners, to the extent that they are able to align) will treat research results and products developed under MAIZE according to appropriate implementation of CGIAR Principles for the Management of Intellectual Assets and the CGIAR Open Access and Data Management Policy, as described below.

Table 3.12: Critical issues to address in CRP implementation from the IA perspective

Barriers to full adoption	Actions implemented to address critical issues	Envisioned improvements
Ensuring CGIAR IA principles, center policies, and center contracts are in compliance with local legislation, local markets and local practices.	Prepare agreements to align with CGIAR principles for the Management of Intellectual Assets and with LEA and RUA requirements when local laws and practices differ. Revise internal policies to address critical issues, as well as to align them with local legislation standards and, when possible, with local markets/practices.	Monitor and train partners on local laws and revise internal and CGIAR policies in view of local laws, potentially as part of CRP "Policies and Markets." Focus on local seed laws and regulations that affect dissemination of research outputs.
Lack of incorporation of IA management principles into the project lifecycle.	Include tools in the project management lifecycle to assist in tracking intellectual assets.	Standardize such practices in MAIZE projects.
	Prepare freedom-to-operate analysis for dissemination of CRP outputs.	
	Formulate flow-down obligations and standards from internal and CGIAR policies to participating center(s) and other partners, according to their capacities.	Monitor and train partners.
Align CGIAR IA principles with private sector partner interests.	Draft and negotiate agreements with private partners, in light of CGIAR principles and, if necessary, draft exceptions while ensuring appropriate justification for appropriate dissemination along with the appropriate search and emergency exceptions.	Continue revising internal policies and extend such policies within the CGIAR.

II. Challenges for CRP implementation vis-a-vis IA management

1. CGIAR policy requirements are at odds with private sector interests and stewardship of GMO technologies. This applies for both outputs created through the use of private sector technology or outputs created solely by a center.
2. There are concerns about confidentiality obligations aimed at maintaining trade secrets and delay disclosure of information to provide ample time for enabling patentable inventions in view of CGIAR IA principles.
3. Ensuring that CRP MAIZE has adequate human resources, funding and capacity development to implement in a timely manner all actions needed for proper IA management.
4. Lack of knowledge among NARES of IA practices at the centers.
5. Nonexistence of IP policies within the various NARES.
6. Collecting, exporting and licensing seed in view of the International Treaty on Plant Genetic Resources for Food and Agriculture and the Nagoya Protocol.

III. Project planning and implementation

1. The Lead Center IP and Legal Unit will intervene in the following phases of the project management lifecycle (highlighted in **Table 3.13** below):

Project phase	Intervention from the IP and Legal Unit
Planning	Direct and/or participate in drafting of documents for work plan, data management, knowledge management, and dissemination of results. IP and Legal will handle contractual obligations (including subgrants) to ensure appropriate planning. If appropriate, prepare preliminary FTO assessment for dissemination of results.
Implementation, monitoring and evaluation	Draft and negotiate agreements, including material transfer agreements. As needed, monitor work scope, risk issues and legal issues in moving forward with project. Draft commercial licenses, if necessary, for dissemination of outputs. Assist with any audits, if necessary. If appropriate, prepare preliminary FTO assessment for dissemination of results. Assist in implementing methods and tools such as legal documents and legal language to be incorporated into documents used in the project lifecycle.
End of the project	Administrative closeout, ensure sharing of information and/or materials, closing out contracts and tracking finalization of any confidentiality clauses.

2. Accountability for the appropriate implementation of CGIAR principles will be handled as follows:
   a. Participating centers are also CG centers and, therefore, their policies and procedures should be consistent with those of the CGIAR; additionally, the Lead Center will ensure this approach by contractual obligation and the right to audit the Participating Center;
   b. The Lead Center will encourage compliance by non-CGIAR partners, to the extent possible, for example, through subgrant contractual obligations.
   c. The Lead Center will create appropriate stewardship issues so not to expose third parties to not be in compliance with IA principles. It is the exception, rather than the rule, that a new language will be needed. For example, in germplasm, CIMMYT does not disclose confidential pedigree information. Additionally, in data and information product management, CIMMYT

repositories and management plans will be applicable to results generated by partners and, to the extent possible, CIMMYT will lead such management.

3. Implementation is subject to available budget; capacity building for incorporating CGIAR policies into project planning and implementation will be developed and provided through guidelines, training, etc.

Table 3.14: Key dissemination pathways for maximizing global impact

Type of Intellectual Asset	**Dissemination pathway**	**IP + Legal contributions**
Data and Information Products (databases, publications, multimedia, reports, training materials, software, algorithms, maps)	- Multi-lingual Open Access repositories - Adapted information dissemination channels to specific target groups, e.g., farmers - Licensing	• Development of global licenses for dissemination as "international public goods" • Legal advice on: - access to third-party technologies/ data/ software/information; - agreements to publish information products through publishers and/or scientific journals; - freedom-to-operate opinions; and - development of IA management strategies to achieve greater impact.
Know-how (protocols, how-to guides, best practices)	- OA repositories - Partnership approaches and capacity development - NARs - Extension specialists - Partners and collaborators	Legal advice on: - development of IA management strategies to achieve greater impact; - dissemination strategies and global licenses for that purpose; - access to third-party know-how; and - management of confidential/ proprietary information.
Germplasm (physical, dissemination)	- As international public goods/through NARs - Public and private partnerships - Networks - Participatory development	• Preparation of licenses and other kinds of applicable agreements to access and give access to germplasm, including SMTA/MTAs; • Legal advice on: - germplasm collection and exportation; - germplasm transfer; - contract negotiation for PPP; - freedom-to-operate opinions; - dissemination strategies for scaling up and out; and - data dissemination.
Agronomic technologies (sustainable intensification, SI)	- On-farm management/ participatory research	Legal advice on: - farmer's rights, germplasm collection and transfer, use of traditional knowledge and prior informed consent; - freedom-to-operate opinions; - ethics in research and privacy matters; - contract negotiation for accessing third-party technologies and/or for collaboration/ use of patents; and - data dissemination.
Agronomic special category: Specialized machinery	- Scaling up and out - Networks	Legal advice on - contract negotiation and drafting, including for accessing third-party technologies and/or for

		granting access to third parties, collaboration/ use of patents; - dissemination strategies for scaling up and out; and - data dissemination.
New tools/protocols, such as newly discovered DNA, RNA, enzymatic and analytical methods and processes for use in biotechnology discovery and/or trait development, including, but not limited to, transformation tools and methods, promoters, introns, enhancers, DNA and RNA modification tools, etc.	- Licensing - Partnerships	Legal advice on - contract negotiation and drafting, including access to third-party technologies; - freedom-to-operate opinions; - use of patents; and - dissemination strategies.
Traits	- Licensing - Partnerships	Legal advice on - contract negotiation and drafting, including access to third-party technologies; - freedom-to-operate opinions; - use of patents; and dissemination strategies.

Table 3.15: Operations (technical infrastructure, planned activities)

IA/IP operations category	Policy, procedure, work process status (provide ref docs if apt)	Policy, procedure, process owner	Estimated cost core budget	Additional investment, budget needed
Incorporation into Lead Center project cycle	Project management lifecycle (in draft form)	Project Managers + IP & Legal	IP & Legal: 5% FTE of one IP Counsel + 3% FTE of General Counsel	+ 5 % FTE of one IP Counsel + 2% FTE of General Counsel
Incorporation into project cycle for participating centers, non-CGIAR partners	In accordance with CIMMYT policies and decisions taken in the CRP-MC; Subgrant	CRP Managers + Participating Centers/ non-CGIAR partners		
IA/IP tracking	Project management lifecycle (in draft)	Project Leader + IP & Legal	IP & Legal: 5% FTE of one IP Counsel	+15 % FTE of one IP Counsel
Negotiation of partner agreements	IP Policy & IP Manual (approved, under revision for update)	Project Leader + IP & Legal	IP & Legal: 15% FTE of each IP Counsel (2)	+10% FTE of each IP Counsel (2)
Convention on Biological Diversity/Farmer's Rights/Nagoya Protocol /International Treaty for Plant Genetic Resources for Food &Agriculture	Germplasm Policy (in draft)	Project Leader + IP & Legal	IP & Legal: 5% FTE of one IP Counsel	+15 % FTE of one IP Counsel
Ethics in Research & Privacy Protection	Ethics in Research Policy (in draft)	Project Leader + IP & Legal	IP & Legal: 5% FTE of one IP Counsel	+15 % FTE of one IP Counsel

Policy development, update of existing policies	IP Policy; IP Manual; Copyright and Authorship Policy; Germplasm Policy (in draft); Ethics in Research Policy (in draft); Project Management lifecycle;	IP + Legal	IP & Legal: 10% FTE of each IP Counsel (2) + 5% FTE of General Counsel	+ 15% FTE of each IP Counsel (2) + 5% FTE of General Counsel
CGIAR Coordination	CRP management	Project Managers	N/A	N/A

Table 3.16: Coordination and decision making (i.e. Policies, procedures, committee, task force)

Topic that triggers coordination of MC with IP + Legal for decision-making	**Coordination /decision-making procedure**	**Applicable policy and status**	**Estimated cost core budget**	**Additional investment , budget needed**
Accessing technology that has or may have restrictions for results dissemination	Legal advice during the project through participation in MC meetings / application of polices in documents produced	CIMMYT Intellectual Property Policy and Manual (approved, under revision for update)	5% FTE of each IP Counsel (2)	+ 3% FTE of each IP Counsel (2)
Granting limited exclusivity agreements for commercialization, whether as part of a partnership or a dissemination strategy	Legal advice during the project through participation in MC meetings / application of polices in documents produced	CIMMYT Intellectual Property Policy and Manual (approved, under revision for update) CGIAR Principles for IA Management	5% FTE of each IP Counsel (2)	+ 10% FTE of each IP Counsel (2)
Partnership or strategies that include the possibility of registering IPRs	Legal advice during the project through participation in MC meetings / application of polices in documents produced	CIMMYT Intellectual Property Policy and Manual (approved, under revision for update) CGIAR Principles for IA Management Germplasm Policy (in draft form)	5% FTE of each IP Counsel (2)	--
Planning direct/specific research activities, particularly if they involve: Germplasm collection and transfer; Licensing of tools and traits Interaction with human subjects/ communities; Scaling up and out; Data dissemination through non-standard platforms.	Legal advice during the project through participation in MC meetings / application of polices in documents produced	Policies applicable to all matters: CIMMYT Intellectual Property Policy and Manual (approved, under revision for update) CGIAR Principles for IA Management For specific topics: Germplasm Collection: CIMMYT Germplasm Policy (in draft); Interaction with human subject/communities: CIMMYT Ethics in Research Policy (in draft); Data dissemination: CIMMYT Research Data and Information Management Policy and CGIAR Open Access Policy.	10% FTE of each IP Counsel (2)	+ 10% FTE of each IP Counsel (2)

* Additional decisions by the Lead Center-MC will be made following relevant CGIAR and Lead Center policies.

IV. Indicative resources (HR and budget statement)

CIMMYT human resources that will support CRP implementation include:

1. CIMMYT general counsel to focus on general coordination and oversight of legal implications (10% FTE devoted to CRPs).
2. CIMMYT IP counsel with background in legal matters related to germplasm development and deployment. (10% FTE devoted to CRP MAIZE, in addition to approximately 25% FTE to be invested in projects that are linked to CRP MAIZE and approximately 20% FTE devoted to policy drafting and implementation as well as capacity building at CIMMYT, which will have a direct impact on CRP MAIZE).
3. CIMMYT IP counsel with background in legal matters related to data and information product development and deployment. (10% FTE devoted to CRP MAIZE, in addition to approximately 25% FTE to be invested in projects that are linked to CRP MAIZE and approximately 20% FTE devoted to policy drafting and implementation as well as capacity building at CIMMYT, which will have a direct impact on CRP MAIZE).
4. CIMMYT legal specialist to support IP Counsel's activities. (5% FTE devoted to CRPs in addition to approximately 20% FTE to be invested in projects that are part of CRP MAIZE).
5. CIMMYT administrative support (as needed).

3.11 Targeted abiotic and biotic stresses under MAIZE FP3

Region	Major abiotic stresses	Major biotic stresses
Sub-Saharan Africa	• Drought • Poor soil fertility (sub-optimal soil N and P; soil acidity) • Heat • Combination of stresses (drought + heat; heat + sub-optimal soil N)	• Maize lethal necrosis (MLN) • Maize streak virus (MSV) • Turcicum leaf blight (*Exserohilum turcicum*) • Gray leaf spot (GLS; *Cercospora zeae-maydis*) • Maydis leaf blight (*Bipolaris maydis*) • Common rust (*Puccinia sorghi*) • Southern rust (*Puccinia polysora*) • Stalk and ear rots (*Diplodia* and *Fusarium* spp.) • Kernel and ear rots *(Aspergillus* and *Fusarium* spp.) • Parasitic weed *Striga* (*Striga asiatica* and *S. hermonthica*) • Stem borers (*Chilo* sp., *Busseola fusca* and *Sesamia calamistis*) • Large grain borer (LGB; *Prostephanus truncatus*) • Maize weevil (*Sitophilus zeamais*)
Asia	• Drought • Drought + heat • Drought + waterlogging • Heat • Waterlogging • Cold • Salinity • Lodging • Soil acidity • Sub-optimal soil P and N	• Downy mildews (*Peronosclerospora* species) • Banded leaf and sheath blight (BLSB; *Rhizoctonia solanai* f.sp. *sasakii*) • Post-flowering stalk rots (PFSR) • Gray leaf spot (GLS; *Cercospora zeae-maydis*) • Turcicum leaf blight (*Exserohilum turcicum*) • Maydis leaf blight (*Bipolaris maydis*) • Common rust (*Puccinia sorghi*) • Southern rust (*Puccinia polysora*) • Kernel and ear rots *(Aspergillus* and *Fusarium* spp.) • Stem borers (*Chilo* sp.; *Busseola fusca*) • Maize weevil (*Sitophilus zeamais*)
Latin America	• Drought • Soil acidity/Al toxicity • Heat • Sub-optimal soil P	• Tar spot complex • Corn stunt complex • Turcicum leaf blight (*Exserohilum turcicum*) • Gray leaf spot (GLS; *Cercospora zeae-maydis*) • Maydis leaf blight (*Bipolaris maydis*) • Common rust (*Puccinia sorghi*) • Southern rust (*Puccinia polysora*) • Stalk and ear rots (*Diplodia* and *Fusarium* spp.) • Kernel and ear rots *(Aspergillus* and *Fusarium* spp.) • Large grain borer (LGB; *Prostephanus truncatus*) • Maize weevil (*Sitophilus zeamais*)

3.12 MAIZE target product profiles for Sub-Saharan Africa, Latin America and Asia (under CoA 3.1 and 3.3).

Sub-Saharan Africa

Sub-region	Agro-ecology	Proportion of maize area in the region (%)	Target products*	Improved germplasm providers (with relative ranking)**	Justification for MAIZE investment in Phase-II
Eastern Africa	**Highlands**	15	Late maturing (170-190 days), high yielding, nitrogen use efficient (NUE), acid soil tolerant, **disease (MLN, MSV, TLB, GLS, PS, ear rots) resistant** maize	Seed companies (1), NARS (2), CIMMYT (3)	MAIZE provides improved highland germplasm to help specific countries where seed companies have not invested (e.g., Rwanda and Burundi). Also, overall genetic gains in the highlands have decreased and productivity has stagnated over the years due to a very narrow genetic base.
	Upper humid mid-altitudes	25	Medium maturing (130-145 days), high yielding, **NUE, DT, acid soil tolerant,** aflatoxin, and disease (**MLN, MSV, TLB, GLS, PS, ear rots)** resistant maize	CIMMYT (1), Seed companies (2), NARS (3)	MAIZE is the major provider of adapted and diverse elite germplasm with relevant traits (e.g., MLN in DT genetic backgrounds); opportunities for upstream research to increase genetic gain and productivity.
	Lower humid mid-altitudes	40	Medium maturing (120-130 days), high yielding, **NUE, DT disease (MLN, TLB, GLS, PS, ear rots) ,** ***Striga*****, aflatoxin,** and insect pest (*B. fusca*) resistant maize	CIMMYT (1), Seed companies (2), NARS (3)	
	Dry mid-altitudes	10	Early maturing (100-120 days), high yielding, **DT, heat, NUE, MLN,** ***Striga*****, aflatoxin**, and post-harvest insect pest resistant maize	CIMMYT (1), Seed companies (2), NARS (3)	MAIZE is the major provider of adapted DT, NUE and heat tolerant germplasm, with relevant traits (e.g., MLN); opportunities for upstream research to increase genetic gain and productivity.
	Humid lowlands	5	Early maturing (90-120 days), high yielding, DT, heat tolerant, NUE, disease (including MLN), aflatoxin, **pre- (*****C. partellus*****) and post-harvest (LGB, maize weevil)** insect pest resistant maize	CIMMYT (1), Seed companies (2), NARS (3)	MAIZE is the major provider of diverse, well-adapted, early-maturing drought, NUE, and heat tolerant germplasm with specific traits in high demand (e.g., MLN); potential for further increasing productivity.

	Dry lowlands	5	Extra-early maturing (80-100 days), high yielding, **DT, heat tolerant, NUE, aflatoxin, pre- (*C. partellus*) and post-harvest (LGB, maize weevil) insect pest resistant** maize	Seed companies (1), CIMMYT (2), NARS (3)	MAIZE is the major provider of diverse, well-adapted, early-maturing drought, NUE, and heat tolerant germplasm with other relevant traits (e.g., MLN); potential for further increasing productivity. Also, overall genetic gains in the highlands have decreased and productivity has stagnated over the years due to a very narrow genetic base.
Southern Africa	**Sub-tropical temperate**	2.1	Early to late maturing (115 to 145 days to PM), high yielding, DT, **heat tolerant**, **NUE**, disease (GLS, TLB, PLS, MSV and ear rots) resistant, and photoperiod sensitive maize	Seed companies (1), NARS (2), CIMMYT (3)	MAIZE provides diverse, well-adapted, early to late maturing, drought, NUE, and heat tolerant germplasm with other relevant traits (e.g., photoperiod sensitive germplasm with unique plant ideotype); potential for further increasing productivity.
	Mid-altitude humid warm	29.6	Early to late maturing (115 to 145 days to PM), high yielding, DT, **heat tolerant**, NUE, **disease** (GLS, MSV, HT, PS, PLS, MLN and ear rots) resistant, **acid soil tolerant**, **low P tolerant**, stem borer and post-harvest insect pest resistant maize	Seed companies (1), CIMMYT (2), NARS (3)	MAIZE is the major provider of stress resilient and diverse elite germplasm with appropriate and gender preferred traits (e.g., heat tolerance, NUE, MLN, aflatoxin, stem borers, post-harvest pests, in DT genetic backgrounds); opportunities for upstream research to increase genetic gains and productivity.
	Mid-altitude humid hot	26.4	Early to late maturing (115 to 145 days to PM), high yielding, DT, **heat tolerant**, NUE, **disease** (GLS, MSV, HT, PS, PLS, MLN and ear rots) resistant, acid soil tolerant, low P tolerant maize	Seed companies (1), CIMMYT (2), NARS (3)	
	Mid-altitude dry	19	Extra-early to medium maturing (90 to 135 days to PM), high yielding, DT, **heat tolerant**, NUE, **disease (PS, MSV, MLN and ear rots) resistant**, low P tolerant and *Striga* tolerant maize	CIMMYT (1), Seed companies (2), NARS (3)	

	Lowland tropical humid	6.8	Extra-early to medium maturing (90 to 135 days to PM), high yielding, DT, **heat tolerant**, NUE, **disease** (DM, MSV, MLN, PS, GLS, HT and cob rots) resistant, **acid soil tolerant**, low P tolerant and *Striga* tolerant maize	CIMMYT (1), NARS (2), Seed companies (3)	MAIZE is the major provider of diverse, well-adapted, extra-early to medium maturing drought, NUE, and heat tolerant germplasm with specific traits (e.g., DM, heat tolerance) of interest, with potential for further increasing productivity (especially in Mozambique and Angola).
	Lowland tropical dry	15.1	Extra-early to medium maturing (90 to 135 days to PM), high yielding, **combined heat and drought tolerant**, disease (PS) resistant, **aflatoxin**, NUE, **stem borer** resistant, and ***Striga*** **tolerant** maize	CIMMYT (1), Seed companies (2), NARS (3)	MAIZE is the major provider of diverse, well-adapted, extra-early to medium maturing germplasm combining drought and heat tolerance with NUE, and with specific traits of interest (aflatoxin, stem borers), with potential for further increasing productivity.
	Highlands	1	Early-medium to late maturing (120 to 145 days to PM), high yielding, NUE, **disease (PS, GLS, MLN, HT, and ear rots) resistan**t, acid soil tolerant, low P tolerant, photoperiod-sensitive, and cold/frost tolerant maize.	CIMMYT (1), Seed companies (2)	MAIZE provides improved highland germplasm to help specific countries in southern Africa. These countries do not have the genetics required to address the needs of their highland areas. Germplasm has to be sourced from as far Ethiopia or South America.
West Africa	**Sudan Savannah**	15	Extra-early (80-85 days) and early (90-95 days) maturing, high yielding, **DT and heat stress tolerant, resistant to** ***Striga hermonthica,*** foliar diseases (SLR, SLB, CLS, and MSV), aflatoxin and NUE.	IITA (1), Seed companies (2), NARS (3)	MAIZE is the major supplier of extra-early and early maturing improved maize germplasm, with relevant abiotic and biotic stress tolerant traits, to meet the needs of smallholders in areas with short growing cycles and further enhance productivity.

	Guinea Savannah	40	Early (90-95 days), medium (105-110 days) and late (110-130 days) maturing, high yielding, **DT and HT, resistant to *Striga hermonthica*, foliar diseases (SLR, SLB, CLS, and MSV), aflatoxin and NUE.**	IITA (1), Seed companies (2), NARS (3)	MAIZE supplies primarily medium (105-110 days) and late (110-130 days) maturing maize germplasm with tolerance to key abiotic and biotic stresses to exploit the long growing period and further enhance farm level productivity.
	Southern Guinea Savannah	25	Early (90-95 days), medium (105-110 days) and late (110-130 days) maturing, high yielding, **DT, resistant to *Striga hermonthica*, foliar diseases (SLR, SLB, CLS, and MSV), ear rots, aflatoxin and NUE.**	IITA (1), Seed companies (2), NARS (3)	
	Forest / Transitional Zone	20	Early (90-95 days), medium (105-110 days) and late (110-130 days) maturing, high yielding, **resistant to foliar diseases (SLR, SLB, CLS, and MSV), ear rots, aflatoxin, insect pests (*Sesamia calamistis* and *Eldana saccharina*) and NUE.**	IITA (1), Seed companies (2), NARS (3)	

*Traits highlighted in bold are particularly limiting genetic gains, and are important for product success.

**Improved maize varieties deployed by SME seed companies and NARS are largely based on MAIZE germplasm, except in the eastern Africa highlands and mid-altitude areas in southern Africa, where unique germplasm is used by seed companies.

Latin America

Sub-region	Agro-ecology	Proprtion of maize area in the region (%)	Target products*	Improved germplasm providers (with relative ranking)**	Justification for MAIZE investment in Phase-II
Meso America and the Caribbean	**Highlands**	15	Medium-early maturing (230-240 days), high yielding, cold tolerant (CT), **drought tolerant (DT), disease (common rust, ear rot)** resistant maize	CIMMYT (1), Seed companies (2), NARS (3)	MAIZE provides unique improved highland germplasm with tolerance to drought and disease resistance (common rust and ear rot) to help smallholders in specific regions where seed companies have not made significant investment (e.g., Mexico's Central Highlands).
	Mid-altitude	25	Medium maturing (170-180 days), high yielding, **DT, NUE and disease (TLB, GLS, stalk and ear rots)** resistant maize	Seed companies (1), NARS (2), CIMMYT (3)	MAIZE is a relevant provider of adapted and diverse elite germplasm with tolerance to abiotic stresses (drought, crowding stress, nitrogen use efficiency) and disease resistance (e.g. TLB, GLS, stalk and ear rots). Opportunities for increasing genetic gain by using modern enabling technologies (e.g., DH, genomic selection, precision phenotyping).
	Lowland Tropics	60	Medium maturing (140-150 days), high yielding, **DT, heat tolerant (HT), NUE and disease (tar spot complex, northern corn leaf blight, corn stunt complex, ear rot)** resistant maize	CIMMYT (1), Seed companies (2), NARS (3)	MAIZE is a major provider of adapted and diverse elite germplasm with tolerance to abiotic stresses (drought, heat, nitrogen use efficiency) and disease resistance (e.g., TSC, NCLB, CSC, and ear rot). Opportunities for increasing genetic gain by using modern enabling technologies (e.g., DH, genomic selection, precision phenotyping).

Western and Northern South America (Andean)	**Highlands**	5	Medium-early maturing (240-250 days), high yielding, cold tolerant (CT), **DT and disease (common rust, ear rot)** resistant maize	NARS (1), CIMMYT (2), Seed companies (3)	MAIZE provides unique improved highland germplasm with tolerance to drought and disease resistance (common rust and ear rot) to help smallholders in specific regions where seed companies have not made significant investment (e.g., Mexico's Central Highlands).
	Mid-altitude	15	Medium maturing (170-180 days), high yielding, **DT, NUE, and disease (TLB, GLS, stalk and ear rots)** resistant maize	Seed companies (1), NARS (2), CIMMYT (3)	MAIZE is a relevant provider of adapted and diverse elite germplasm with tolerance to abiotic stresses (drought, crowding stress, nitrogen use efficiency) and disease resistance (e.g., TLB, GLS, stalk and ear rots). Opportunities for increasing genetic gain by using modern enabling technologies (e.g., DH, genomic selection, precision phenotyping).
	Lowland Tropics	80	Medium maturing (140-150 days), high yielding, **DT, HT, NUE and disease (TLB, GLS, ear rot)** resistant maize	Seed companies (1), CIMMYT (2), NARS (3)	MAIZE is a major provider of adapted and diverse elite germplasm with tolerance to abiotic stresses (drought, heat, nitrogen use efficiency) and disease resistance (e.g., NCLB, GLS, and ear rot). Opportunities for increasing genetic gain by using modern enabling technologies (e.g., DH, genomic selection, precision phenotyping).

*Traits highlighted in bold are particularly limiting genetic gains, and are important for product success.

**Improved maize varieties deployed by SME seed companies and NARS are largely based on MAIZE germplasm, except in mid-altitude areas where unique germplasm is used by seed companies.

Asia

Moisture regime*	Irrigation	Proportion of maize area in the region (%)	Target products**	Comparative advantage***	MAIZE target countries/areas
Rainfed season; High rainfall areas	Nil	15	Medium-full maturity, high-yielding, short to medium height, **waterlogging tolerant (WLT)**, disease [TLB, MLB, **BLSB, DM (Indonesia)**, rust, GLS] resistant maize	MAIZE: 80 MNCs: 20	NE India, Indonesia, Bangladesh, Vietnam, Philippines, Cambodia, Sri Lanka
Rainfed season; Assured moisture areas	Protective	11	Full maturity, high-yielding, **water use efficient (WUE), nutrient use efficient,** and disease (TLB, DM, rust, **BLSB,** GLS) resistant maize	MAIZE: 20 MNCs: 80	South India, Thailand, South China, Indonesia, Sri Lanka
Rainfed season; Low rainfall (<500 mm) areas	Nil	16	Early maturity, high-yielding, short to medium height, **drought tolerant (DT) or DT + heat tolerant (HT)** and disease (**PFSR**, ear rots, DM) resistant maize	MAIZE: 80 MNCs: 20	C & W India, Pakistan, Afghanistan, and northwestern Bangladesh
Rainfed; Medium rainfall (800-1200 mm) areas, but with erratic rainfall distribution	Nil	38	Early to medium maturity, high-yielding, **DT + WLT / DT + HT**, and disease (**PFSR, BLSB**, MLB, GLS) resistant maize	MAIZE: 60 MNCs: 40	IGP (India), Sri Lanka, Nepal, Bhutan, Thailand, Myanmar, Laos, Vietnam
Irrigated; Dry season	Full	13	Full maturity, high-yielding, short to medium height, **cold tolerant, WUE, nutrient use efficient**, and disease [***Macrophomina*****, DM (Indonesia)**] resistant maize	MAIZE: 20 MNCs: 80	India, Bangladesh, southern China, Thailand, Indonesia, Vietnam, Nepal
Irrigated; Spring season	Full	7	Early maturity, high-yielding, **HT, WUE**, and shoot fly resistant maize	MAIZE: 80 MNCs: 20	Pakistan, India, Vietnam, Nepal

*In yellow-highlighted seasons, there is high penetration of hybrids from MNCs; however, SME seed companies do serve niche/unreached markets and require MAIZE germplasm. Also, MAIZE contributes improved donors for abiotic/biotic stress traits to both public and private sectors serving across regions in Asia.
**Traits highlighted in bold are particularly limiting genetic gains, and are important for product success.
***MAIZE largely denotes CIMMYT maize germplasm in Asia, deployed through NARS and SMEs.

3.13 MAIZE target nutritional traits under FP3 (CoA 3.3)

Region	Target countries	Spill-over countries	Products with nutritional traits	Rationale of prioritization
Africa	• Ethiopia • Kenya • Countries where A4NH activities on provitamin A are focus (Zambia, Nigeria, Malawi, etc.)	• Tanzania • Malawi • Zimbabwe • Ghana	• Provitamin A • Kernel Zn in QPM and non-QPM backgrounds	• Malnutrition indices in the countries • White maize consumption • Complementation of priority areas of A4NH
Asia	• Nepal • India • Indonesia	• Bangladesh • Vietnam • Pakistan	• Combinations of Provitamin A, kernel methionine, high oil • Kernel Zn in both non-QPM and QPM (yellow and white) backgrounds	• Maize for food consumption patterns • Spill-over countries have increasing demand for maize feed
Latin America	• Haiti • Bolivia • Countries where A4NH activities on high Zn and provitamin A are focus (southern Mexico, Guatemala, Nicaragua, Colombia)	• Honduras • El Salvador • Ecuador • Peru	• Kernel Zn in QPM and non-QPM backgrounds	• Malnutrition indices in countries • Maize pattern consumption • Complementation of priority areas of A4NH

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3.15 MAIZE Ongoing Projects (as of March 2016)

S.No.	Project Title	Funding Agency	Target Countries	FP1	FP2	FP3	FP4	FP5
Global / Cross-cutting Continents								
1	Genomic and Open-source Breeding Informatics Initiative	Bill & Melinda Gates Foundation (BMGF)	Global		yes			
2	Integrated Breeding Platform / Breeding Management System	BMGF, UKAID, European Commission, IFAD, CGIAR, SDC	Global		yes			
3	Establishing Elevated Temperature Thresholds for Grain Set and Reproductive Growth of Tropical Maize Hybrids for Use in Models to Determine Regions of Vulnerability. Implementing organization: University of Florida	CGIAR: MAIZE CRP Competitive Partners' Grant	Global			yes		
4	Towards farm innovation and enabling policies	Wageningen University	Global	yes				
5	MAIZE CRP Innovation Systems: An opportunity to operationalize innovation system thinking for improved research impact – Phase III. Implementing organization: Royal Tropical Institute (KIT)	CGIAR: MAIZE CRP Competitive Partners' Grant	Zambia, Kenya, India, Mexico (linked to SIMLEZA, CSISA, MASAGRO, SIMLESA)	yes			yes	
6	Biofortification of tropical maize to combat micronutrient malnutrition (high proVA and high zinc)	HarvestPlus through CRP A4NH	Benin Republic, DRC, Ghana, Mali, Nigeria, Zambia, Zimbabwe, Malawi, Nicaragua, Guatemala, Mexico and Colombia			yes		yes
7	Lime-cooking maize processing technology (nixtamalization) from Mexico to Kenya	Mexican Agency for International Cooperation	Mexico, Kenya					yes
8	Spurring a Transformation in Agriculture through Remote Sensing (STARS)	BMGF	Bangladesh, Nigeria, Mali, Tanzania, Uganda				yes	

9	System trajectories, diversity and cross-scale trade-offs; targeting innovations for the sustainable intensification of maize-based agro-ecosystems. Implementing organization: Wageningen UR	CGIAR: MAIZE CRP Competitive Partners' Grant	Nepal, Bangladesh, Ethiopia, Mexico				yes	
10	Feed-the-Future Initiative	USAID	Ghana, Kenya, Senegal, Guatemala, Haiti	yes			yes	yes
11	Developing approaches for sustainable access to mechanization for smallholder farmers - focus on dryland farming. Implementing organization: Syngenta Foundation for Sustainable Agriculture	CGIAR: MAIZE CRP Competitive Partners' Grant	Nepal, Bangladesh, Mexico				yes	
12	How to assure access to affordable high quality maize seed: what works and consequences for program design. Implementing organization: Royal Tropical Institute (KIT)	CGIAR: MAIZE CRP Competitive Partners' Grant	Mexico, Zambia, Malawi, India	yes				
Africa								
13	Stress Tolerant Maize for Africa (STMA)	BMGF and USAID	Benin, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, South Africa, Tanzania, Uganda, Zambia, and Zimbabwe	yes	yes	yes		
14	Improved Maize for African Soils (IMAS)	BMGF and USAID	Kenya, South Africa, USA		yes	yes		
15	Water Efficient Maize for Africa (WEMA)	BMGF and USAID	Kenya, Mozambique, South Africa, Tanzania and Uganda		yes	yes		
16	Africa Rising Project – IITA	USAID	Africa	yes		yes	yes	
17	Managing maize lethal necrosis (MLN) in eastern Africa through accelerated development and delivery of resistant maize germplasm and seed systems support	BMGF & Syngenta Foundation for Sustainable Agriculture (SFSA)	Eastern Africa			yes		

18	Controlling the spread and impact of MLN in Sub-Saharan Africa through improved diagnostic capacity and MCMV-free commercial seed production	USAID	Kenya, Tanzania, Uganda, Ethiopia, Rwanda, Malawi, Zambia, Zimbabwe			yes		
19	Drought tolerant maize for Africa seed scale-up (DTMASS)	USAID	Ethiopia, Kenya, Mozambique, Tanzania, Uganda, Zambia	yes		yes		
20	Malawi Improved Seed Systems and Technologies (MISST) – ICRISAT	USAID	Malawi	yes		yes		
21	Role of crop diversification for food and nutrition security in sub-Saharan Africa	Food and Agriculture Organization (FAO) of the United Nations (UN)	Ethiopia, Malawi	yes				
22	Infant foods from local resources as a pathway to better food and nutrition security in Benin	Food & Business Applied Research Fund (ARF)	Benin					yes
23	West Africa Seed Program	CORAF/WECARD	Benin, Burkina Faso, Ghana, Mali, Niger, Nigeria, Senegal			yes		
24	The Multinational - CGIAR Project: Support to Agricultural Research for Development on Strategic Commodities in Africa (SARD-SC)	AfDB, SARD-SC, IPI	Benin, C'te d'Ivoire, DR, Congo, Eritrea, Ethiopia, Ghana, Kenya, Madagascar, Mali, Niger, Nigeria, Senegal, Sierra Leone, Sudan, Tanzania	yes		yes	yes	yes
25	Increasing research technicians capacity for supporting plant breeding through short training courses	AGRA	Burkina Faso, Ghana, Mali, Niger, Nigeria			yes		
26	Agricultural Investment and Market Development Project (AIMDP)-IITA	MINADER	Cameroon	yes				
27	The development and expansion of sustainable agriculture activities in the periphery south of Faunal Reserve of Lomako Yokokala mainly in the territory of Djolu and Befale (MLW Landscape)	AWF	DR Congo				yes	
28	Youth Agribusiness Development Initiative (YADI)	IFAD	DR Congo, Kenya, Nigeria	yes				

29	Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa (N2Africa) Phase II	Wageningen, WVI, ZOA Uganda	DR Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda				yes	
30	Appropriate mechanization for sustainable intensification of smallholder farming in Ethiopia	Deutsche Gesellschaft für Internationale Zusammenarbeit	Ethiopia				yes	
31	Nutritious Maize for Ethiopia (NuME)	Ministry of Foreign Affairs, Trade and Development, Canada	Ethiopia			yes	yes	yes
32	Harvard U/ATAI-Quality Protein Maize in Ethiopia	Harvard University	Ethiopia					yes
33	Sustainable intensification of maize-legume cropping systems for food security in eastern and southern Africa (SIMLESA)	Australian Centre for International Agricultural Research (ACIAR)	Ethiopia, Kenya, Malawi, Mozambique, Tanzania			yes	yes	
34	Identifying socioeconomic constraints to and incentives for faster technology adoption: Pathways to sustainable intensification in eastern and southern Africa	ACIAR	Ethiopia, Kenya, Malawi, Tanzania, Mozambique	yes				
35	Taking Maize Agronomy to Scale in Africa (TAMASA)	BMGF	Ethiopia, Kenya, Nigeria, Tanzania				yes	
36	Farm Mechanization & Conservation Agriculture for Sustainable Intensification (FACASI)	ACIAR	Ethiopia, Kenya, Tanzania, Zimbabwe				yes	
37	WACCI PhD Plant Breeders Training	UG_LEGON, WACCI	Ghana			yes		
38	Aflatoxin Genetic Resistance in Maize	USDA-ARS	Ghana, Nigeria			yes		
39	Sustainable Intensification of Key Farming Systems in the Sudano-Sahelian Zone of West Africa	USAID	Ghana, Mali				yes	

40	Integrated Management of Maize Lethal Necrosis in Eastern and Central Africa	Association for Strengthening Agricultural Research in Eastern and Central Africa (ASERECA)	Ethiopia, Kenya, Uganda, Tanzania, Rwanda, Burundi, Sudan		yes	yes	yes	
41	Trees 4 Food Security (sub-grant)	ACIAR	Ethiopia, Rwanda				yes	
42	Improving and Sustaining Maize and Cowpea Productivity among Smallholder Farmers through use of conservation agriculture technologies in Mozambique and Malawi	IIAM	Malawi, Mozambique,				yes	
43	How to use crop growth models for designing and evaluating new maize-based cropping systems for smallholder farms in southern Africa. Implementing organization: Unité de Recherche AIDA, CIRAD-Persyst	CGIAR: MAIZE CRP Competitive Partners' Grant	Malawi, Mozambique, Zambia and Zimbabwe			yes	yes	
44	Transforming Key Production Systems: Maize Mixed Systems in East and Southern Africa	USAID	Malawi, Tanzania,				yes	
45	Fertilizer, Maize and Sustainable Intensification in Sub-Saharan Africa. Implementing organization: Michigan State University	CGIAR: MAIZE CRP Competitive Partners' Grant	Malawi, Zambia	yes			yes	
46	Assessment of the suitability for intercropping of contrasting maize and cassava varieties under intensified agronomic regimes along a transect through southern DR Congo. Implementing organization: IITA	CGIAR: MAIZE CRP Competitive Partners' Grant	Nigeria				yes	
47	Maize lethal necrosis disease: investigating risks and pre-emptive management in West Africa. Implementing organization: IITA (Federal University of Technology (FUT)	CGIAR: MAIZE CRP Competitive Partners' Grant	Nigeria			yes		
48	Dissemination of foundation seeds and planting materials of improved varieties of maize, soybean and cassava to stimulate the production of good quality certified seeds/planting materials in Nigeria.	AGRA	Nigeria			yes	yes	
49	PICS 3 project – dissemination of PICS bags for maize storage in Nigeria and Ghana	BMGF	Nigeria, Ghana					yes

50	N2Africa Phase II - Putting nitrogen fixation to work for smallholder farmers in Africa	BMGF	Nigeria, Ghana, Tanzania, Uganda, Rwanda, DR Congo, Malawi, Mozambique				yes	
51	Maize foresight and targeting poor maize consumers: research implications. Implementing organization: University of Pretoria	CGIAR: MAIZE CRP Competitive Partners' Grant	South Africa	yes				
52	Taking stock: the evolving nutritional roles of maize for human nutrition through food and feed in developing countries. Implementing organization: University of the Free State	CGIAR: MAIZE CRP Competitive Partners' Grant	South Africa	yes				yes
53	HTPPs (High-throughput Phenotyping Platforms) and open-source image processing tools for maize foliar disease assessments. Implementing organization: University of Barcelona	CGIAR: MAIZE CRP Competitive Partners' Grant	Sub-Saharan Africa			yes		
54	The Dynamics of Improved Maize Varieties Adoption in Tanzania. Implementing organization: Southern University and A&M College	CGIAR: MAIZE CRP Competitive Partners' Grant	Tanzania	yes				
55	Macronutrient fortification of first-line food cereals with milk protein to produce affordable value-added cereal products in Uganda/East Africa	Food & Business Applied Research Fund (ARF)	Uganda					yes
56	Production and use of biochar, compost and lime as component of integrated soil fertility management in smallholder farming systems of eastern Uganda	ADA	Uganda				yes	
57	Enhanced nutrition security through traditional fermented foods in Zambia	Food & Business Global Challenges Programme (GCP) of NWO-WOTRO, the division of the Netherlands Organization for Scientific Research (NWO)	Zambia					yes
58	Enhancing the effectiveness of systems analysis tools to support learning and innovation in multi-stakeholder platforms. Implementing organization: Royal Tropical Institute (KIT) and Wageningen UR	CGIAR: MAIZE CRP Competitive Partners' Grant	Zambia	yes			yes	

59	Support to agricultural research for development of strategic crops in Africa	SARD-SC	Zambia, Nigeria, Mali, Ghana	yes		yes	yes	yes
60	Integrating Crop and Livestock production for Improved Food Security and livelihoods in rural Zimbabwe (ZimCLIFS)	ACIAR (through ILRI)	Zimbabwe				yes	
61	Screening maize germplasm for tolerance to combined heat and drought stress in Zimbabwe: Crop Breeding Institute	CGIAR: MAIZE CRP Competitive Partners' Grant	Zimbabwe			yes		
Asia								
62	Climate resilient maize for Asia (CRMA) for ensuring food security and enhancing income for resource-poor farming communities in the tropics	BMZ/GIZ	India, Bangladesh, Vietnam, Thailand	yes		yes		
63	Sustainable and resilient farming systems intensification in the Eastern Gangetic Plains (SRFSI)	ACIAR	Bangladesh, India, Nepal				yes	
64	Cereal Systems Initiative for South Asia, Mechanization & Irrigation (CSISA-MI)	USAID	Bangladesh			yes	yes	
65	Ensure sufficient food and nutrition through maize cultivation for marginalized groups of people in Bangladesh. Implementing organization: BRAC	CGIAR: MAIZE CRP Competitive Partners' Grant	Bangladesh				yes	
66	Cereal Systems Initiative for South Asia (CSISA)	USAID and BMGF	Bangladesh, India, Nepal	yes		yes	yes	
67	Heat stress resilient maize for South Asia through a public-private partnership (HTMA)	USAID	Bangladesh, Nepal, India, Pakistan			yes		
68	Training program for Chinese young scientists	Chinese Academy of Agricultural Sciences	China		yes			
69	Toward sustainable maize production in China: Discovery and validation of elite genetic and genomic resources for high nitrogen and phosphorus use efficiency and tolerance to poor soil fertility	Natural Science Foundation of China	China			yes		
70	Development of high QPM + methionine-enriched inbred lines	ICAR and MAIZE	India			yes		yes

71	Evaluation and deployment of stress resilient maize hybrids (derived through MAIZE CRP) in the rainfed maize regions of Southern Karnataka. Implementing organization: University of Agricultural Sciences, Bangalore	CGIAR: MAIZE CRP Competitive Partners' Grant	India			yes		
72	Identification of maize hybrids suitable for rainfed conditions of Odisha. Implementing organization: Orissa University of Agriculture & Technology	CGIAR: MAIZE CRP Competitive Partners' Grant	India			yes		
73	Production Risks and Welfare Implications of Maize Hybrids on the Subsistence Farms of South India. Implementing organization: Tamil Nadu Agricultural University	CGIAR: MAIZE CRP Competitive Partners' Grant	India	yes				
74	Promotion of hybrid maize through evaluation seed production and on-farm demonstration. Implementing organization: G. B. Pant University of Agriculture & Technology, Pantnagar	CGIAR: MAIZE CRP Competitive Partners' Grant	India			yes		
75	Testing and deployment of new drought resilent maize hybrids in the rainfed maize regions of Karnataka, India. Implementing organization: University of Agricultural Sciences, Raichur	CGIAR: MAIZE CRP Competitive Partners' Grant	India			yes		
76	Feed the Future Nepal Seed and Fertilizer Project	USAID	Nepal	yes		yes	yes	
77	Identification and deployment of hybrid maize varieties to promote food security, nutrition and economic growth of disadvantaged farmers in the hills of Nepal. Implementing organization: Hariyali Community Seed Company Pvt. Ltd. Nepal	CGIAR: MAIZE CRP Competitive Partners' Grant	Nepal			yes		
78	Maize seed system – case study Pakistan. Implementing organization: Inter-cooperation, Pakistan	CGIAR: MAIZE CRP Competitive Partners' Grant	Pakistan	yes				
79	Evaluation & commercialization of CIMMYT maize hybrids resilient for drought and heat tolerance in Pakistan: Jullundur Pvt Limited	CGIAR: MAIZE CRP Competitive Partners' Grant	Pakistan			yes		
80	Agricultural Innovation Project (AIP)	USAID	Pakistan	yes		yes		

81	Economics of maize seed production in Thailand. Implementing organization: Kasetsart University	CGIAR: MAIZE CRP Competitive Partners' Grant	Thailand	yes				
Latin America								
82	Biofortified maize for improved human nutrition	HarvestPlus	Guatemala, Nicaragua, El Salvador, Honduras, Colombia, Panama, Haiti		yes	yes		yes
83	Assessment of maize-based farming systems and their contribution to food secure and resilient farms in The Mountain region of Guerrero, México. Implementing organization: Universidad Nacional Autónoma de México	CGIAR: MAIZE CRP Competitive Partners' Grant	Mexico	yes			yes	
84	Desarrollo y promoción del uso de semillas mejoradas en el sur de Mexico y Centro América para agricultores de temporal. Implementing organization: Universidad Autónoma Chapingo	CGIAR: MAIZE CRP Competitive Partners' Grant	Mexico				yes	
85	Identify/ Optimize strategies for sustainable Management of Tar Spot Complex (TSC) of Maize in Central America and Colombia. Implementing organization: Universidad Autónoma de Chiapas (UNACH)	CGIAR: MAIZE CRP Competitive Partners' Grant	Mexico				yes	
86	Identify/ Optimize strategies for sustainable Management of Tar Spot Complex (TSC) of Maize in Central America and Colombia. Implementing organization: Universidad de San Carlos, Guatemala	CGIAR: MAIZE CRP Competitive Partners' Grant	Mexico				yes	
87	MasAgro	SAGARPA	Mexico	yes	yes	yes		yes
88	Resistance Mechanism of Maize to Tar Spot Complex and Germplasm Selection. Implementing organization: INIFAP	CGIAR: MAIZE CRP Competitive Partners' Grant	Mexico		yes	yes		
89	Retention of provitamin A carotenoids and anthocyanin content in traditional maize food products	Mexican Council of Science	Mexico					yes

90	La Panamericana supporting a more sustainable intensification of family agriculture in Central America: CIAT	CGIAR: MAIZE CRP Competitive Partners' Grant	Nicaragua	yes			yes	
91	Peru-Apoyo al CIMMYT para generar technologias rentables y ambientalmente	Government of Peru	Peru			yes		

3.16 MAIZE Existing and Potential Partners (as of March 2016)

Note: MAIZE has more than 350 research and development partners worldwide. The table below is a non-exhaustive list of the major partners either already involved in MAIZE projects during Phase-I or can be potential partners in MAIZE Phase-II.

S. No.	Reference to specific or multiple CoA and/or FP	Partner Institution	Type of organization (standardization of type)	Existing partner?	Purpose of collaboration (indicative, and not certainly exhaustive)	Competitive advantage of the partner
1	MAIZE FPs	Australian Centre for International Agricultural (ACIAR)	Government Agency	Yes	Strategy planning and implementation. Financial support	Regional strategy development and implementation
2	MAIZE FPs	Bill and Melinda Gates Foundation (BMGF)	International cooperation agency / donor	Yes	Strategy planning and implementation. Financial support for maize breeding, seed systems and maize agronomy/production.	Regional strategy development and implementation; advocacy partnerships and networking
3	MAIZE FPs	Global Affairs Canada	Government Agency	Yes	Strategy planning and implementation. Financial support	Regional strategy development and implementation
4	MAIZE FPs	Deutsche Gesellschaft für Internationale	Government Agency	Yes	Strategy planning and implementation. Financial support	Regional strategy development and implementation;
5	MAIZE FPs	Ethiopian Institute of Agricultural Research (EIAR)	NARES	Yes	Development, demonstration and promotion of improved maize technologies and practices	Previous experience in an array of projects on maize R&D in Ethiopia

6	MAIZE FPs	Indian Council of Agricultural Research (ICAR), Indian Institute of Maize Research (IIMR), and All-India Coordinated Research Project on Maize	NARES	Yes	Partner in maize breeding; phenotyping sites with representative agro-ecology in target environments; IMIC partner; conservation agriculture; socio-economics.	Previous experience in an array of projects on maize R&D in India.
7	MAIZE FPs	SAGARPA -Secretaria de Agricultura, Ganaderia, Desarrollo	Government agency	Yes	Strategy planning and implementation. Financial support	Previous experience in an array of projects on maize R&D in Mexico.
8	MAIZE FPs	Swiss Agency for Development and Cooperation	Government agency	Yes	Strategy planning and implementation. Financial support	Regional strategy development and implementation
9	MAIZE FPs	USAID	International cooperation agencies (e.g., CIRAD or GIZ)	Yes	Strategy planning and implementation	Regional strategy development and implementation, advocacy partnerships and networking
10	MAIZE FPs	Various media (print, audio, visual and web-based)	Other (specify)	Yes	Advocacy and extension	Awareness creating, capacity development and implementation
11	MAIZE FPs	Various National Agriculture Research Organizations in SSA, Asia and Latin America	NARES	Yes	Phenotyping, breeding, seed systems, data collection, training and data analysis. Germplasm evaluation and release. Lead surveys and survey report analysis. Participate in joint research publication. Lead and organize research outreach activities. Generate technology, provide training to extension agents, farmers and other partners; receive training. Surveys, consumer	Physical resources (land, irrigation), human capacity, strong evaluation network, locally adapted germplasm, links to small and medium-size seed sectors. Research collaboration and implementation, incl. context-specific knowledge, expertise and policy linkages. Competent in capacity building. Technology evaluation and dissemination. Rich experience in research

					preferences, processing	and variety release and registration.
12	MAIZE FPs	Various universities (in-country and ex-patriate)	University	Yes	Leverage quality resources to maximize research and technical capacity building	Experience and well-established facility for research and training
13	MAIZE FPs	Nepal Agricultural Research Council (National Maize Research Program)	NARES	Yes	Enhancing maize production and productivity through the best varieties and nutrient management practices in Nepal	Geographic location. Increase production and productivity of maize and maize-based cropping system for improving the food and feed security in Nepal
14	1.1	DLO/LEI (Ruben and team)	ARI	Yes	Yield gap analysis; poverty, food security and nutrition linkages	
15	1.1	PEP	International NGO	Yes	Economy-wide modeling	Previous experience
16	1.1	Tamil Nadu Agricultural University	University	Yes	Production Risks and Welfare Implications of Maize Hybrids on the Subsistence Farms of South India	Location, expertise
17	1.1	Universidad Nacional Autónoma de México	University	Yes	Assessment of maize-based farming systems and their contribution to food secure and resilient farms in The Mountain region of Guerrero, México	Expertise
18	1.1	University of the Free State	University	Yes	Taking stock: the evolving nutritional roles of maize for human nutrition through food and feed in developing countries	Expertise
19	1.1	University of Pretoria	University	Yes	Maize foresight and targeting poor maize consumers:	Experience

					research implications	
20	1.2	Ethiopian Public Health Institute (EPHI)	NARES	Yes	Impact assessment in health and nutrition	Knowledge and experience in health and nutritional impacts in Ethiopia
21	1.2	Gottingen University	ARI	Yes	Nutritional impacts	Previous experience
22	1.2	Institute of Agricultural research of Mozambique - IIAM	NARES	Yes	Increasing sustainable agricultural production in Mozambique (Maize/Legume) through conservation agriculture.	Expertise, Location
23	1.2	Norwegian University of Life Sciences	University	Yes	Conduct research on impact of maize biofortification and storage on human nutrition and health using RCTs, household modeling and CGE; capacity building	Scientific expertise in nutrition, health and statistics, RCTs, bio-economic and household modeling and computable general equilibrium (CGE) complements well with ours
24	1.2	Other CRPs – ME&L Community of Practice	Other CGIAR centers	Yes	Develop consistent and aligned ME&L framework, share best practices, build capacity	Research and capacity building
25	1.2	ReNAPRI (Regional Network of Agricultural Policy Research Institutes in Africa)	Other	Yes	Policy dialogue and data analysis	ReNAPRI has a comparative advantage in outreach activities and reaching policy makers. It is a network of seven national agricultural policy research institutes (DR Congo, Kenya, Tanzania, Malawi, Mozambique, South Africa and Zambia)
26	1.2	Southern University and A&M College	University	Yes	The Dynamics of Improved Maize Varieties Adoption in Tanzania	Expertise, location

27	1.2	Virginia Tech (Alwang and team)	ARI	Yes	Impact assessment	Previous experience
28	1.3	International Plant Institute -IPNI -Africa Program	ARI	Yes	Ex-ante assessment of Agronomic and Economic benefits of fertilizer use in maize production under variable farm, climatic and soil fertility conditions in Kenya and Zimbabwe/ Enhancing the capacity for dissemination of site-specific maize production intensification technologies under variable farm, climatic and soil fertility conditions in Kenya and Zimbabwe.	Expertise in smallholder precision nutrient management, decision support tools for diverse farming systems
29	1.3	International Plant Institute (IPNI) - Asia Program	ARI	Yes	Assessment of agronomic and economic benefits of fertilizer use in maize production systems under variable farm size, climate and soil fertility conditions in Eastern India. Agronomic, economic, social and environmental benefits of improved nutrient management practices in maize production systems under variable farm size, climate, soil fertility conditions and farmer resource endowment in India and Nepal	Expertise in smallholder precision nutrient management, decision support tools for diverse farming systems

30	1.3	Zambia Agriculture Research Institute	NARES	Yes	Develop and adapt crop, soil and plant protection technologies so as to provide a high-quality, appropriate and cost effective service to farmers	Largest agricultural research entity in the country.
31	2.1	CIMAT	Research Institute	Yes	Research center of excellence and scientific development; recognized nationally and internationally; strengthened its convening and integration of a critical mass in groups of high scientific performance, and be a model of efficiency and growth and social impact for other research centers.	Previous experience
32	2.3	COLPOS	University	Yes	Genetic analysis, phenotyping	Good previous experience; Genetic resource research
33	2.3	North Carolina State University, USA	University		Contributing to genetic analysis and identification of donor germplasm and alleles	Expertise in genetic resource research
34	2.4	Dow AgroSciences	Multinational private sector		1) Drought evaluation; 2) Heat evaluation; 3) Fusarium ear rot evaluation; 4) Tar spot evaluation	Geography (sites in key areas where CIMMYT does not have a station), expertise in phenotyping, in-kind services for planting and harvesting
35	2.4	Universidad Autónoma Agraria Antonio Narro	University		Abiotic and biotic stress evaluation	Geography (sites in key areas where CIMMYT does not have a station)

36	2.4	Universidad Autónoma de Nuevo León	University		Fusarium ear rot evaluation	Geography (sites in key areas where CIMMYT does not have a station). Expertise in Fusarium ear rot evaluation.
37	3.1	DICTA	NARES	Yes	Local testing of improved germplasm. Phenotyping for key diseases in hot spots	Local presence, infrastructure, hot spot and expertise
38	3.1	DuPont-Pioneer	Multinational private sector	Yes	In Mexico: 1) Drought evaluation 2) Heat evaluation 3) Fusarium ear rot evaluation 4) Tar spot evaluation; In Asia: Heat tolerant maize	Expertise in genomics, transgenic technologies, phenotyping, DH, seed systems, and in-kind services
39	3.1	Free State University	University	Yes	Training of Ph.D. students	Strong history of collaboration in breeding
40	3.1	GMRI, China	NARES	Yes	Phenotyping sites with representative agro-ecology in target environment	Geographical location. Previous experience on abiotic and biotic stress breeding and phenotyping
41	3.1	IAS, Ho Chi Minh city, Vietnam	NARES		Phenotyping sites with representative agro-ecology in target environment	Geographical location. Previous experience on abiotic and biotic stress breeding and phenotyping
42	3.1	ICTA	NARES	Yes	Local testing of improved germplasm. Phenotyping for key diseases in hot spots	Local presence, infrastructure and expertise
43	3.1	IDIAP (Panama)	NARES	Yes	Local testing of improved germplasm. Phenotyping for drought	Local presence, infrastructure, dry environment and expertise

44	3.1	INTA (Nicaragua)	NARES	Yes	Local testing of improved germplasm. Phenotyping for key diseases in hot spots	Local presence, infrastructure, hot spot and expertise
45	3.1	MMRI, Pakistan	NARES	Yes	Heat stress phenotyping sites with representative agro-ecology in target environment	Geographic location. Previous experience on abiotic and biotic stress breeding and phenotyping
46	3.1	NMRI, Hanoi, Vietnam	NARES	Yes	Phenotyping sites with representative agro-ecology in target environment	Geographic location. Previous experience on abiotic and biotic stress breeding and phenotyping
47	3.1	NSFCRC, Thailand	NARES	Yes	Phenotyping sites with representative agro-ecology in target environment	Geographic location. Previous experience on abiotic and biotic stress breeding and phenotyping
48	3.1	Universidad de San Carlos	University	Yes	Phenotyping for key diseases in hot spots	Local presence, infrastructure and expertise
49	3.1	University of Leeds, UK	University	Yes	Meta-data analysis combined with climate data	Leading in climate projections (lead author of IPCC) and agricultural modeling
50	3.2	DSMZ, Germany	ARI	Yes	Diagnostics and virology	Experience in diagnostics
51	3.2	IAPSC	International cooperation agency	Yes	Surveillance, phytosanitary policy and advocacy	African regional phytosanitary body
52	3.2	ICIPE	ARI	Yes	MLN vector ecology and biocontrol	Expertise in entomology
53	3.2	RECs (CORAF, ASARECA, ACTESA)	International cooperation agency	Yes	Policy, advocacy, capacity development	African regional agricultural policy and implementation
54	3.2	Regional Seed Trade Associations (e.g., AFSTA)	Other	Yes	Supporting commercial seed sector for MLN-free seed production; policy and advocacy; phenotyping sites	Development of seed enterprise capacity in Africa; niche phenotyping network; technology scaling up

					with representative/distinct agro-ecology in target environment	
55	3.2	University of Western Australia	University		Epidemiology	Modeling
56	3.2	University of KwaZulu-Natal South Africa	University	Yes	Introgression of host plant resistance to aflatoxin and fumonisins contamination into adapted and elite line parents of maize hybrids	leading institution of higher learning on the African continent
57	3.2	USDA-ARS/Ohio State University	National agriculture research organizations (NARS)	Yes	MLN epidemiology and genetics	Experience in maize virology
58	3.2	Various regulatory agencies in Africa	Ministries or other public offices (not public research organizations)	Yes	Quarantine; pest/disease surveillance monitoring; seed certification; policy and regulatory guidelines	Capacity development and policy implementation
59	3.2	Various NPPOs (National Plant Protection Organizations in eastern and southern Africa)	Government	Yes	MLN Phytosanitary Community of Practice	Regulatory role in phytosanitation
60	3.3	National Maize Research Program-Nepal	NARES	Yes	Identification and dissemination of farmers' preferred nutritious maize varieties suitable for food, feed, silage and fodder in Nepal	Previous Experience

61	3.3	University of Flinders (Australia)	University	Yes	Contribute to develop and validate methodologies (quality traits)	Good previous experience in developing and validating micronutrient analytical tools to support breeding programs
62	3.3	University of Wisconsin	University	Yes	Carotenoid expertise	Provide scientific capacity for provitamin A maize
63	3.3	Various health and nutrition clinical agencies	Other (specify)	Yes	Evaluate nutritional quality of genotypes (e.g., QPM)	Well-equipped labs and experience in nutritional assessment
64	3.4	International Center for Bio-saline Agriculture (ICBA), Dubai	ARI		Salt tolerance phenotyping tools and system	Expertise in phenotyping tools and salt stress technologies
65	3.4	University of Barcelona, Spain	University	Yes	Collaboration in developing, validating and deploying digital imaging platform for phenotyping	Expertise in digital imaging platform and maize physiology
66	3.6	Hariyali Community Seed Company Pvt. Ltd. Nepal	Private Sector	Yes	Identification and deployment of improved maize varieties to promote food security, nutrition and economic growth of disadvantaged farmers in the hills of Nepal	Community based seed production in remote areas of Nepal
67	3.6	Kasetsart University	University	Yes	Economics of maize seed production in Thailand	Expertise, location
68	3.6	NASECO Seeds Ltd.	Private Sector	Yes	Fulfill the need for improved seeds of the farming community in Uganda and beyond, to help them build more prosperous and successful lives	Contributes to food security by being a leading supplier of improved seeds for food crops in Uganda and the Great Lakes Region.

69	3.6	SEAN Seed Service Centre Limited (SSSC)	Private Sector	Yes	Identification and promotion of multiple stress tolerant high yielding and low cost hybrids towards doubling maize productivity in mid-hills of Nepal	Expertise
70	3.6	SeedCo Ltd.	Private Sector	Yes	Seed Co develops and markets certified crop seeds, mainly hybrid maize seed, but also cotton seed, wheat, soya bean, barley, sorghum and ground nut seed.	Expertise and location
71	3.6	Semilla Nueva	National NGO	Yes	Local testing of improved germplasm	Local presence, infrastructure and expertise
72	3.6	Suba Agro-Trading & engineering Co. Ltd.	Private Sector	Yes	Identification of multiple stress tolerant, high yielding, easy to produce and low cost hybrids for smallholder farmers in mid-altitude zone of Northern Tanzania	Reliable extension service a nationwide distribution network and infrastructures, a team of highly qualified personnel as well as extensive and well-tailored product range. We also provide key technology on input use and management.
73	3.6	Somali Agricultural Technical group	Private Sector	Yes	Test drought-tolerant maize hybrids in the Lower Shebelle region of Somalia	Cooperate with international, national, regional, and local communities in the sustainable development of Somali agriculture, and conservation of the natural resource base to solve the prevailing food crisis in Somalia

74	3.6	G. B. Pant University of Agriculture & Technology, Pantnagar, India	University	Yes	Promotion on hybrid maize through evaluation seed production and on farm demonstration	Expertise in plant breeding
75	3.6	University of Agricultural Sciences, Raichur, India	University	Yes	Testing and deployment of new drought resilient maize hybrids in the rainfed maize regions of Karnataka India	Expertise in plant breeding
76	3.6	Orissa University of Agriculture & Technology, India	University	Yes	Identification Maize Hybrid suitable for rainfed condition of Odisha	Geographical location, expertise
77	3.6	UdeG	University	Yes	Local testing of improved germplasm	Local presence, infrastructure and expertise
78	3.6	WinWin Agri-Tech Ltd., Rwanda	Private Sector	Yes	increase awareness on quality seed production and marketing, and to improve the skills and knowledge among new small seed companies, as quality seed production and marketing are challenges the sector is yet to overcome	Promoting the use of improved maize varieties
79	3.6	Various farmer organizations, CBOs and NGOs	Farmer organizations and CBOs	Yes	On-farm monitoring; technology testing and adoption; Supply and processing of certified seed	Stakeholders and beneficiaries
80	3.6	Various indigenous seed companies and community-based seed producers in target countries	Seed companies	Yes	Produce and market certified seeds of nutrient-rich maize varieties	Endowed with the requisite infrastructure for seed production and marketing. Can sustainably market nutritious maize to farmers

81	3.6	Various Ministries/Bureaus of Agriculture	Ministries or other public offices (not public research organizations)	Yes	Institutionalize ("scale up") improved varieties, practices and equity	Leverage in national-level policies, standards and protocols, including access issues such as finance
82	3.6	Various poultry and farmer associations	Farmer organizations and CBOs	Yes	Provide information on maize needs and preferences. Also link with farmers to purchase maize grain	End users of maize grain
83	3.6	Various seed industry organizations	National private sector		Facilitating communication among partners, end users and regulators, about maize hybrids and resolve conflicts, if any	Communication with partners, end users and national regulators
84	4.1	CIRAD, France	ARI	Yes	Secondment of CIRAD modeler to CIMMYT/Nairobi to support meta-analysis (from Sept. 2015) co-funded by W1/2,TAMASA, and CIRAD	Previous experience
85	4.1	Global Agricultural Monitoring (GEOGLAM)		Yes	Contribution to remote sensing and crop monitoring efforts	Previous experience
86	4.2	Bayero University, Kano (Nigeria)	University	Yes	Development and testing DST for matching maize varieties to environments	Technology development
87	4.2	Savanna Agricultural Institute (Ghana)	NARES	Yes	Evaluate and disseminate maize technologies	Local adaptation of technologies
88	4.2	University of Ghana, Legon (Ghana)	University	Yes	Development and testing of DST to match maize varieties to environments	Technology development

89	4.3	Dryland Seed Ltd -DSL	Private Sector	Yes	Focuses on seed for the drier parts of Kenya	Dryland has taken varieties of a range of crops that researchers had produced and has commercialized them and is changing the lives of thousands of poor people
90	4.3	Oklahoma State University, USA	University	Yes	Collaboration on GreenSeeker technology	Previous experience
91	4.4	Amio (Ethiopia)	National private sector	Yes	Import/ manufacture of 2WTand accessories	Assurance of sustainability.
92	4.4	Bain New Holland, Grownet (Zimbabwe)	National private sector	Yes	Import/ manufacture of 2WTand accessories	Assurance of sustainability.
93	4.4	CSIR-Savanna Agricultural Research Institute	NARES	Yes	Linkages with farmers in the Northern, Upper East and Upper West Regions with appropriate technologies to increase their food and fibre crop production based on a sustainable production system which maintains and/or increases soil fertility	Responsive to farmer needs and national development
94	4.4	IDE	International NGOs	Yes	Facilitate partnerships with the private sector for scaling up	Considerable experience in the development of new technologies. IDE: Lead activities related to market development but under close CIMMYT guidance
95	4.4	Kishen Farm Equipment (Tanzania)	National private sector	Yes	Import/ manufacture of 2WT and accessories	Assurance of sustainability. Manufacturers are likely to contribute
96	4.4	OXFAM	International NGO	Yes	Facilitate partnership with the private sector for scaling up	Considerable experience in the development of new technologies

97	4.4	Save the Children	International NGO	Yes	Facilitate partnership with the private sector for scaling up	Considerable experience in the development of new technologies
98	4.4	World Vision	International NGO	Yes	Facilitate partnerships with the private sector for scaling up	Considerable experience in the development of new technologies. World vision: Broad outreach in eastern and southern Africa. Access to markets and finance
99	4.4	Various financial organizations, incl. micro-finance	National private sector	New	Access to finance for value chain actors for scaling up.	Essential condition for adoption and scaling up
100	4.4	Various private food processing companies	National private sector	Yes	Access to knowledge related to grain quality and sustainability standards	Access to information on nutrition and sustainability indicators and integration of the value chain
101	5.1	Consejo Empresarial de la Industria del Maíz y sus Derivados,A.C. (Enterprise Council for Maize Industry)	National private sector	Yes	Network of maize millers and processors in Mexico	Previous experience linking with maize millers and processors in Mexico
102	5.1	Hampton Creek Co.	International private sector (not multinational)		Exploring plant proteins	Expertise on use of plant-derived proteins in food
103	5.1	Instituto de Nutrición de Centroamérica y Panamá (INCAP) (Nutrition Institute for Central America and Panama)	Ministries or other public offices (not public research organizations)	Yes	Conduct survey on consumption of nutritious foods; evaluate nutrition impact of agricultural interventions	Previous experience
104	5.1	Kellogg’s	International private sector	Yes	Food science and product development	Expertise in food business

105	5.4	Obafemi Awolowo University	University	Yes	The technological flagship of the West African sub-region, as evidenced by its application of modern technology	International Reputation
106	1.1; 1.2; 1.3; 1.4	PIM CRP (IFPRI-led)	Other CGIAR centers and associated partners	Yes	Foresight and bio-economic modeling; global futures (PIM 1.1); science policy (PIM 1.2); ex-post impact assessment (PIM 1.3); gender tools, collaboration; value chain analysis tools (PIM 3)	Previous experience
107	1.1; 1.2; 1.4; 3.4; 4.1; 4.2; 4.3; 4.4; 5.1; 5.2; 5.3; 5.4	Wageningen UR	University	Yes	Inter laboratory assessment (quality traits); conduct research on impact of maize biofortification and storage on human nutrition and health using RCTs; lead the inter-laboratory assessment of analytical platforms hubs. Research on adoption and scaling up. Research on service provider business models. Seed value chains. Leading Activity 5.2. Assessing risk management tools (Managing risk of maize farmers in Zambia)	Provider of high quality and worldwide inter-laboratory tests. Expertise in food product development form harvest to plate

108	1.1; 1.2; 2.3; 4.2; 4.3; 4.4; Capacity development	UC Davis, USA	University	Yes	Advising of Ph.D. and M.Sc. students embedded in MAIZE supported research projects. Research on adoption and scaling up. Research on service provider business models. Impact assessment (DT maize and weather index insurance RCT). Diversity analysis	Expertise in population genetics, genomics, climate adaptation traits
109	1.1; 1.2; 4.1; 4.2; 4.3	Michigan State University, USA	Advanced research institutes (ARIs)	Yes	Conduct research on impact of maize biofortification and storage on human nutrition and health using RCTs; initial contacts with Sieg Snapp to further develop collaboration on maize-legume agronomy in SSA and development of Indicators and metrics for SI (SIIL related), household modeling and CGE; capacity building; modeling DT maize	Their scientific expertise in nutrition, health and statistics, RCTs, bio-economic and household modeling and computable general equilibrium (CGE) complements well with ours
110	1.1; 1.4	University of Pretoria + MSU	University	Yes	Maize markets foresight in SSA	Previous experience
111	1.1; 1.4; 3.1; 4.1; 4.2; 4.3	CCAFS	Other CGIAR centers and associated partners	Yes	To improve crop models, identify changes in future breeding targets, targeting of new technologies for climate-vulnerable hotspots, mining of meta-data, scaling up and out of climate-resilient G/E*M combinations. Bio-economic modeling. Weather index-	CCAFS is leading climate research for agricultural purposes. Working at village level in system mode.

					based insurance	
112	1.1; 2.1; 3.1; 3.2	UMN-InStepp	University	Yes	Impact and foresight of MAIZE. MLN epidemiology. Big Data	Experience in maize virology, socioeconomics, big data analysis
113	1.1; 4.1; 4.2; 4.3	Oak Ridge National Laboratory (ORNL), USA	ARI	Yes	Data analysis and integration; leading the development of Landscape Crop Assessment Tool (LOCAT) funded by CSISA. In Phase II, additional collaborations related to big data and geospatial tools are envisaged	Previous experience
114	1.1; 4.1; 4.2; 4.3; 4.4	Georgia Tech University, USA	University	Yes	Ex-ante impact assessment; valuation reduced risk. Scale-appropriate machinery engineering and prototype development under CSISA. Research on adoption and scaling up. Research on service provider business models	Previous experience
115	1.2; 1.3; 1.4; 4.2	Royal Tropical Institute (KIT)	ARI	Yes	Gender integration, equality and professional capacity enhancement; fuzzy cognitive mapping, games, agent-based simulation (ESAP); agricultural innovation systems, gender and mechanization. Facilitate a greater understand of gender-preferred traits by region/area; seed value chains; mechanization	Leading research groups in gender and agriculture

116	1.2; 3.1; 3.3; 4.4; 5.1; 5.4	Purdue University	University	Yes	Provide source maize germplasm to enhance pro-vitamin A; conduct research on impact of maize biofortification and storage on human nutrition and health using RCTs; partner in HTMA Project; product development and processing. Research on adoption and scaling up. Research on service provider business models. Conduct research on maize drying, mycotoxins and food processing	Critical supplier of novel sources for pro-vitamin A enrichment. Expertise in food product development
117	1.2; 5.4	Harvard School of Public Health	University	Yes	Conduct research on impact of maize biofortification and storage on human nutrition and health using RCTs and household modelling and CGE; capacity building	Their scientific expertise in nutrition, health and statistics, RCTs, bio-economic and household modeling and computable general equilibrium(CGE) complements well with ours
118	1.3; 4.4	WOCAN; Total Landcare; Fondo para la Paz	International NGO	Yes	Research implementation, context-specific knowledge and expertise, subject matter expertise, research-into-use collaboration	Previous experience
119	2.1; 2.2	Tecnologico de Monterrey	University	Yes	Insect tolerance in maize	Good previous experience and expertise on conducting insect bioassays in maize

120	2.1; 2.2	TGAC – The Genome Analysis Centre	Multinational private sector		Genotypic data storage and computationally intensive analysis	Good reputation; performs bioinformatics analysis on multiple, complex data sets; hosts one of the largest computing hardware facilities dedicated to life science research in Europe
121	2.1; 2.2; 2.3	Cornell University	University	Yes	1) Contributing to the ultra-high-density genotypic characterization of maize lines and single plants from populations; 2) Leading the GOBII project to provide solutions for storing and utilizing low-to-ultra-high-density genotypic data in routine (e.g., QC) and advanced (e.g., GS) breeding applications. Research on adoption and scaling up. Research on service provider business models.	Good previous experience; provider of low-cost, high quality data provision and capacity building
122	2.1; 2.2; 2.3	Diversity Arrays Technology (DArT)	Multinational private sector	Yes	1) Genotyping, phenotyping and data analysis; 2) Mobile data capture application and data curation software. Contributing to the high density genotypic characterization of maize lines and populations using single plant and composite methods, expertise on linkage mapping and diversity analysis	Good previous experience; provider of proprietary tools and technologies; low-cost, high quality data provision and capacity building; currently working to establish feasibility of PPP

123	2.1; 2.2; 2.3	Integrated Breeding Platform	Other	Yes	Breeding management system	Co-located with CIMMYT; selected to deliver tools of the GOBII work; developing a system of regional support hubs around the globe; training members of NARS and SMEs in their use; providing a free, open-source product
124	2.1; 2.2; 2.3	James Hutton Institute	ARI	Yes	Phenotypic and genotypic data warehouses and visualization tools. Leading the development and regular update of the Germinate software as well as other data visualization tools including: Genotypic: Flapjack, Strudel; PCA: Curly Whirly; Pedigree: Helium	Good previous experience, good record of providing useful visualization tools; experience with private sector entities but desire to provide open-source software; member of the plant breeding API development group
125	2.1; 2.2; 2.3	Langebio	University	Yes	Genetic analysis, greenhouse phenotyping	Good previous experience. Genetic resource research
126	2.1; 2.3	Huazhong Agricultural University, Wuhan, China	University		1) High-throughput and functional genomics for biotic and abiotic stress tolerance; 2) Candidate gene analysis and marker conversion	1) Expertise on identification of candidate genes and development of trait-specific markers 2) Complementary funding from the national program; research students; expertise
127	2.1; 2.3; 2.4	LGC technologies	Multinational private sector	Yes	Developing final, trait-linked, routinely usable markers: Low density markers and KASP assays	1) Previous experience developing trait-specific markers and genotyping assays. 2) Relatively low cost, efficient in time, reliability

128	2.1; 2.3; 3.1	CAAS	NARES	Yes	Genomic analysis. Contribution to development of the maize pan-genome and markers, and stress tolerant maize.	Genomic data analysis and improvement of the reference genome. Maize breeding.
129	2.2; 2.3	Center for Research and Advanced Studies of the National Polytechnic Institute (CINVESTAV), Mexico	Advanced research institute (ARI)	Yes	Leader in below-ground microbial interactions. Advising of Ph.D. and M.Sc. students embedded in MAIZE-supported research projects. With economic contribution (tuition, costs)	Previous experience
130	2.2; 2.3	DivSeek	International NGO	Yes	Information sharing systems	Will work with existing, emerging and future initiatives to characterize crop diversity and develop a unified, coordinated and cohesive information management platform to provide easy access to genotypic and phenotypic data associated with genebank germplasm.
131	2.2; 2.3; 3.1	University of Hohenheim, Germany	University	Yes	Maize doubled haploid technology. Genomic selection for complex trait improvement in maize.	Jointly developed and deployed tropical haploid inducers. Genetic basis of maternal haploid induction in maize. Models for genomic selection in maize.
132	2.3; 2.4; 3.1	INIFAP	NARES	Yes	1) Drought evaluation; 2) Rapid cycle nursery 3) Phenotyping and data analysis 4) Tar spot evaluation	1) Good previous experience, germplasm experts, GIS resources, geographical advantage; 2) Geography (sites in key areas where CIMMYT does not have a

						station)
133	2.3; 3.1	UAAAN	University	Yes	Phenotyping and data analysis	Geographic advantage. Previous experience on abiotic and biotic stress breeding and phenotyping
134	2.3; 3.1; 3.6	UACH	University	Yes	Genetic analysis, local testing of improved germplasm. Phenotyping for key diseases in hot spots	Good previous experience; genetic resource research. Local presence, infrastructure and expertise
135	2.3; 4.4	University of Texas-Austin	University		Data analysis and capacity building. Research on adoption and scaling up. Research on service provider business models	Expertise in population genetics, genomics, climate adaptation traits, field phenotyping
136	2.4; 3.1	Semillas Moreno Retis	Multinational private sector		Rapid cycle nursery services	Geography (sites in key areas where CIMMYT does not have a station)
137	2.4; 3.1	Servicios Agrobal	Multinational private sector	Yes	Rapid cycle nursery services	Geography (sites in key areas where CIMMYT does not have a station)
138	2.4; 3.1; 3.2; 3.6	Various private medium-size seed companies	Seeds company	Yes	Phenotyping, joint product development, seed deployment, MLN-free commercial seed production; leading local promotion of new technologies and practices. Identifying hybrids for niche target area and supplying seed in a sustainable manner.	Niche phenotyping network, commercially viable germplasm, seed scale-up and marketing. Trial expenses and cost of deployment borne by partner.

139	3.1; 3.2; 3.6	Various small and medium enterprise (SME) seed companies in SSA, Asia and LA.	Seeds companies	Yes	Testing of stress resilience hybrids, lines and OPVs; uptake of new stress resilient germplasm for product development and/or release.	Physical resources (land, irrigation), human capacity, expanded testing network
140	3.1; 3.2; 3.6	AATF (African Agricultural Technology Foundation)	International NGO	Yes	Supporting development and deployment of improved maize hybrids in eastern and southern Africa. Collaboration on transgenic technologies. MLN-free commercial seed production.	Development of seed enterprise capacity in Africa
141	3.1; 3.2; 3.6	Various medium and large seed companies (including Pioneer and Monsanto)	Multinational private sector	Yes	Identification of the best hybrids, rapid multiplication and sell to farmers; MLN diagnostics and MLN-free commercial seed production protocols	Have facility, know-how and dissemination network to rapidly scale up improved hybrids and reach more farmers
142	3.1; 3.2; 3.6; 4.3; 4.4	Syngenta Foundation for Sustainable Agriculture (SFSA)	International NGO	Yes	Abiotic and biotic stress resilient maize germplasm; MLN R4D; advocacy; scale-appropriate mechanization; PPP	Geography (sites in key areas where CIMMYT does not have a station); expertise in phenotyping; in-kind services for planting and harvesting, Public and private partnerships, extension
143	3.1; 3.2; 3.6; 5.2; FP1, FP2, FP4	Kenya Agriculture and Livestock Research Organization (KALRO)	NARES	Yes	Breeding, phenotyping, DH, MLN, consumer acceptance of lime-cooked products, seed systems, conservation agriculture, socioeconomics	Expertise in Kenyan agricultural systems and value chains
144	3.1; 3.3; 3.6	Yunnan Academy of Agricultural Sciences (YAAS), China	NARES	Yes	Phenotyping sites with representative agro-ecology in target environment. Deploying improved maize	Hosts CIMMYT-China team in YAAS. Sub-tropical maize breeding; previous experience on abiotic and biotic stress

					varieties.	breeding and nutritious maize
145	3.1; 3.6	BARI, Bangladesh	NARES	Yes	Phenotyping sites with representative agro-ecology in target environment. Development and delivery of stress tolerant maize.	Geographical location. Previous experience with abiotic and biotic stress breeding and phenotyping
146	3.1; 3.6	CENTA	NARES	Yes	Local testing of improved germplasm; phenotyping for key diseases in hot spots	Local presence, infrastructure and expertise
147	3.1; 3.6	CHIBAS	National NGO		Local testing, promotion and pilot seed production of improved germplasm	Local presence, infrastructure, and expertise
148	3.1; 3.6	CORPOICA	NARES	Yes	Local testing of improved germplasm	Local presence, infrastructure, and expertise
149	3.1; 3.6	CRDD	Ministries or other public offices		Local testing of improved germplasm	Local presence, infrastructure, and expertise
150	3.1; 3.6	FEDERECAFE	National NGO	Yes	Local testing of improved germplasm; phenotyping for key diseases	Local presence, infrastructure, hot spot and expertise
151	3.1; 3.6	FIDAR	National NGO		Local testing of improved germplasm	Local presence, infrastructure, and expertise
152	3.1; 3.6	FIPAH	National NGO	Yes	Local testing of improved germplasm	Local presence, infrastructure and expertise
153	3.1; 3.6	ICeRI, Indonesia	NARES	Yes	Phenotyping sites with representative agro-ecology in target environments	Geographical location. Previous experience on abiotic and biotic stress breeding and phenotyping
154	3.1; 3.6	INIA (Peru)	NARES	Yes	Local testing of improved germplasm	Local presence, infrastructure, and expertise
155	3.1; 3.6	INIA (Venezuela)	NARES		Local testing of improved germplasm	Local presence, infrastructure, and expertise

156	3.1; 3.6	INIAF (Bolivia)	NARES	Yes	Local testing of improved germplasm	Local presence, infrastructure, and expertise
157	3.1; 3.6	INIAP (Ecuador)	NARES	Yes	Local testing of improved germplasm	Local presence, infrastructure, and expertise
158	3.1; 3.6	Jullundur Pvt. Limited	Private Sector	Yes	Evaluation & commercialization of CIMMYT maize hybrids resilient for drought and heat tolerance in Pakistan	Geographical location, expertise
159	3.1; 3.6	Novasem, Mexico	Multinational private sector	Yes	1) Drought evaluation 2) Heat evaluation 3) Fusarium ear rot evaluation 4) Phenotyping; 5) Deployment of improved maize hybrids	Geography (sites in key areas where CIMMYT does not have a station), expertise in phenotyping, in-kind services for planting and harvesting
160	3.1; 3.6	ORE	National NGO	Yes	Local testing, promotion and pilot seed production of improved germplasm	Local presence, infrastructure, and expertise
161	3.1; 3.6	Selected State Agriculture Univeristies (SAUs)	University	Yes	Phenotyping, breeding, seed systems, physical infrastructure for DH facility	Strong evaluation network; locally adapted germplasm; links to small and medium seed sector
162	3.1; 3.6	University of Agricultural Science, Bangalore	University	Yes	Evaluation and deployment of stress resilient maize hybrids (derived through MAIZE CRP) in the rainfed maize regions of Southern Karnataka	Expertise in plant breeding
163	3.1; 3.6	Various NGOs	National NGOs	Yes	Provide training to farmers and other partners; receive training. Hybrid testing for deployment	Competent in seed marketing. Localized presence. Grassroot reach in target regions

164	3.1; 4.1; 4.2; 4.3	Stanford University	University	Yes	Meta-data analysis combined with climate data; new research collaboration is under discussion for crop monitoring work in South Asia under CSISA Phase III	Leading in modeling and meta-data analysis
165	3.1; 5.1	EMBRAPA	NARES	Yes	Knowledge exchange in breeding for low soil fertility and maize product development and processing	EMBRAPA has made major advances in maize breeding for low P and soil acidity (through conventional and molecular techniques). Expertise on food product development form harvest to plate
166	3.1; 5.2	University of Nairobi, Kenya	University	Yes	Food science in target country. Breeding for aflatoxin resistance	Expertise in food science and local maize consumption in Kenya
167	3.2; 3.6	Alliance for Green Revolution in Africa (AGRA)	International NGO	Yes	Supporting commercial seed sector for MLN-free seed production; policy and advocacy for improved seed delivery.	Development of seed enterprise capacity in Africa
168	3.2; 4.2; 4.3	Washington State University (USA)	University	Yes	MLN virology and genetics. Conservation agriculture.	Experience in *Potyvirus* virology
169	3.3; 4.1; 4.2; 4.3; FP5	ILRI	CGIAR center	Yes	Good previous experience in identifying superior maize for livestock, feed and fodder phenotyping (quality traits); integrated research in mixed crop-livestock systems (Ethiopia, Zimbabwe, South Asia). To be further developed	Development of maize for feed; lead the feed and fodder phenotyping platform to support breeding of dual-purpose maize

170	3.3; 5.1	A4NH	Other CGIAR centers and associated partners	Yes	Survey and consumption of nutritious foods	Cross-cutting CRP on Agriculture for Nutrition and Health
171	3.4; 4.1; 4.2; 4.3	Quanta Lab, Cordoba, Spain	ARI	Yes	Collaboration on developing, validating and deploying digital imaging platform for phenotyping. World leading group on UAV remote sensing, high resolution image analysis to support our PA work. W1/2 grant recipient	Expertise in digital imaging platform and data processing
172	3.6; 4.2	BRAC	International development organization	Yes	Ensure sufficient food and nutrition through maize cultivation for marginalized groups of people in Bangladesh	Considerable experience in agricultural development
173	3.6; 4.2	Meru Agro-Tours & Consultants Co. Ltd. (Meru)	Local Private Sector	Yes	Specializes in Agricultural inputs business. Currently the main business activities and services are multiplication, distribution and retailing of agro seeds; importation, distribution and retailing of agrochemicals, fertilizers, agricultural equipment and provision of advisory services on farm input use and management	Agro input business in Northern Tanzania and through its network of agents/stockiest for the rest of the country.
174	3.6; 4.4	CARE	International NGO	Yes	Facilitate partnerships with the private sector for scaling up	Considerable experience in the development and scaling of new technologies and innovations

175	3.6; 4.4	Catholic Relief Services	International NGO	Yes	Facilitate partnerships with the private sector for scaling up	Considerable experience in development and scaling of new technologies and innovations
176	3.6; 4.4	Institute of Agricultural Research (IAR) (Nigeria)	NARES	Yes	Evaluate and disseminate maize technologies	Local adaptation of technologies
177	3.6; 4.4	World Vision; Plan Intl; Save the Children, etc.	International NGO	Yes	Large-scale technology dissemination	Experience in and dedication to livelihood and health promotion
178	3.6; 4.4	Various extension services	Extension agencies	Yes	Conduct training for farmers and other partners, and promote the adoption of improved seed	Competent in technology transfer
179	3.6; 4.4	Various multinational private sector input providers (Synenta, BASF, …)	Multinational private sector	Yes	Access to marketing networks, efforts and methodologies; import/ manufacture of 2WTand accessories. For identifying hybrids for niche target areas and supplying seed in a sustainable manner	Outreach capacity. Assurance of sustainability
180	3.6; 4.4	Various SME (seed and input suppliers, grain processors, input suppliers)	National private sector	Yes	Distribute seed to farmers; process and market grain and grain products; supply inputs	Competent in seed marketing; competent in grain processing and marketing
181	3.6; FP5	Various maize industries	National private sector	Yes	Provide info on sector preferences; link farmers to purchase maize grain	End users of maize grain
182	4.1; 4.2	FAO	International cooperation agency	Yes	Surveillance, policy and advocacy. Collaboration under FACASI on CA and joint development of training materials.	Global network and experience in implementing regional surveillance programs

183	4.1; 4.2; 4.3	CIAT	CGIAR center	Yes	Farm level analysis and trajectories, data on crops common in maize-based systems and common bean breeding and agronomy	Previous experience
184	4.1; 4.2; 4.3	Earth Institute at Columbia University, USA	University	Yes	Collaboration on geospatial issues through TAMASA + AfSIS linkages	
185	4.1; 4.2; 4.3	DCL CRP	Other CGIAR centers and associated partners		Providing legume germplasm. Development and harmonization of methods and approaches	Site sharing. Collaborative work in agro-ecologies where maize and millet/sorghum co-exist (Southern and West Africa)
186	4.1; 4.2; 4.3	International Institute for Applied Systems Analysis (IIASA), Austria	ARI	Yes	Development of indicator, metrics to assist SI assessment at landscape and regional scale. Land use/land cover change analysis. Crowd sourcing of environmental indicators	Development of data capturing, acquiring and analytical strategies in the cocntext of ICT4Agr efforts
187	4.1; 4.2; 4.3	International Plant Nutrition Institute (IPNI), Canada	ARI	Yes	Development of nutrient expert decision support tool for maize. MAIZE W1/2 Asia and Africa and TAMASA subgrantee	Expertise in smallholder precision nutrient management, decision support tools for diverse farming systems
188	4.1; 4.2; 4.3	Kansas State University, USA	University	Yes	Collaboration under Sustainable Intensification Innovation Lab (SIIL). Regional SIIL coordinator based at CIMMYT Bangladesh. Future work to develop indicators and metrics for SI. Small-scale mechanization. Several	Previous experience

					project proposals recently submitted to KSU/SIIL	
189	4.1; 4.2; 4.3	KU Leuven, Belgium	University	Yes	TAMASA Ph.D. scholarships and graduate students co-supervision in Mexico	Previous experience
190	4.1; 4.2; 4.3	Universidad Autónoma Metropolitana (UAM), Mexico	University	Yes	Contributing to development and implementation of multi-scale farming systems analysis in Mexico; leverage quality resources to maximize research and technical capacity building	Experience and well-established facility for research and training
191	4.1; 4.2; 4.3	Université Catholique de Louvain, Belgium	University		Development of ESA Sentinel-2 project to support remote sensing work to be developed during P. Defourny's sabbatical leave at CIMMYT in 2016	Previous experience
192	4.1; 4.2; 4.3	University of Twente, ITC, Netherlands	University	Yes	Remote sensing (STARS project)	Previous experience
193	4.1; 4.2; 4.3	Water Center at Columbia University, USA	University		Geospatial water-related research under CSISA Phase III	Strong expertise in key research topics
194	4.1; 4.2; 4.3	WHEAT	WHEAT partners	Yes	Deep synergies between the two CRPs FP4 with common design, methodologies and technical innovation. Large bilateral projects covering both crops (CSISA, SRFSI, MasAgro)	Previous experience
195	4.1; 4.2; 4.3	WLE	Other CGIAR centers		Soil conservation at landscape scale. Development and harmonization of methods	Strong expertise in key research topics, shared locations and goals.

					and approaches. Site sharing	
196	4.2; 4.3	Charles Sturt University, Australia	University	Yes	Research on mechanization in support of FACASI. W1/2 funding	Previous experience
197	4.2; 4.3	CSIRO, Australia	ARI	Yes	Salinity assessment, hydrological assessment, APSIM. Work in Bangladesh under CSISA-MI and SRFSI	
198	4.2; 4.3	ICRAF	CGIAR center	Yes	Collaboration under Tree for Food Project. New collaboration to be developed for soil quality indices and rapid soil quality assessment	Previous experience; hosts CIMMYT-Kenya team
199	4.2; 4.3; 4.4	RICE (old GRiSP) CRP	Other CGIAR centers and associated partners	Yes	Joint work in South Asia (e.g., CSISA); possibilities of site integration	Builds on same framework as rice crop manager
200	Capacity development	Texas A&M (Agricultural and Mechanical College of Texas)	University	Yes	Training and capacity development	Strong history in plant breeding and training
201	Capacity development	University of California, Davis – African Plant Breeding Academy (AfPBA)	University	Yes	Training and capacity development	Good experience in organizing capacity development courses for local partners in Africa
202	FP5	University of Vienna, Austria	University	Yes	Development of cheap/accurate aflatoxin detection kit.	Experience in aflatoxin detection.
203	FP5	Various national institutes of food processing and post-harvest technologies	National private sector		Sample testing	Laboratory facilities

3.17 Technical Competencies of Selected Key Partners of MAIZE

Note: MAIZE has more than 350 research and development partners worldwide, including an array of outstanding scientists and professionals. Since it is not possible to highlight the technical competencies of all these partners here due to space limitation, we present here a limited number of key partners who serve as Principal Investigators of MAIZE-supported projects and/or provided significant inputs for MAIZE Phase-II conceptualization. We acknowledge the invaluable support and contributions of all other partners who could not be listed here.

FP1: Enhancing MAIZE's R4D Strategy for Impact

Principal Investigator / Key Collaborator	Organization	Key Project(s) / Product(s)	Relevant Key Publications / Experience
Erwin Bulte	Wageningen Univ	Impact assessment	Bulte, E., Beekman, G., Di Falco, S., Hella, J., & Lei, P. (2014). Behavioral Responses and the Impact of New Agricultural Technologies: Evidence from a Double-blind Field Experiment in Tanzania. AJAE, 96(3), 813-830
Michael Carter & Travis Lybbert	Univ. of California, Davis	Impact assessment (drought tolerant maize & weather index insurance randomized-control trials)	Carter, M. R., Laajaj, R., & Yang, D. (2013). The Impact of Voucher Coupons on the Uptake of Fertilizer and Improved Seeds: Evidence from a Randomized Trial in Mozambique. AJAE, 95(5), 1345-1351. Lybbert, T. J., Magnan, N., Bhargava, A. K., Gulati, K., & Spielman, D. J. (2013). Farmers' Heterogeneous Valuation of Laser Land Leveling in Eastern Uttar Pradesh: An Experimental Auction to Inform Segmentation and Subsidy Strategies. AJAE, 95(2), 339-345.
Nilupa Gunaratna	Harvard Univ	Nutritional impacts	Gunaratna, N. S., De Groote, H., Nestel, P., Pixley, K. V., & McCabe, G. P. (2010). A meta-analysis of community-based studies on quality protein maize. Food Policy, 35(3), 202-210.
Thomas Jayne	Michigan State Univ.	Maize markets foresight in SSA	Jayne, T. S., Chamberlin, J., & Headey, D. D. (2014). Land pressures, the evolution of farming systems, and development strategies in Africa: A synthesis. Food Policy, 48, 1-17.
Genti Kostandini	Univ. of Georgia	Ex-ante impact assessment; valuation reduced risk	Kostandini, G., La Rovere, R., & Abdoulaye, T. (2013). Potential impacts of increasing average yields and reducing maize yield variability in Africa. Food Policy, 43, 213-226.
Ruerd Ruben	Wageningen Univ Research Centre/DLO	Yield gap analysis; poverty, food security and nutrition linkages	Ruben, R., & Pender, J. (2004). Rural diversity and heterogeneity in less-favoured areas: the quest for policy targeting. Food Policy, 29(4), 303-320.

Phil Pardey	Univ. of Minnesota	Ex ante impact and foresight	Pardey, P. G., Beddow, J. M., Hurley, T. M., Beatty, T. K. M., & Eidman, V. R. (2014). A Bounds Analysis of World Food Futures: Global Agriculture Through to 2050. Australian Journal of Agricultural and Resource Economics, 58(4), 571-589.
Franz Wong	Royal Tropical Institute (KIT)	Gender integration, equality and professional capacity enhancement	Wong, F. F. (2012). The micro-politics of gender mainstreaming: the administration of policy in humanitarian work in Cambodia. Gender & Development, 20(3), 467-480.
Matin Qaim	Gottingen	Nutritional impacts	Qaim, M., & Kouser, S. (2013). Genetically Modified Crops and Food Security. PLoS ONE, 8(6), e64879
Ken Cassman; Martin van Ittersum	Univ. of Nebraska; Wageningen UR	Agro-ecological spatial framework for improved upscaling, impact assessment, and locating fieldwork and innovation testing	Van Bussel, L.G.J., P. Grassini, J. van Wart, J. Wolf, L. Claessens, H. Yang, H. Boogaard, H. de Groot, K. Saito, K.G. Cassman and M.K. van Ittersum. 2015. From field to atlas: Upscaling of location-specific yield gap estimates. Field Crops Res. 177: 98–108; Van Wart J, van Bussel LGJ, Wolf J, Licker R, Grassini P, Nelson A, Boogaard H, Gerber J, Mueller ND, Claessens L, van Ittersum MK, Cassman KG. 2013. Use of agro-climatic zones to upscale simulated crop yield potential. Field Crops Res. 143:44-55

FP2: Novel Diversity and Tools for Increasing Genetic Gains

Principal Investigator / Key Collaborator	**Organization**	**Key Project(s) / Product(s)**	**Relevant Key Publications / Experience**
David Marshall	James Hutton Institute	Germinate Database; Genomic data visualization software tools (e.g. Curly Whirly); Genomic analyses	Milne, I, **David Marshall.** 2013. Using tablet for visual exploration of second-generation sequencing data. Brief Bioinform. 14(2):193-202.
Edward Buckler	Cornell University	Seeds of Discovery and others; Genomic data analysis, allele mining	Tian, F., E.S. Buckler. 2011. Genome-wide association study of leaf architecture in the maize nested association mapping population. Nature Genetics 43:159-162.
Peter Wenzl	DivSeek/Global Crop Diversity Trust	Seeds of Discovery and similar; trait discovery; applied genomics research	Akbari, M., P. Wenzl, A. Kilian. 2006. Diversity arrays technology (DArT) for high-throughput profiling of the hexaploid wheat genome. Theor Appl Genet 113:1409-1420.

John Hickey	Roslin Institute, University of Edinburg	Applied genomic selection models	Clark, S.A., J.M. Hickey, H.D. Daetwyler and J.H.J. van der Werf. 2012. The importance of information on relatives for the prediction of genomic breeding values and the implications for the makeup of reference data sets in livestock breeding schemes. Genetics Selection Evolution 44:4
Fernando Gonzalez	DuPont Pioneer, Mexico	MasAgro, SeeD and others. Provide phenotyping sites for key traits, e.g. GLS and tar spot	DuPont Pioneer is a key private sector partner for phenotyping and breeding collaboration.
Ricardo Ernesto Preciado	INIFAP Mexico	MasAgro, SeeD and others. Oversees phenotyping and breeding nursery site.	INIFAP (Mexico) is a key National Program partner that provides access and technical support at several locations in Mexico.
Ruairidh Sawers	CINVESTAV-Langebio, Mexico	MasAgro, SeeD. Genomics expertise; gene discovery and validation.	Gonzalez-Munoz, E., R.J.H. Sawers. 2015. The maize (*Zea mays* ssp. *mays* var. B73) genome encodes 33 members of the purple acid phosphatase family. Front. Plant Sci. 6:341. doi: 10.3389/fpls.2015.00341
James Holland	North Carolina State Univ -	MasAgro, SeeD and others. Pre-breeding (use of genetic resources); genomics	McMullen, M.D.,… J.B. Holland and E.S. Buckler. 2009. Genetic Properties of the Maize Nested Association Mapping Population. Science 235:737-740.
Jianbing Yan	Huazhong Agricultural University, Wuhan, China	SeeD and other projects. Genomics; marker development expertise.	Li, H.,… and J. Yan. 2013. Genome-wide association study dissects the genetic architecture of oil biosynthesis in maize kernels. Nat. Gen. 45:43-50.
Andrzej Killian	Diversity Arrays Technology	MasAgro, SeeD and others. Next generation sequencing technology and associated expertise	Milczarski, P.,… A. Kilian and M. Rackoczy-Trojanowska. 2011. A High Density Consensus Map of Rye (Secale cereale L.) Based on DArT Markers. PLoS ONE 6(12): e28495
Sidney N. Parentoni	EMBRAPA Brazil	SeeD and others; discover & apply haplotypes for biotic & abiotic stress; develop predictive models incorporating high density markers, GxE effects.	Teixeira FF, S.N. Parentoni,…and M.J. Cardoso. 2010. Evaluation of maize core collection for drought tolerance. Crop Breed. Appl. Biotech. 10:312-320

FP3: Stress Tolerant and Nutritious Maize

Principal Investigator / Key Collaborator	Organization	Key Project(s) / Product(s)	Relevant Key Publications / Experience
Mark Edge	Monsanto	Water Efficient Maize for Africa (WEMA) Project Lead for Monsanto	Mark Edge's expertise is in biotech research ánd seed business development. He is responsible for leading commercial introduction of Monsanto's biotech corn drought trait and developing commercial business related to water management issues. Previously, he was Monsanto's Europe and Africa marketing team leader.
Marc Albertsen	DuPont-Pioneer	Improved Maize for African Soils (IMAS) project (funded by BMGF and USAID) Project Lead for DuPont-Pioneer	Marc is DuPont Fellow, Research Director, and leader of Pioneer's reproductive biology group, a research discovery and development group assembled to increase the reproductive productivity of crops, including maize.
Mitch Tuinstra	Purdue University, USA	Heat Tolerant Maize for Asia (HTMA) Project Lead for Purdue University	Ciampitti IA, Murrell T, Camberato J, Tuinstra MR, Friedemann P, Vyn T. 2013. Physiological Dynamics of Maize Nitrogen Uptake and Partitioning in Response to Plant Density and N Stress Factors: II. Reproductive Phase. Crop Science 53: 2588-2602.
Trilochan Mohapatra	Indian Council of Agricultural Research	ICAR-CIMMYT Collaborative Program on Maize R4D	Director-General of ICAR; Has significant experience in developing climate-resilient and nutritionally enriched improved crop varieties, besides genomics of crop plants.
Shihuang Zhang	Chinese Academy of Agricultural Sciences (CAAS)	ICAR-CIMMYT Collaborative Program on Maize R4D	Coordinator of National Maize Research & Development Program in China, and a long-term partner of CIMMYT, including MAIZE Phase-I.
Md. Amiruzzaman	Bangladesh Agricultural Research Institute (BARI)	Heat Tolerant Maize for Asia (HTMA) Project Lead for Bangladesh Team	Chief Scientific Officer & Head, Plant Breeding Division of BARI; long-term partner of CIMMYT, including MAIZE Phase-I.
Torbert Rocheford	Purdue University, USA	Collaborative HarvestPlus Project on 'Biofortification of Tropical Maize to Combat Micronutrient Malnutrition'	Owens BF, Lipka AE, Magallanes-Lundback M, Tiede T, Diepenbrock CH, Kandianis CB, Kim E, Cepela J, Mateos-Hernandez M, Buell CR, Buckler ES, DellaPenna D, Gore MA, Rocheford TR (2014) A foundation for provitamin A biofortification of maize: Genome-wide association and genomic prediction models of carotenoid levels. Genetics 198: 1699-1716.
Margaret G. Redinbaugh	USDA-ARS/Ohio State University, USA	"Controlling the spread and impact of MLN in Sub-Saharan Africa through improved diagnostic capacity and MCMV-free	Redinbaugh, M.G., and Zambrano-Mendoza, J.L. (2014) Control of virus diseases in maize. In: Lobenstein G, Katis N, eds. Control of Plant Virus Disease: Seed-Propagated Crops. Waltham, MA USA: Academic Press,

		commercial seed production" (Project funded by USAID and BMGF)	pp. 391-429.
Anne W. Wangai	KALRO, Kenya	MLN Project in Africa (funded by BMGF and SFSA)	Wangai, A.W., Redinbaugh, M.G., Kinyua, Z.M., Mahuku, G., Sheets, K., and Jeffers, D. (2012) First report of *Maize chlorotic mottle virus* and maize lethal necrosis in Kenya. Plant Dis. 96:1582.
Jose Luis Araus	University of Barcelona, Spain	MAIZE Phase-I Competitive Grant Project on "Development of low-cost, high throughput phenotyping platforms"	Araus JL, Cairns JE (2014) Field high-throughput phenotyping: the new crop breeding frontier. Trends in Plant Sci. 19: 52-61.
Robert L. Brown	USDA-ARS/Southern Regional Research Center, USA	MAIZE Phase-I Competitive Grant Project on "Identification of gene markers in aflatoxin-resistant maize lines developed through the IITA-ARS Collaboration"	Chen Z-Y, Brown RL, Menkir A, Cleveland TE (2012) Identification of resistance-associated proteins in closely-related maize lines varying in aflatoxin accumulation. Mol. Breeding 30: 53-68.
Charles Spillane	National University of Ireland, Galway	Collaborative NUIG-IITA on 'Post-Graduate Research and Training Programme focusing on Research to Nourish Africa'	Azmach G, Gedil M, Menkir A, Spillane C (2013) Marker-trait association analysis of functional gene markers for provitamin A levels across diverse tropical yellow maize inbred lines: BMC Plant Biology 13:227
Ephrame Havazvidi, Joseph Mito & Dean Muungani	SeedCo, Africa	SeedCo is an important partner in scaling-up and delivering several MAIZE hybrids in SSA through projects such as DTMA and DTMASS.	http://www.seedco.org
William Bett	Kenya Seed Company	KSC has been a long-term partner of CIMMYT, and actively commercializes a large number of MAIZE hybrids in eastern Africa; presently scaling-up and commercializing several improved hybrids derived from DTMA, WEMA and MLN-Africa Projects.	http://www.kenyaseed.com
John MacRobert	Quality Seed CC & Mukushi Seeds, Africa	Both Quality Seeds and Mukushi Seeds partner with MAIZE in scaling-up and commercializing several MAIZE hybrids (including normal and QPM) in southern Africa.	Quality Seed CC is a supplier of quality-assured seed of the best available Quality Protein Maize (QPM), common maize and specialty maize varieties for farmers in specific farming contexts producing maize for particular markets. Quality Seed CC also provides a confidential and quality-assured foundation seed production service to African Seed Companies on a contractual basis.
Nicolai Rodeyns	NASECO Seeds	Active partner in scaling-up and delivering several MAIZE hybrids in Uganda, through various projects, including DTMA, WEMA, DTMASS and MLN-Africa.	http://www.nasecoseeds.com

Zubeda Mduruma	Aminata Qualiy Seeds	Aminata Quality Seeds & Consultancy Ltd is a local, private seed company, owned by Zubeda. All of the Aminata's products are CIMMYT-derived, and deployed for the benefit of smallholders in Tanzania.	
Joe DeVries and George Bigirwa	Alliance for Green Revolution in Africa (AGRA)/Program for Africa's Seed Systems (PASS)	AGRA complements as well as partners with MAIZE in supporting SME seed companies in Africa, besides capacity building. AGRA, through PASS, plays a key role in MLN-Africa Project, especially in supporting MLN-free commercial seed production and deployment.	http://www.agra.org
Denise Kyetere	African Agricultural Technology Foundation (AATF)	WEMA Project lead implementing institution; also active partner for MAIZE in Phase-I in deploying Striga resistant hybrids in eastern Africa.	Deploying improved MAIZE hybrids, through an array of seed company partners in eastern and southern Africa.
Aberra Debelo	Sasakawa Africa Association / Sasakawa Global 2000	Active partner of MAIZE in Ethiopia, Nigeria, Mali and Uganda, focusing on improved adoption of higher-yielding varieties (including QPM under NuME Project in Ethiopia) and enhanced production practices by smallholders.	http://www.safe.org
Ivan Rwomushana	AFSTA (African Seed Trade Association)	AFSTA is a not-for-profit membership association formed in 2000 to champion interests of private seed companies in Africa. Currently, AFSTA has about 100 members comprising of seed companies and National Seed Trade Associations, among others. AFSTA actively partners with MAIZE in the MLN-Africa Project.	http://afsta.org
Bijendra Pal	Bioseed-Asia	Active partner under International Maize Improvement Consortium (IMIC) in Asia.	Long experience in developing and deploying improved maize hybrids in South and SE Asia
D.B. Bhandari	Hariyali Community Seed Company, Nepal	MAIZE Phase-I Competitive Grant Project. First community seed company producing and marketing improved maize seed in the hills of Nepal (established and supported by	Gadal N, Bhandari DB, Pandey A, Dilli Bahadur KC, Dhami NB (2014) Community-managed seed production company in the hills of Nepal. In: Prasanna BM et al. (Eds). Book of Extended Summaries, 12th Asian Maize Conference and Expert Consultation on Maize for Food, Feed,

		Hill Maize Research Project till 2015)	Nutrition and Environmental Security. Bangkok, Thailand, October 30 – November 1, 2014. CIMMYT, Mexico D.F. and APAARI, Bangkok, pp. 238-242.
Md. Abdul Mazid & Sudhir Chandra Nath	BRAC (Bangladesh Rural Advancement Committee)	Partners with MAIZE in scaling-up and deploying improved MAIZE hybrids in Bangladesh, and more recently in eastern Africa.	http://www.brac.net
Maria Esther Rivas	Bidasem, Mexico	Maria Esther Rivas is director general of a small seed company, Bidasem, based in the central Mexican plains region known as the Bajio. Each year her company produces >20,000 bags of maize seed, each holding 22.5 kg. The company's maize hybrids have all been developed from freely-available CIMMYT parent lines.	http://www.bidasem.com

FP4: Sustainable Intensification of Maize-based Systems for Better Livelihoods of Smallholders

Principal Investigator / Key Collaborator	**Organization**	**Key Project(s) / Collaboration**	**Relevant Key Publications / Experience**
Ken Cassman	Univ. of Nebraska	Collaboration with Global Yield Gap Atlas which is an international project with collaboration among agronomists with knowledge of production systems, soils, and climate governing crop performance in their countries. A standard protocol for assessing yield gap and water productivity will be applied for all crops and countries using a bottom-up approach based on actual data and robust crop simulation models.	Stevenson, J.R., Serraj, R., Cassman, K.G., 2014. Evaluating conservation agriculture for small-scale farmers in Sub-Saharan Africa and South Asia. Agric. Ecosyst. Environ.
Martin van Ittersum	Wageningen University and Research Center (WUR)	Same as above + contribution to IITA/CIMMYT TAMASA project in Ethiopia, Tanzania and Nigeria (co-supervision of project funded PhD students)	Ittersum, M. van, Cassman, K., Grassini, P., 2012. Yield gap analysis with local to global relevance—A review. F. Crop. Res.

Sieg Snapp	Michigan State University	Mentoring graduate students and young scientists in agronomy, soil science (particularly biology), geography, applied economics, and agricultural systems modeling. In addition to PhD student advising, MSU has considerable experience in short courses and training in research for development skills, including: applied agroecology, participatory research, remote sensing and management/analysis of big data. Contribution on SI indicators and metrics (USAID SIIL/KSU) funding to MSU	Chikowo, R., Zingore, S., Snapp, S., Johnston, A., 2014. Farm typologies, soil fertility variability and nutrient management in smallholder farming in Sub-Saharan Africa. Nutr. Cycl. Agroecosystems 100, 1–18.
Cheryl Palm	Earth Institute at Columbia University	Mentoring of graduate and post-graduate students. Contributions to: 1) develop, test and evaluate cost effect methods for measuring the SI indicators as multiple scale and for multiple stakeholders; 2) efficient monitoring systems using these methods for field collection, to analysis workflows, to tools for effective feedback-interactions with the multiple stakeholders. Along with Sieg at MSU, Cheryl is co-leading the USAID project (through SIIL/KSU) on SI metrics and indicators	Palm, C., Blanco-Canqui, H., DeClerck, F., Gatere, L., Grace, P., 2013. Conservation agriculture and ecosystem services: An overview. Agric. Ecosyst. Environ.
Eric Scoppel and Marc Corbels	CIRAD	Secondment of Marc Corbels from September 2015 to CIMMYT Nairobi to support MAIZE FP1 and FP4 on system's analysis and modeling. CIRAD, CIMMYT and IITA are intending to develop closer collaboration throuhg the development of W3/bilateral project under Phase II. CIRAD is also willing to integrate their research in south-east Asian maize-based systems under MAIZE CRP.	Corbeels, M., de Graaff, J., Ndah, T.H., Penot, E., Baudron, F., Naudin, K., Andrieu, N., Chirat, G., Schuler, J., Nyagumbo, I., Rusinamhodzi, L., Traore, K., Mzoba, H.D., Adolwa, I.S., 2014. Understanding the impact and adoption of conservation agriculture in Africa: A multi-scale analysis. Agric. Ecosyst. Environ. 187, 155–170.
Mariana Wongtschowski	KIT, Netherlands	Mariana has been a MAIZE key partner during Phase-I (W1/2 funded) contributing to methodological development and implementation of innovation approaches in Africa, Asia and Latin America. Other KIT scientists also contributed to gender research and research on institutional arrangements. KIT will continue to be a partner in MAIZE Phase-II.	Nederlof, S., Wongtschowski, M., van der Lee, F. (2011) Putting heads together: agricultural innovation platforms in practice. KIT Publishers, KIT Development, Policy & Practice.
Roel Merckx	KU, Leuven	Roel Merckx is presently involved in TAMASA project through PhD students. His contribution related to the 'state of the art' methods and tools for improved nutrient management will be enhanced in Phase-II	Six, L., Smolders, E., Merckx, R., 2014. Testing phosphorus availability for maize with DGT in weathered soils amended with organic materials. Plant Soil 376, 177–192.
Johan Six	ETH, Zurich	Johan Six will contribute to MAIZE research on SI and soil fertility issues from a system's perspective.	Vanlauwe, B., Six, J., Sanginga, N., Adesina, A.A., 2015. Soil fertility decline at the base of rural poverty in sub-Saharan Africa. Nat. Plants 1.

Pablo Zarco-Tejada	Institute for Sustainable Agriculture (IAS), National Resaearch Council, Cordoba, Spain	Pablo Zarco has been the recipient of MAIZE and WHEAT W1/2 funding to build CIMMYT's capacity on the use of UAV and airborne instruments, and management/processing of RS data. The on-going collaboration will be maintained/reinforced during Phase II (including contribution to phenotyping).	Delalieux, S., Zarco-Tejada, P.J., Tits, L., Jimenez Bello, M.A., Intrigliolo, D.S., Somers, B., 2014. Unmixing-based fusion of hyperspatial and hyperspectral airborne imagery for early detection of vegetation stress. Sel. Top. Appl. Earth Obs. Remote Sensing, IEEE J. 7, 2571–2582.
Raul Zurita-Milla	ITC, University of Twente	ITC is leading the remote sensing STARS project funded by BMGF. Raul and ITC colleagues will assist MAIZE to implement best RS methods and practices, and contribute to capacity building of several partners in the field of geospatial research.	Imran, M., Stein, A., Zurita-Milla, R., 2015. Using geographically weighted regression kriging for crop yield mapping in West Africa. Int. J. Geogr. Inf. Sci. 29, 234–257.
Kaushik Majumdar	International Plant Nutrition Insitute (IPNI)	Kaushik has been the recipient of MAIZE W1/2 funding under phase I to develop field level nutrient management decision support tools in South Asia. IPNI Africa (Shamie Zingore) was also the recipient a MAIZE grant. Further IPNI contribution is expected in Phase-II on scaling soil fertility management tools.	Dutta, S.K., Majumdar, K., Satyanarayana, T., 2014. India: Nutrient Expert: A precision nutrient management tool for smallholder production systems of India. Crop. Soils 47, 23–25.
Jeroen Groot	Wageningen University and Research Center (WUR)	Jeroen and other colleagues at Farming Systems Ecology Group received MAIZE and WHEAT W1/2 funding. The research project 'Trajectories and Trade-offs for Intensification of Cereal-based Systems (ATTIC)' is hosting four PhD students working in Ethiopia, Bangladesh, Nepal, and Mexico. ATTIC provides an excellent platform to research and exchange on farming systems analyses and modeling.	Valbuena, D., Groot, J.C.J., Mukalama, J., Gérard, B., Tittonell, P., 2014. Improving rural livelihoods as a “moving target”: trajectories of change in smallholder farming systems of Western Kenya. Reg. Environ. Chang. 1–13.
Saidi Mkomwa	African Conservation Tillage Network (ACTN)	ACTN is a registered as a pan-African not-for-profit membership association that was initially commissioned with geographical focus on Southern, Central and East Africa. However, the Network has expanded responding to active interest from rest of the continent to west and North Africa. Existing potential for synergistic collaborations and knowledge sharing, enriched by the diversity, across the continent has justified ACTN reformation into a pan-African establishment with networking value within and between regions. Membership to the Network is voluntary bringing together stakeholders. Strong collaboration with CIMMYT/MAIZE was developed under FACASI project and should further develop under Phase-II.	Baudron, F., Sims, B., Justice, S., Kahan, D.G., Rose, R., Mkomwa, S., Kaumbutho, P., Sariah, J., Nazare, R., Moges, G., Gérard, B., 2015. Re-examining appropriate mechanization in Eastern and Southern Africa: two-wheel tractors, conservation agriculture, and private sector involvement. Food Security. 1–16.

Trent Bunderson	Total Landcare	TLC's mandate is to improve the livelihoods of smallholder farmers in the region with a focus on community based approaches to increase agricultural production, food security and incomes within a context that ensures sound management of their natural resources. A key thrust is to provide information to decision-makers to improve policies that support economic development and growth in a sustainable manner. CIMMYT has collaborated extensively with TLC in Zambia and Malawi, providing scientific backstoping to TLC scaling efforts.	http://www.totallandcare.org/
iDE, Bangladesh		iDE is a non-profit, non-governmental organization with over 30 years of experience in designing and delivering market based anti-poverty programs. We believe that markets can be a powerful force for improving the prosperity of rural communities. Throughout our programs we deploy business models, appropriate technologies, and agricultural science to facilitate market systems which work for the poor. iDE is a key scaling partner for our CSISA-MI project.	http://www.ide-bangladesh.org/
Ken Cassman; Martin van Ittersum	Univ. of Nebraska; Wageningen UR	Agro-ecological spatial framework for improved upscaling, impact assessment, and locating fieldwork and innovation testing	Van Bussel, L.G.J., P. Grassini, J. van Wart, J. Wolf, L. Claessens, H. Yang, H. Boogaard, H. de Groot, K. Saito, K.G. Cassman and M.K. van Ittersum. 2015. From field to atlas: Upscaling of location-specific yield gap estimates. Field Crops Res. 177: 98–108. Van Wart J, van Bussel LGJ, Wolf J, Licker R, Grassini P, Nelson A, Boogaard H, Gerber J, Mueller ND, Claessens L, van Ittersum MK, Cassman KG. 2013. Use of agro-climatic zones to upscale simulated crop yield potential. Field Crops Res. 143:44-55.

FP5: Adding Value for Maize Producers, Processors and Consumers

Principal Investigator / Key Collaborator	Organization	Key Project(s) / Product(s)	Relevant Key Publications / Experience
Silverio Garcia	Tecnologico de Monterrey	Postharvest technologies for Mexico and Central America (Project funded by Mexican government-SAGARPA)	Castro-Alvarez F, William M, Bergvinson D, Garcia-Lara S. 2014. Genetic mapping of QTL for maize weevil resistance in a RIL population of tropical maize. Theoretical and Applied Genetics 128
Gricelda Vazquez	INIFAP (Mexico)	Maize grain quality for lime-cooking (Project funded by Mexican government-SAGARPA)	Miranda, A., Vázquez-Carrillo, G., Garcia-Lara, S., San Vicente, F., Torres, J.L., Ortiz, S., Salinas-Moreno, Y., Palacios-Rojas, N. (2012). Influence of genotype and environmental adaptation into the maize quality traits for nixtamalization. *CyTA Journal of Food (*DOI:10.1080/19476337.2013.763862)
Michael Blummel	ILRI	Superior dual-purpose maize hybrids for more and better food and fodder- MAIZE phase I	Erenstein, O., Blümmel, M. and Grings, E. 2013. Potential for dual-purpose maize varieties to meet changing maize demands: Overview. Field crop res.
Kingsly Ambrose	Purdue University	Reduction is post-harvest losses of cereal grains (Feed the Future Innovation Lab). Effect of aeration on grain pack factor for corn.	J. Boac, R.P. Kingsly Ambrose, M. Casada, R. Maghirang, and Dirk Maier. 2014. Applications of discrete element method in modeling of grain postharvest operations. Food Engineering Reviews, 6:128-149.
Betty Bugusu	Purdue University	USAID Feed The Future Food Processing and Post-harvest handling Innovation Lab Focus Development and Assessment of a Fortified Instant Cereal Produce for Senegalese Market.	Sarah Davis Ohlhorst, SD, Slavin, M, Bhide, JM, Bugusu, B. 2012. Use of Iodized Salt in Processed Foods in Select Countries around the World and the Role of Food Processors. Comprehensive Reviews in Food Science and Food Safety 11(2): 233-284.
James Lowenberg-DeBoer	Purdue University	Postharvest storage	Otoo, Miriam, Germaine Ibro, Joan Fulton and J. Lowenberg-DeBoer (2015). Micro-Entrepreneurship in Niger: Factors Affecting Success of Women Street Food Vendors," *Journal of African Business* (forthcoming).
Klein E. Ileleji	Purdue University	Global Food Security Initiative Seed funded project on Post-Harvest Loss and Mycotoxin Reduction in the Commodity Value Chain in Maize (Corn) Production in Ghana. Purdue Improved Drying Stove (PIDS) R&D.	Opit, G.P., S. McNeill, and K. Ileleji*. 2011. Use Integrated Pest Management (IPM) when Storing Grain… for Good and Safe Control of Grain Pests, & for Increased Food Availability and Profits. Poster. Oklahoma State University Cooperative Extension, Stillwater, OK. Extension Publication # L-351.

Mario G. Ferruzzi	Purdue University	Phytochemicals, micronutrients and health: Analysis in food and biological matrices; Bioavailability of polyphenols and carotenoids; Effects of processing on micronutrient and phytochemical stability, bioavailability and bioactivity; Nutritional/functional product development.	Ferruzzi, M.G., Bordenave, N., Hamaker, B.R. (2012) Does flavor impact function? Potential consequences of polyphenol-protein interactions in delivery and bioactivity of flavan-3-ols from foods. *Physiology and Behavior.* 107(4):591-597.

3.18 MAIZE Performance Indicator Matrix (PIM) Tables

Table A: MAIZE Contributions to the CGIAR SRF Targets (2022)

SRF targets	Unit of target	MAIZE Targets	Amount Needed ($)	W1&2 (%)	W3 (%)	Bilateral (%)	Other (%)
100 million more farm households have adopted improved varieties, breeds or trees, and/or improved management practices	million farm households	15	$ 57,816,186	30%	10%	60%	0
30 million people, of which 50% are female, assisted to exit poverty	million people	7.5	$ 72,270,233	20%	10%	70%	0
Improve the rate of yield increase for major food staples from current <1% to 1.2-1.5%/year	%	1.2	$ 65,043,209	20%	10%	70%	0
30 million more people, of which 50% are female, meeting minimum dietary energy requirement	million people	5	$ 65,043,209	10%	10%	80%	0
150 million more people , of which 50% are female, without deficiencies of one or more of the following essential micronutrients: iron, zinc, iodine, vitamin A, folate, and vitamin B12	million people	15	$ 43,362,140	10%	10%	80%	0
10% reduction in women of reproductive age who are consuming less than the adequate number of food groups	%	1.5	$ 43,362,194	30%	10%	60%	0
5% increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse	%	1%	$ 65,043,209	25%	5%	70%	0
Reduce agriculturally-related greenhouse gas emissions by 0.2 Gt CO2-e yr–1 (5%)	Gt CO2e/yr	0.01	$ 50,589,163	30%	10%	60%	0

PIM Table A: MAIZE target (2022) contributions, by country

SRF targets	Unit of target	MAIZE Targets	MAIZE by CGIAR Priority Countries													
			Ethiopia	Kenya	Malawi	Nigeria	Tanzania	Uganda	Zambia	Bangladesh	India	Nepal	Guatemala	Mexico	The Rest	
100 million more farm households have adopted improved varieties, breeds or trees, and/or improved management practices	million farm households	15	2.5	0.9	0.7	1.0	1.1	0.3	0.3	0.8	3.7	0.5	0.2	1.4	1.6	
30 million people, of which 50% are female, assisted to exit poverty	million people	7.5	0.8	0.2	0.4	1.0	0.5	0.2	0.2	0.2	2.9	0.4	0.1	0.1	0.4	PIM
Improve the rate of yield increase for major food staples from current <1% to 1.2-1.5%/year	%	1.2	16	16		4	4	3	3	16	15	4	4	15		Genetic Gains platform, Genebank platform, Big Data platform
30 million more people, of which 50% are female, meeting minimum dietary energy requirement	million people	5	0.5	0.1	0.3	0.7	0.4	0.2	0.2	0.2	2	0.3	0.05	0.05	0.2	PIM
150 million more people , of which 50% are female, without deficiencies of one or more of the following essential micronutrients: iron, zinc, iodine, vitamin A, folate, and vitamin B12	million people	15	1.9	0.5	1.0	2.4	1.3	0.5	0.6	0.5	7	1	0.2	0.2	0.9	A4NH
10% reduction in women of reproductive age who are consuming less than the adequate number of food groups	%	1.5	0.16	0.04	0.08	0.2	0.11	0.04	0.05	0.05	.59	0.08	0.01	0.01	0.1	MAIZE, WHEAT, FISH, LIVESTOCK, FTA, DCL, RTB
5% increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse	%	1%								25	30		15	30		WLE
Reduce agriculturally-related greenhouse gas emissions by 0.2 Gt CO2-e yr–1 (5%)	Gt CO2e/yr	0.01								25	30		15	30		CCAFS

PIM Table B: MAIZE Flagship-level Outcomes by Funding Sources

FP and CoAs	Outcomes (see ToCs)	Sub-IDOs	Amount Needed ($)	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other (%)	W1 + W2 (Amount)	W3 (Amount)	Bilateral (Amount)	Other (Amount)	2022 Outcomes
FP1												
1.1	1.1	C.1.1	$ 8,569,006	37%	30%	33%	0%	$ 3,170,532	$ 2,570,702	$ 2,827,772	$ -	FP1-1 Increased capacity of partner organizations through MAIZE foresight and ex-ante analysis
1.2	1.1	C.1.1	$ 10,282,807	37%	30%	33%	0%	$ 3,804,638	$ 3,084,842	$ 3,393,326	$ -	FP1-2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment
1.3	1.1	B.1.3	$ 8,569,006	37%	30%	33%	0%	$ 3,170,532	$ 2,570,702	$ 2,827,772	$ -	FP1-3 Improved capacity of women and young people to participate in decision-making through MAIZE's gender and social inclusiveness
1.4	1.1	1.3.4 D.1.1	$ 6,855,204	37%	30%	33%	0%	$ 2,536,426	$ 2,056,561	$ 2,262,217	$ -	FP1-4 Increased capacity of partner organizations through MAIZE market/value chain opportunities prioritized for their livelihoods enhancing potential
FP2												
2.1	2.2	1.4.3; 1.4.4; D.1.1	$ 5,604,915.09	31%	59%	10%	0%	$ 1,737,523.68	$ 3,306,899.90	$ 560,491.51	$ -	FP2-1 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of new data capture, storage and analysis tools
2.2	2.4	1.4.3; A.1.4; B.1.2; D.1.1	$ 29,553,188.65	31%	59%	10%	0%	$ 9,161,488.48	$ 17,436,381.30	$ 2,955,318.86	$ -	FP2-3 Increased use of doubled haploids by MAIZE partners, accelerating genetic gains
2.3	2.2	1.4.3; 1.4.4; A.1.4; D.1.1	$ 10,700,292.44	31%	59%	10%	0%	$ 3,317,090.66	$ 6,313,172.54	$ 1,070,029.24	$ -	FP2-5 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners
2.4	2.5	1.4.3; 1.4.4; A.1.4; D.1.1	$ 5,095,377.35	31%	59%	10%	0%	$ 1,579,566.98	$ 3,006,272.64	$ 509,537.74	$ -	FP2-8 MAIZE partners and global research community use novel sources of useful genetic variance for drought, MLN, tar spot and other key traits

FP3												
3.1	3.5	1.1.2; 1.3.4; 1.4.1; A.1.4; C.1.1; D.1.1	$ 94,928,996	11%	53%	36%	0%	$ 10,442,190	$ 50,312,368	$ 34,174,439	$ -	FP3-3 Increase in the rate of genetic gain for grain yield (as measured in breeders' trials) in rainfed, climate-vulnerable environments of SSA from 0.6% to 1.2% annually, and from ≤1% to at least 1.75% in Asia and LA (linked to FP2 and Genetic Gains Platform)
3.2	3.1	1.1.2; 1.4.1; C.1.1; D.1.1	$ 9,492,900	11%	53%	36%	0%	$ 1,044,219	$ 5,031,237	$ 3,417,444	$ -	FP3-4 Effective pest/disease surveillance, monitoring and diagnostics protocols/procedures for controlling the spread and impact of existing/emerging threats (e.g., MLN), established in SSA
3.3	3.1	2.1.1; C.1.1	$ 15,188,639	11%	53%	36%	0%	$ 1,670,750	$ 8,049,979	$ 5,467,910	$ -	FP3-6 Nutritious maize hybrids/varieties with superior agronomic performance and desirable gender-informed traits (processing properties, palatability and storability) adopted in targeted geographies in SSA, Asia and LA (linked to FP5 and A4NH)
3.4	3.3	1.3.4; C.1.1; D.1.1	$ 15,188,639	11%	53%	36%	0%	$ 1,670,750	$ 8,049,979	$ 5,467,910	$ -	FP3-8 Reduction in product development and elite line recycling time and costs through integration of novel tools/technologies in breeding programs.
3.5	3.4	1.1.3; B.1.3; C.1.1	$ 17,087,219	11%	53%	36%	0%	$ 1,879,594	$ 9,056,226	$ 6,151,399	$ -	FP3-10 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.
3.6	3.7	1.1.3; 1.4.1; A.1.4; B.1.3; C.1.1; D.1.1	$ 37,971,599	11%	53%	36%	0%	$ 4,176,876	$ 20,124,947	$ 13,669,775	$ -	FP3-12 Enhanced adoption of climate resilient and nutritious maize varieties by smallholder farmers in stress-prone rainfed environments of SSA, Asia and LA providing better yields and stability
FP4												
4.1	4.7		$ 24,178,197	11%	38%	51%	0%	$ 2,659,602	$ 9,187,715	$ 12,330,880	$ -	FP4-1 Improved understanding of farmers' livelihood strategies and their diversity, allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)

4.2	4.9		$ 40,296,995	11%	38%	51%	0%	$ 4,432,669	$ 15,312,858	$ 20,551,467	$ -	FP4-6 Decision support systems for nutrient and water management used by development partners
4.3	4.1		$ 40,296,995	11%	38%	51%	0%	$ 4,432,669	$ 15,312,858	$ 20,551,467	$ -	FP4-3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods
4.4	4.7		$ 56,415,793	11%	38%	51%	0%	$ 6,205,737	$ 21,438,001	$ 28,772,054	$ -	FP4-5 Improved understanding of farmers' livelihood strategies and their diversity allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
FP5													
5.1	5.1	2.1.1	$ 5,326,603	46%	16%	38%	0%	$ 2,450,237	$ 852,256	$ 2,024,109	$ -	FP5-2 Increased consumption of improved and novel maize-based nutritious food products by consumers, especially women and preschool children
5.2	5.6	2.1.1	$ 5,326,603	46%	16%	38%	0%	$ 2,450,237	$ 852,256	$ 2,024,109	$ -	FP5-4 Enhanced adoption of improved processing methods and labor saving technologies by NARES, NGOs and SMEs
5.3	5.5	1.3.2	$ 4,565,660	46%	16%	38%	0%	$ 2,100,203	$ 730,506	$ 1,734,951	$ -	FP5-5 Increased adoption of improved storage and drying technologies by NARES, NGOs and SMEs
5.4	5.8	1.4.1	$ - uplift	46%	16%	38%	0%	$ - uplift	$ - uplift	$ - uplift	$ -	FP5-6 Optimized feed processing options using maize and its by-products by feed industries and livestock owners adopt

Table C: Flagship Level: Investment by Sub-IDOs

FP/ CoAs	IDO	Sub-IDO	Sub- IDO narrative	Amount needed ($)	W1 + W2 (%)	W3 (%)	Bilateral (%)	Other (%)	W1 + W2 (Amount)	W3 (Amount)	Bilateral (Amount)	Other (Amount)
FP1												
SLOs related				**14,053,169**								
SLO 1: Reduced poverty	1.1	1.1.2	Reduced production risk	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
		1.3.1	Diversified enterprise opportunities	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
	1.3	1.3.2	Increased livelihood opportunities	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
		1.3.3	Increased value capture by producers	3,084,842	37%	30%	33%	0%	$ 1,141,392	$ 925,453	$ 1,017,998	$ -
		1.3.4	More efficient use of inputs	1,713,801	37%	30%	33%	0%	$ 634,106	$ 514,140	$ 565,554	$ -
	1.4	1.4.1	Reduced pre- and post-harvest losses, including those caused by climate change	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
		1.4.2	Closed yield gaps	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -

		1.4.3	Enhanced genetic gain	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
		1.4.4	Increase conservation and use of genetic resources	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
SLO 2: Improved food and nutrition security for health	2.1	2.1.1	Increased availability of diverse nutrient-rich foods	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
SLO 3: Improved natural resource systems and ecosystem service	3.2	3.2.2	Agricultural systems diversified and intensified in ways that protect soils and water	$ 1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
Cross-cutting												
Climate Change		A.1.4	Enhanced capacity to deal with climatic risks and extremes	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
Gender & Youth		B.1.2	Technologies that reduce women's labor and energy expenditure developed and disseminated	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
		B.1.3	Improved capacity of women and young people in decision-making	5,141,403	37%	30%	33%	0%	$ 1,902,319	$ 1,542,421	$ 1,696,663	$ -

Policies and Institutions		C.1.1	increased capacity of beneficiaries to adopt research outputs	5,141,403	37%	30%	33%	0%	$ 1,902,319	$ 1,542,421	$ 1,696,663	$ -
Capacity Development		D.1.1	Enhanced institutional capacity of partner research organizations	6,855,204	37%	30%	33%	0%	$ 2,536,426	$ 2,056,561	$ 2,262,217	$ -
		D.1.3	Increased capacity for innovation in partner research organizations	1,028,281	37%	30%	33%	0%	$ 380,464	$ 308,484	$ 339,333	$ -
FP2												
SLOs related												
SLO 1: Reduced poverty	1.4	1.4.3	Enhanced genetic gain	21,145,816.01	31%	59%	10%	0%	$ 6,555,202.96	$ 12,476,031.45	$ 2,114,581.60	$ -
SLO 2: Improved food and nutrition security for health		1.4.4	Increased conservation and use of genetic resources	9,681,216.97	31%	59%	10%	0%	$ 3,001,177.26	$ 5,711,918.01	$ 968,121.70	$ -
Cross-cutting												
Climate Change		A.1.4	Enhanced capacity to deal with climatic risks and extremes	8,407,372.63	31%	59%	10%	0%	$ 2,606,285.52	$ 4,960,349.85	$ 840,737.26	$ -
Gender & Youth		B.1.2	Technologies that reduce women's labor and energy expenditure	4,076,301.88	31%	59%	10%	0%	$ 1,263,653.58	$ 2,405,018.11	$ 407,630.19	$ -

			developed and disseminated									
Capacity Development		D.1.1	Enhanced institutional capacity of partner research organizations	7,643,066.03	31%	59%	10%	0%	$ 2,369,350.47	$ 4,509,408.96	$ 764,306.60	$ -
FP3												
SLOs related												
SLO 1: Reduced poverty	1.1	1.1.2	Reduced production risk	26,580,119	11%	53%	36%	0%	$ 2,923,813	$ 14,087,463	$ 9,568,843	$ -
	1.1	1.1.3	Increased value capture by producers	20,884,379	11%	53%	36%	0%	$ 2,297,282	$ 11,068,721	$ 7,518,377	$ -
	1.3	1.3.4	More efficient use of Inputs	26,580,119	11%	53%	36%	0%	$ 2,923,813	$ 14,087,463	$ 9,568,843	$ -
	1.4	1.4.1	Reduced pre- and post-harvest losses, including those caused by climate change	29,427,989	11%	53%	36%	0%	$ 3,237,079	$ 15,596,834	$ 10,594,076	$ -
SLO 2: Improved food and nutrition security for health	2.1	2.1.1	Increased availability of diverse nutrient-rich foods	16,137,929	11%	53%	36%	0%	$ 1,775,172	$ 8,553,103	$ 5,809,655	$ -
Cross-cutting												
Climate Change		A.1.4	Enhanced capacity to deal with climatic risks and extremes	31,326,569	11%	53%	36%	0%	$ 3,445,922.57	$ 16,603,081.46	$ 11,277,564.77	$ -

Gender & Youth		B.1.3	Improved capacity of women and young people in decision-making	9,492,900	11%	53%	36%	0%	$ 1,044,218.96	$ 5,031,236.81	$ 3,417,443.87	$ -
Policies and Institutions		C.1.1	Increased capacity of beneficiaries to adopt research outputs	15,188,639	11%	53%	36%	0%	$ 1,670,750.34	$ 8,049,978.89	$ 5,467,910.19	$ -
Capacity Development		D.1.1	Enhanced institutional capacity of partner research organizations	14,239,349	11%	53%	36%	0%	$ 1,566,328.44	$ 7,546,855.21	$ 5,126,165.80	$ -
FP4												
SLOs related												
SLO 1: Reduced poverty	1.3	1.3.4	More efficient use of Inputs	48,356,394	11%	38%	51%	0%	$ 5,319,203	$ 18,375,430	$ 24,661,761	$ -
SLO 2: Improved food and nutrition security for health	1.4	1.4.2	Closed yield gaps through improved agronomic and animal husbandry practices	48,356,394	11%	38%	51%	0%	$ 5,319,203	$ 18,375,430	$ 24,661,761	$ -
SLO 3: Improved natural resource systems and ecosystem services	3.2	3.2.2.	Agricultural systems diversified and intensified in ways that protect soils and water	32,237,596	11%	38%	51%	0%	$ 3,546,136	$ 12,250,286	$ 16,441,174	$ -
Cross-cutting												
Climate Change		A.1.4	Enhanced capacity to deal with climatic risks and extremes	32,237,596	11%	38%	51%	0%	$ 3,546,136	$ 12,250,286	$ 16,441,174	$ -

FP5												
SLOs related												
SLO 1: Reduced poverty	1.3	1.3.1	Diversified enterprise opportunities	2,282,830	46%	16%	38%	0%	$ 1,050,102	$ 365,253	$ 867,475	$ -
	1.4	1.3.2	Increased livelihood opportunities	2,282,830	46%	16%	38%	0%	$ 1,050,102	$ 365,253	$ 867,475	$ -
SLO 2: Improved food and nutrition security for health		1.4.1	Reduced pe & post-harvest looses, including those caused by climate change	3,043,773	46%	16%	38%	0%	$ 1,400,136	$ 487,004	$ 1,156,634	$ -
	2.1	2.1.1	Increased availability of diverse nutrient-rich foods	3,043,773	46%	16%	38%	0%	$ 1,400,136	$ 487,004	$ 1,156,634	$ -
Cross-cutting												
Gender & Youth		B.1.2	Technologies that reduce women's labor and energy expenditure developed and disseminated	2,282,830	46%	16%	38%	0%	$ 1,050,102	$ 365,253	$ 867,475	$ -
Capacity Development		D.1.1	Enhanced institutional capacity of partner research organizations	2,282,830	46%	16%	38%	0%	$ 1,050,102	$ 365,253	$ 867,475	$ -

MAIZE PIM Table D FP1

Year	Milestone description	Means of verifying	For which outcome?
2017	Ex-ante impact assessments identify potential opportunities, threats and game changers for MAIZE	Reports, policy briefs, dissemination documentation	FP1-1 Increased capacity of partner organizations through MAIZE foresight and ex-ante analysis
2019	Ex-ante impact assessments assess how major drivers like climate change and rural transformation will alter MAIZE in the developing world	Reports, policy briefs, dissemination documentation	FP1-1 Increased capacity of partner organizations through MAIZE foresight and ex-ante analysis
2021	Ex-ante impact assessments assess future preferences of maize producers and consumers and implications for maize innovation	Reports, policy briefs, dissemination documentation	FP1-1 Increased capacity of partner organizations through MAIZE foresight and ex-ante analysis
2022	MAIZE innovation portfolio guided by systematic ex-ante studies.	Reports, policy briefs, dissemination documentation	FP1-5 Increased capacity of beneficiaries to adopt research outputs through better MAIZE targeting
2017	Adoption and impact studies on technologies– rolling plan based on progress of technologies along the theory of change	Reports, policy briefs, dissemination documentation	FP1-2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment
2018	Adoption and impact studies on technologies– rolling plan based on progress of technologies along the theory of change	Reports, policy briefs, dissemination documentation	FP1-2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment
2019	Adoption and impact studies on technologies– rolling plan based on progress of technologies along the theory of change	Reports, policy briefs, dissemination documentation	FP1-2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment
2020	Adoption and impact studies on technologies– rolling plan based on progress of technologies along the theory of change	Reports, policy briefs, dissemination documentation	FP1-2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment

2021	Adoption and impact studies on technologies– rolling plan based on progress of technologies along the theory of change	Reports, policy briefs, dissemination documentation	FP1-2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment
2022	Robust and systematic evidence base of MAIZE technology adoption and impacts	Reports, policy briefs, dissemination documentation	FP1-6 Increased value capture by producers through MAIZE's learning from impact assessment
2017	Gender / Social inclusion lenses will be applied to 2- 4 MAIZE innovation pipelines and assessments	Reports, global recognized women empowerment indicators, case studies	FP1-3 Improved capacity of women and young people to participate in decision-making through MAIZE's gender and social inclusiveness
2019	Measure of women's empowerment quantified based on global recognized indicators (baseline)	Reports, global recognized women empowerment indicators, case studies	FP1-3 Improved capacity of women and young people to participate in decision-making through MAIZE's gender and social inclusiveness
2021	Study of the implementation of gender mainstreaming in MAIZE and its impact on inclusivity and equity	Reports, global recognized women empowerment indicators, case studies	FP1-3 Improved capacity of women and young people to participate in decision-making through MAIZE's gender and social inclusiveness
2022	Gender / Social inclusion lenses will be routinely applied to major MAIZE innovation pipelines and assessments	Reports, global recognized women empowerment indicators, case studies	FP1-3 Improved capacity of women and young people to participate in decision-making through MAIZE's gender and social inclusiveness
2018	Rapid value chain assessments with proper gender lens conducted in selected countries to identify opportunities and bottlenecks in MAIZE	Reports, case studies, dissemination documentation	FP1-4 Increased capacity of partner organizations through MAIZE market/value chain opportunities prioritized for their livelihoods enhancing potential
2020	Benchmarking information of maize value chain collected in selected countries to support identified priorities and effective interventions	Reports, case studies, dissemination documentation	FP1-4 Increased capacity of partner organizations through MAIZE market/value chain opportunities prioritized for their livelihoods enhancing potential
2022	Farm to fork value chain analyses in both selected established and emerging maize producers to assess implication for MAIZE priorities	Reports, case studies, dissemination documentation	FP1-4 Increased capacity of partner organizations through MAIZE market/value chain opportunities prioritized for their livelihoods enhancing potential

MAIZE PIM Table D FP2

Year	Milestone description	Means of verifying	For which outcome?
2017	Most recent 5 years phenotypic, genotypic and geneological data curated and stored in centralized data repositories.	Annual storage of data in open access databases and other data repositories. Annual download of data metrics. Project reports	FP2-1 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of new data capture, storage, dissemination and analysis tools
2018	Established tools and methods that enable more efficient management and utilization of data and knowledge implemented and used by all MAIZE breeders	Metrics on the implementation of software, protocols and methodologies in MAIZE. Project reports	FP2-2 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of a suite of breeding program management and pipelined decision support tools
2019	Information on gender, youth and market-based preferences for germplasm selection integrated into breeding management informatics systems	Metrics on the implementation of software, protocols and methodologies in MAIZE. Project reports	FP2-2 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of a suite of breeding program management and pipelined decision support tools
2020	New approaches for data capture, curation and analysis piloted and implemetation guidelines developed	Metrics on the implementation of software, protocols and methodologies in MAIZE. Annual storage of data in open access databases and other data repositories. Project reports	FP2-1 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of new data capture, storage, dissemination and analysis tools
2021	High value historic phenotypic, genotypic and geneological data curated and stored in centralized open access data repositories.	Annual storage of data in open access databases and other data repositories. Annual download of data metrics. Project reports	FP2-1 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of new data capture, storage, dissemination and analysis tools
2022	MAIZE breeding programs, including NARS and SMEs enhancing efficiencies through the broad adoption of breeding and discovery informatics tools and methods	Metrics on the implementation of software, protocols and methodologies in MAIZE. Annual storage of data in open access databases and other data repositories. Annual download of data metrics. Project reports	FP2-2 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of a suite of breeding program management and pipelined decision support tools

2017	Second-generation tropicalized haploid inducers with at least 10% haploid induction rate (HIR) developed and made available to maize researchers globally.	List of institutions receiving second-generation haploid inducers. Training materials. Project reports.	FP2-3 Increased use of doubled haploids and molecular markers by MAIZE partners, accelerating genetic gains
2018	Tools and protocols adopted for enhanced efficiency and lower cost of maize doubled haploid (DH) line development in tropical germplasm and environments.	List of institutions receiving second-generation haploid inducers. Training materials. Project reports.	FP2-3 Increased use of doubled haploids and molecular markers by MAIZE partners, accelerating genetic gains
2019	Breeder-ready markers/haplotypes discovered and validated in breeding populations for at least four priority traits (Striga, TSC, Heat, MLN) for forward breeding.	Open-access data/publications on breeder-ready markers/haplotypes. Project reports.	FP2-3 Increased use of doubled haploids and molecular markers by MAIZE partners, accelerating genetic gains
2020	Strategy for effective integration of vaidated breeder-ready markers/haplotypes for at least 4 priority traits with DH and seed chipping technology in forward breeding designed (in FP2; linkage with Genetic Gains Platform) and implemented in MAIZE breeding programs (through FP3).	Improved trait pipelines. Training materials. Project reports.	FP2-3 Increased use of doubled haploids and molecular markers by MAIZE partners, accelerating genetic gains
2021	Genomic prediction replaces up to 50% of the stage 1 testing efforts in the MAIZE breeding programs of SSA, Asia and LA	Improved trait pipelines, genomic selection and prediction models. Training materials. Project reports.	FP2-4 Rates of genetic gain in adopting breeding programs increased through the use of pipelined genomic prediction and selection tools/methods
2022	A comprehensive (sub-)tropical trait pipeline established for increasing genetic gains and breeding efficiency of MAIZE breeding programs in SSA, Asia and LA.	Open-access data/publications on breeder-ready markers/haplotypes; List of institutions receiving second-generation haploid inducers; Improved trait pipelines, genomic selection and prediction models. Training materials. Project reports.	FP2-4 Rates of genetic gain in adopting breeding programs increased through the use of pipelined genomic prediction and selection tools/methods

2017	Comprehensive characterization of genebank accessions using genotypic, geospatial and adaptive distribution data conducted, and at least 1000 high value accessions identified through in-silico approaches	Metrics on annual genebank accession shipments to maize researchers globally. Project reports. Training materials. Genomic selection models, marker and haplotype and accession information provided in open access and other data repositories	FP2-5 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners
2018	Novel alleles, haplotypes and landrace donors identified for atleast three priority traits (MLN, TSC and drought) and moved into pre-breeding and/or breeding pipeline	Marker and haplotype and exotic germplasm information provided in open access and other data repositories. Project reports.	FP2-5 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners
2019	Recommendations for genomic prediction in pre-breeding for at least 4 priority polygenic traits developed, validated and disseminated	Genomic prediction models and information provided in open access and other data repositories. Project reports	FP2-6 Increased capacity to identify and use allelic diversity to accelerate breeding progress
2020	Molecular characterization used by more MAIZE breeders to investigate uncharacterized germplasm	Surveys and genotyping metrics. Project reports.	FP2-6 Increased capacity to identify and use allelic diversity to accelerate breeding progress
2021	Novel alleles and haplotypes for at least 4 priority traits selected from biotic and abiotic stresses and nutritional and end user quality traits, identified and moved into pre-breeding and/or breeding pipeline	Marker and haplotype and exotic germplasm information provided in open access and other data repositories. Project reports.	FP2-5 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners
2022	Novel diversity validated or created using genetic engineering tools for at least two priority traits	Marker and haplotype information provided in open access and other data repositories. Project reports.	FP2-7 New genetic diversity available from editing of native genes for breeders to address key traits
2017	Multilocation testing of at least 300 pre-bridging germplasm entries for at least two priority traits (TSC, drought) and general hybrid performance	Project reports.	FP2-8 MAIZE partners and global research community use novel sources of useful genetic variance for drought, MLN, tar spot and other key traits

2018	At least 15 early generation pre-bred lines available for TSC and drought , incorporating useful genetic diversity from selected landraces into elite or semi-elite backgrounds.	Germplasm and haplotype announcements on MAIZE website. Metrics on annual maize germplasm shipments to MAIZE breeding programs, public and private sector researchers globally. Project reports.	FP2-8 MAIZE partners and global research community use novel sources of useful genetic variance for drought, MLN, tar spot and other key traits
2019	Useful haplotypes or alleles from genetic resources validated and information disseminated publically for drought, TSC and MLN	Germplasm and haplotype announcements on MAIZE website. Project reports.	FP2-5 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners
2020	At least 15 additional early generation pre-bred lines available, incorporating novel genetic diversity for key traits (MLN, drought, heat) from exotic germplasm sources into elite or semi-elite backgrounds.	Germplasm and haplotype announcements on MAIZE website. Metrics on annual maize germplasm shipments to MAIZE breeding programs, public and private sector researchers globally. Project reports.	FP2-8 MAIZE partners and global research community use novel sources of useful genetic variance for drought, MLN, tar spot and other key traits
2021	Useful haplotypes or alleles from genetic resources validated and information disseminated publically for at least three priority traits including heat and Striga	Germplasm and haplotype announcements on MAIZE website. Project reports.	FP2-5 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners
2022	Novel genetic variation for high value climate change and defensive traits made available and adopted by MAIZE breeders and the broader maize scientific community.	Germplasm and haplotype announcements on MAIZE website. Metrics on annual maize germplasm shipments to MAIZE breeding programs, public and private sector researchers globally. Project reports.	FP2-8 MAIZE partners and global research community use novel sources of useful genetic variance for drought, MLN, tar spot and other key traits

MAIZE PIM Table D FP3

Year	Milestone description	Means of verifying	For which outcome?
2017	Stage 4 hybrid advancement cohort with a 3% annual yield advantage under targeted abiotic and biotic stresses in SSA, Asia and LA, as compared to previous year's benchmark hybrids; Integration of key GIS information into MAIZE breeding pipelines for developing new varieties with traits required for future environments; Baseline studies on genetic gains under optimal and relevant stress environments undertaken in Asia and Latin America.	Open access databases; publications; reports	FP3-3 Increase in the rate of genetic gain for grain yield (as measured in breeders' trials) in rainfed, climate-vulnerable environments of SSA from 0.6% to 1.2% annually, and from ≤1% to at least 1.75% in Asia and LA (linked to FP2 and Genetic Gains Platform)
2018	Multiple stress tolerant MAIZE hybrids (with MLN resistance) replace at least 5 dominant but 15+ year old maize varieties in MLN-endemic countries in eastern Africa; At least 20% yield advantage under heat stress in Stage 4 hybrids cohort relative to popular commercial hybrids grown in the spring season in South Asia.	Improved MAIZE varieties released by seed enterprises and national programs (presented in MAIZE Atlas); Open access databases; publications; reports	FP3-1 Reduced production risk due to adoption of new multiple stress tolerant maize hybrids, including MLN resistance, replacing MLN-susceptible, stress-vulnerable maize varieties in the market.
2019	Maize breeding programs, including those of NARES and SME seed companies, in SSA, Asia and LA reduce product development time by deploying novel tools / technologies (DH, molecular markers, high-throughput and precision phenotying) validated and disseminated through MAIZE FP3 (link with FP2 and Genetic Gains Platform).	Open access databases; publications; reports	FP3-3 Increase in the rate of genetic gain for grain yield (as measured in breeders' trials) in rainfed, climate-vulnerable environments of SSA from 0.6% to 1.2% annually, and from ≤1% to at least 1.75% in Asia and LA (linked to FP2 and Genetic Gains Platform)
2020	At least 20 new MLN resistant hybrids commercialized by seed company partners in MLN-endemic countries in eastern Africa, replacing at least 10-15 dominant but 15+ year old maize varieties in ESA.	Improved MAIZE varieties released by seed enterprises and national programs (presented in MAIZE Atlas); Publications; reports	FP3-1 Reduced production risk due to adoption of new multiple stress tolerant maize hybrids, including MLN resistance, replacing MLN-susceptible, stress-vulnerable maize varieties in the market.

2021	New germplasm, traits and technologies incorporated in MAIZE breeding products to effectively tackle abiotic stresses (drought, heat, waterlogging), emerging diseases (e.g., MLN in eastern Africa), and expanding threats (e.g., invasive and parasitic weeds).	Open access databases; publications; reports; annual MAIZE germplasm shipments to public and private sector partners in SSA, LA and Asia	FP3-3 Increase in the rate of genetic gain for grain yield (as measured in breeders' trials) in rainfed, climate-vulnerable environments of SSA from 0.6% to 1.2% annually, and from ≤1% to at least 1.75% in Asia and LA (linked to FP2 and Genetic Gains Platform)
2022	At least 45-50 kg/ha/year improvement in mean yield of improved MAIZE hybrids relative to baseline checks under drought stress, and at least 100 kg/ha/year under optimum environments in SSA; Documentation of genetic gains in maize under optimal, drought, heat and low N stress conditions in SSA and South Asia.	Open access databases; publications; reports	FP3-3 Increase in the rate of genetic gain for grain yield (as measured in breeders' trials) in rainfed, climate-vulnerable environments of SSA from 0.6% to 1.2% annually, and from ≤1% to at least 1.75% in Asia and LA (linked to FP2 and Genetic Gains Platform)
2017	An MLN Phytosanitary Community of Practice (CoP) established and functional in ESA, implementing harmonized protocols for effectively detecting and preventing trans-boundary movement of MLN pathogens, especially MCMV.	CoP Meeting Minutes; Communications products.	FP3-4 Effective pest/disease surveillance, monitoring and diagnostics protocols/procedures for controlling the spread and impact of existing/emerging threats (e.g., MLN), established in SSA
2018	A dedicated MAIZE pathogen/pest/parasitic weed web portal and data management system (toolbox) with core databases, established under MAIZE Atlas; Reliable and cost-effective diagnostic protocols for curbing the spread of pathogens (e.g., MCMV) through seed implemented by NPPOs and commercial seed companies in ESA.	Tracking online tools; Web portal; Consolidated MLN Survey Reports from SSA; SOPs and surveillance tools/documents	FP3-4 Effective pest/disease surveillance, monitoring and diagnostics protocols/procedures for controlling the spread and impact of existing/emerging threats (e.g., MLN), established in SSA
2019	Economical treatments to reduce or prevent seed contamination with pathogens (e.g., MCMV) identified, validated and disseminated to commercial seed sector.	Publications, Reports; Web portal	FP3-5 Reduced incidence and impact of trans-boundary pathogens/pests/parasitic weeds on farmers and commercial seed sector.
2020	Remote sensing/earth observation tools explored for understanding the maize pest and disease dynamics in an area-wide approach.	Publications, Reports; Web portal	FP3-4 Effective pest/disease surveillance, monitoring and diagnostics protocols/procedures for controlling the spread and impact of existing/emerging threats (e.g., MLN), established in SSA

2021	MAIZE Atlas/web portal populated with available information (resistant germplasm, pathogen / pest /parasitic weed survey data, management recommendations, etc.)	Tracking online tools; Web portal	FP3-5 Reduced incidence and impact of trans-boundary pathogens/pests/parasitic weeds on farmers and commercial seed sector.
2022	MLN incidence significantly reduced in the countries endemic in 2017 due to the implementation of a comprehensive action plan through MAIZE; Learning, knowledge, and products created by the CoPs used to inform new strategies, activities, technologies and business models for the future.	Tracking online tools; Web portal; Consolidated MLN Survey Reports from SSA; Publications; Reports	FP3-5 Reduced incidence and impact of trans-boundary pathogens/pests/parasitic weeds on farmers and commercial seed sector.
2017	At least 300 hybrids and 30 OPVs with high levels of micronutrients and desirable grain quality traits evaluated in multiple locations for agronomic performance and nutrient levels.	Open access databases; publications; reports	FP3-6 Nutritious maize hybrids/varieties with superior agronomic performance and desirable gender-informed traits (processing properties, palatability and storability) adopted in targeted geographies in SSA, Asia and LA (linked to FP5 and A4NH)
2018	Donor germplasm with desirable stover quality, kernel carotenoid stability and processing properties identified and shared with partners in target countries.	Open access databases; publications; reports; annual MAIZE germplasm shipments to public and private sector partners in SSA, LA and Asia	FP3-7 Commercial release and adoption of improved maize varieties with specific end-use traits (e.g., dual purpose maize with stover/fodder quality; specialty corn; blue maize) coupled with agronomic performance (linked to FP5)
2019	Improved maize varieties with prioritized end-use quality traits developed, for enhanced use of maize as food/feed, storability, processing and palatability.	Improved MAIZE varieties released by seed enterprises and national programs (presented in MAIZE Atlas); Publications; reports	FP3-7 Commercial release and adoption of improved maize varieties with specific end-use traits coupled with agronomic performance (linked to FP5)
2020	At least 5-10 new dual-purpose / specialty maize hybrids released for commercialization in SSA, Asia and LA.	Improved MAIZE varieties released by seed enterprises and national programs (presented in MAIZE Atlas); Publications; reports	FP3-7 Commercial release and adoption of improved maize varieties with specific end-use traits coupled with agronomic performance (linked to FP5)
2021	Specialty maize (e.g., blue maize) hybrids / varieties with desirable agronomic, quality and adaptive traits identified and made available to partners in target countries for testing and	Improved MAIZE varieties released by seed enterprises and national programs (presented in MAIZE Atlas); Publications; reports	FP3-7 Commercial release and adoption of improved maize varieties with specific end-use traits coupled with agronomic performance (linked to FP5)

	eventual release.		
2022	At least 20-25% of tropical and subtropical breeding programs in target countries in SSA, Asia and LA incorporating enhanced nutritional quality and end-use traits in breeding products.	Surveys; Reports	FP3-6 Nutritious maize hybrids/varieties with superior agronomic performance and desirable gender-informed traits (processing properties, palatability and storability) adopted in targeted geographies in SSA, Asia and LA (linked to FP5 and A4NH)
2017	Digital platform (proximal and remote) on unmanned aerial vehicle (UAVs) equipped with various high resolution cameras (hyper-spectral, multi-spectral, thermal, RGB etc., depending on targeted traits) in support of high-throughput phenotyping and real-time data capture; linkages developed with Phenotyping Modules in the Genetic Gains Platform.	Surveys; literature review; Qualitative data on improvement in collection of phenotypic data and efficiency of breeding programs	FP3-8 Reduction in product development and elite line recycling time and costs through integration of novel tools/technologies in breeding programs.
2018	Precision phenotyping sites, including well-equipped benchmark phenotyping sites and complementary satellite phenotyping sites, established in SSA and South Asia in partnership with public and private sector partners.	Phenotyping site surveys; Reports	FP3-9 Enhanced breeding capacity and efficiency of NARES and SMEs to develop and make available improved stress tolerant and nutritious maize varieties
2019	Adoption of mechanization approaches for trial and nursery operations enabled in at least 3-4 MAIZE breeding hubs developing international public goods.	Breeding hubs surveys; Reports	FP3-9 Enhanced breeding capacity and efficiency of NARES and SMEs to develop and make available improved stress tolerant and nutritious maize varieties
2020	New high throughput phenotyping tools for breeder preferred traits, including plant height, phenology, stand count and yield components, developed and disseminated.	Surveys; literature review; Qualitative data on improvement in collection of phenotypic data and efficiency of breeding programs	FP3-9 Enhanced breeding capacity and efficiency of NARES and SMEs to develop and make available improved stress tolerant and nutritious maize varieties
2021	Image data management and data processing scaled-up and disseminated to MAIZE partners; Targeted co-investments by MAIZE and partner organizations enabling adoption of selected mechanization approaches for trial and nursery operations.	Surveys; Reports	FP3-9 Enhanced breeding capacity and efficiency of NARES and SMEs to develop and make available improved stress tolerant and nutritious maize varieties

2022	Harmonized high-throughput phenotyping protocols for key abiotic and biotic stresses published and disseminated to the partners for routine use in breeding programs.	Literature review; Communication products	FP3-9 Enhanced breeding capacity and efficiency of NARES and SMEs to develop and make available improved stress tolerant and nutritious maize varieties
2017	Parental lines of improved MAIZE hybrids evaluated annually for seed producibility, herbicide sensitivity, and other desirable agronomic traits; Gender and socio-economic considerations included when designing crosses for developing products, seed production research and determining recommendation domains.	Online information on seed production information packages of MAIZE parental lines and hybrids	FP3-10 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.
2018	Seed production studies across a range of target seed production environments in collaboration with public/private sector partners; Research into the economics of seed production of single-cross and three-way cross hybrids in SSA.	Online information on seed production information packages of MAIZE parental lines and hybrids; Surveys; Reports	FP3-10 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.
2019	Web-based documentation and dissemination of the seed production research results and recommendation domains to the MAIZE partners for cost-effective seed scale-up.	Online information on seed production information packages of MAIZE parental lines and hybrids	FP3-10 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.
2020	Development of maize source populations for male sterility to make seed more affordable (by reducing the cost of seed production)	Reduced cost of goods sold (COGS); Reports	FP3-10 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.
2021	Development of male sterility-based maize seed production systems, especially for SSA.	Reduced cost of goods sold (COGS); Reports	FP3-10 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.
2022	NARES and private seed sector institutions in target geographies access information on improved MAIZE hybrids with at least 20-25% improvement in mean seed producibility index score.	Tracking online tools; Surveys; Reports	FP3-11 More competitive and vibrant local, national and regional maize seed systems

2017	Availability and affordability of MAIZE derived novel varieties improved in target geographies through public-private partnerships.	Tracking online tools; Surveys; Reports	FP3-12 Enhanced adoption of climate resilient and nutritious maize varieties by smallholder farmers in stress-prone rainfed environments of SSA, Asia and LA providing better yields and stability
2018	Sustainable early-generation seed (breeder, pre-basic, and foundation seed) supply systems promoted, especially in SSA; Deployment of a new seed system management software in regional hubs, linked to institutional phenotypic and genotypic databases, to streamline inventory management, routine QC/QA operations, phytosanitary regulation compliance, and shipment tracking.	Surveys; Reports; Qualitative data.	FP3-11 More competitive and vibrant local, national and regional maize seed systems
2019	Sustainable commercialization, marketing, and promotion of new climate-resilient and nutritious MAIZE varieties catalyzed, to enhance both local production and adoption; Digital map of suitable new maize seed production sites in South Asia, based on GIS data.	Surveys; Reports; Qualitative data.	FP3-12 Enhanced adoption of climate resilient and nutritious maize varieties by smallholder farmers in stress-prone rainfed environments of SSA, Asia and LA providing better yields and stability
2020	Women and youth participation across the maize seed value chain promoted; Information generated and documented on technology adoption patterns and key drivers to design marketing strategies (linkage with FP1).	Surveys; Reports; Qualitative data.	FP3-13 Increased access of women to improved, good quality maize seed, and enhanced engagement of women and youth in maize-based agri-business and value chains.
2021	International Maize Improvement Consortium (IMIC) in Africa, with at least 25 local/regional seed companies as members.	Consortium membership	FP3-11 More competitive and vibrant local, national and regional maize seed systems
2022	At least 30 obsolete, climate-vulnerable but dominant varieties (15-20+ year old) replaced from the market with improved MAIZE varieties, in active interface with seed companies in SSA.	Documentation of old and obsolete maize varieties replaced by seed companies with improved MAIZE hybrids; Variety adoption monitoring reports	FP3-12 Enhanced adoption of climate resilient and nutritious maize varieties by smallholder farmers in stress-prone rainfed environments of SSA, Asia and LA providing better yields and stability

MAIZE PIM Table D FP4

Year	Milestone description	Means of verifying	For which outcome?
2017	Multi-criteria assessments taking into account environmental and social acceptability aspects, based on standardized protocols for multi-criteria 'step' assessments of advanced crop management packages (not individual technologies)	Reports, case study documentation, significant change stories, management options and ICT systems	FP4-1 Improved understanding of farmers' livelihood strategies and their diversity, allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2018	Strengthened ability to synthesize and apply available knowledge related to SI oriented research methodologies (multi-criteria assessments), management practices, technologies, machinery, in 10-15 partner orgs	Reports, case study documentation, significant change stories, management options and ICT systems	FP4-1 Improved understanding of farmers' livelihood strategies and their diversity, allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2019	Better understand and model relationship between commercialization / market-oriented production and diversification / productivity increases, for scaling-up purposes, e.g. consider input and output markets	Reports, case study documentation, significant change stories, management options and ICT systems	FP4-1 Improved understanding of farmers' livelihood strategies and their diversity, allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2020	better understand and model farmer perception, farmer diversity, and farm-level integration of technologies	Reports, case study documentation, significant change stories, management options and ICT systems	FP4-1 Improved understanding of farmers' livelihood strategies and their diversity, allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2022	improved understanding translated into ICT for improved farmer decision making projects	Reports, case study documentation, significant change stories, management options and ICT systems	FP4-1 Improved understanding of farmers' livelihood strategies and their diversity, allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)

2020	Tools and methods for assessing agricultural systems for sustainable intensification	Study reports, case studies, CRP Commissioned External Evaluation reports, farmer organizations & innovation platforms	FP4-2 Sustainable intensification indicators and metrics at field, farm and landscape levels developed and used for monitoring systems' trajectories of changes and efficiency of interventions
2021	Decision support tools for farmers, service providers and development actors	Study reports, case studies, CRP Commissioned External Evaluation reports, farmer organizations & innovation platforms	FP4-2 Sustainable intensification indicators and metrics at field, farm and landscape levels developed and used for monitoring systems' trajectories of changes and efficiency of interventions
2022	Mixed method approaches for multi-scale assessment of sustainable intensification options at farm and landscape level	Study reports, case studies, CRP Commissioned External Evaluation reports, farmer organizations & innovation platforms	FP4-2 Sustainable intensification indicators and metrics at field, farm and landscape levels developed and used for monitoring systems' trajectories of changes and efficiency of interventions
2019	Innovative tools, methods and multi-media extension materials to enhanced soil quality, nutrient and water use efficiency	Reports, case studies, materials, dissemination documentation, tools	FP4-6 Decision support systems for nutrient and water management used by development partners
2020	Decision support tools for nutrient and irrigation management using remote sensing and geospatial frameworks	Reports, case studies, materials, dissemination documentation, tools	FP4-6 Decision support systems for nutrient and water management used by development partners
2021	Improved integrated weed management practices that decreases farmers' drudgery, particularly for women	Reports, case studies, materials, dissemination documentation, tools	FP4-6 Decision support systems for nutrient and water management used by development partners
2022	Improved planting, intercultural operation and irrigation machineries appropriate to smallholders' small and fragmented fields	Reports, case studies, materials, dissemination documentation, tools	FP4-6 Decision support systems for nutrient and water management used by development partners
2018	increased adoption of combinations of SI strategies, technologies in specific target geographies compared to 2016	CRP Commissioned External Evaluation reports , project/donor-driven impact studies; partner self-assessments	FP4-3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods
2019	strengthened ability to synthesize and apply available knowledge related to SI oriented research methodologies	CRP Commissioned External Evaluation reports , project/donor-driven impact studies; partner self-	FP4-3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods

	(multi-criteria assessments), management practices, technologies, machinery, in 10-15 partner orgs	assessments	
2020	Adaptive research improves understanding of gender, youth and adoption, adaptation and scaling-up processes, with focus on market demand as trigger of innovation	CRP Commissioned External Evaluation reports , project/donor-driven impact studies; partner self-assessments	FP4-3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods
2021	more team work and interdisciplinary research practice in 10-15 partner organizations in specific scaling-out projects	CRP Commissioned External Evaluation reports , project/donor-driven impact studies; partner self-assessments	FP4-3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods
2022	more team work and interdisciplinary research practice in 10-15 partner organizations in specific scaling-out projects increased adoption of combinations of SI strategies, technologies with poverty reduction impact in specific target geographies compared to 2019	CRP Commissioned External Evaluation reports , project/donor-driven impact studies; partner self-assessments	FP4-3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods
2017	better understand smallholder farming systems diversity and trajectories (which drive adoption) and feedback between farming systems and their operating landscapes	Documentation review, Survey of private sector CRP Commissioned External Evaluation reports	FP4-5 Improved understanding of farmers' livelihood strategies and their diversity allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2018	Smart mechanization lessons learnt routinely applied in other FP4 projects	Documentation review, Survey of private sector CRP Commissioned External Evaluation reports	FP4-5 Improved understanding of farmers' livelihood strategies and their diversity allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2019	extension of crop mgmt practices that arrest soil degradation	Documentation review, Survey of private sector CRP Commissioned External Evaluation reports	FP4-5 Improved understanding of farmers' livelihood strategies and their diversity allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)

2020	Decision support-, mechanization and other tools, processes improve target groups' ability to seize opp's and avoid losses	Documentation review, Survey of private sector CRP Commissioned External Evaluation reports	FP4-5 Improved understanding of farmers’ livelihood strategies and their diversity allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)
2022	Intensified, diversified farming systems developed, with increased systems intensity, reduces pressure on land	Documentation review, Survey of private sector CRP Commissioned External Evaluation reports	FP4-5 Improved understanding of farmers’ livelihood strategies and their diversity allowing NARES and extension partners to target and implement institutional and technical interventions (in collaboration with other CRPs with a systems Flagship)

MAIZE PIM Table D FP5

Year	Milestone description	Means of verifying	For which outcome?
2017	Develop enriched maize varieties agronomically and nutritionally superior	Reports, case study documentation, significant change stories,	FP5-2 Increased consumption of improved and novel maize-based nutritious food products by consumers, especially women and preschool children
2018	Improve women's and children's diet spreading nutritious and novel maize-based products	Reports, case study documentation, significant change stories,	FP5-2 Increased consumption of improved and novel maize-based nutritious food products by consumers, especially women and preschool children
2019	Include women in markets by developing opportunities in the informal sector/ markets,	Reports, case study documentation, significant change stories,	FP5-2 Increased consumption of improved and novel maize-based nutritious food products by consumers, especially women and preschool children
2020	Include maize landraces and their improved versions in the value chain	Reports, case study documentation, significant change stories,	FP5-2 Increased consumption of improved and novel maize-based nutritious food products by consumers, especially women and preschool children
2018	Provide Support processing technology and equipment to achieve self-sufficiency in maize products	Methodologies and tools	FP5-4 Enhanced adoption of improved processing methods and labor saving technologies by NARES, NGOs and SMEs
2020	Adapt technologies, to improve nutritional quality and reduce food losses, and small-scale maize technologies for development of value-added products.	Methodologies and tools	FP5-4 Enhanced adoption of improved processing methods and labor saving technologies by NARES, NGOs and SMEs
2022	Designing locally-adapted and cost-efficient processing equipment	Methodologies and tools	FP5-4 Enhanced adoption of improved processing methods and labor saving technologies by NARES, NGOs and SMEs
2017	Develop tools and methods to provide post-harvest grain loss assessment	Tools and methods, Reports, case study documentation	FP5-5 Increased adoption of improved storage and drying technologies by NARES, NGOs and SMEs

2019	Produce Storage technologies to reduce post-harvest losses and improve grain qualify of stored grain	Tools and methods, Reports, case study documentation	FP5-5 Increased adoption of improved storage and drying technologies by NARES, NGOs and SMEs
2021	Promotion of improved post-harvest technologies	Tools and methods, Reports, case study documentation	FP5-5 Increased adoption of improved storage and drying technologies by NARES, NGOs and SMEs
2017	Provide training for the best use of stover for animal feed	Surveys, reports, case study documentation	FP5-6 Optimized feed processing options using maize and its by-products by feed industries and livestock owners adopt
2018	Develop and adoption of suitable processing technologies	Surveys, reports, case study documentation	FP5-6 Optimized feed processing options using maize and its by-products by feed industries and livestock owners adopt
2019	formulation of compound feeds based on maize by-products for feeding ruminants	Surveys, reports, case study documentation	FP5-6 Optimized feed processing options using maize and its by-products by feed industries and livestock owners adopt
2020	refinement of maize by-products for inclusion in feed for monogastric species such as poultry	Surveys, reports, case study documentation	FP5-6 Optimized feed processing options using maize and its by-products by feed industries and livestock owners adopt

3.19 Flagship Budget and Analysis

FP1 Budget

General Information

CRP on Maize
FP1 Enhancing Maize's R4D Strategy for impact

Prepared by: Ramiro Tovar

Date submitted:

Template version 2015-01-14.1

Legend for cell formatting:
Enter information into light yellow cells
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GENERAL INFORMATION

Proposal Information

CRP Name	CRP on Maize
Flagship Title	FP1 Enhancing Maize's R4D Strategy for impact
How are you using the template?	Consolidated Flagship
CRP Lead Center's Name	CIMMYT
Requested Amount	$23,082,509
Total Project Cost	$34,276,022

Budgeting & Reporting Periods

Anticipated Start Date	01-Jan-17
Anticipated End Date	31-Dec-22
Project Duration (months)	72.0

Reporting Periods	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period Start Date	01-Jan-17	01-Jan-18	01-Jan-19	01-Jan-20	01-Jan-21	01-Jan-22		
Period End Date	31-Dec-17	31-Dec-18	31-Dec-19	31-Dec-20	31-Dec-21	31-Dec-22		
Number of Months	12.0	12.0	12.0	12.0	12.0	12.0		

Other Budget Factors

Is this a new version of a previously approved budget? No

Participating Partners' information

	List of Participating Partners	Primary Indirect Cost (IDC) Rate	Pass-thru IDC Rate
1	CIMMYT	15.0%	5.0%
2	IITA	16.5%	16.5%
3			
4			
5			

Financial Summary

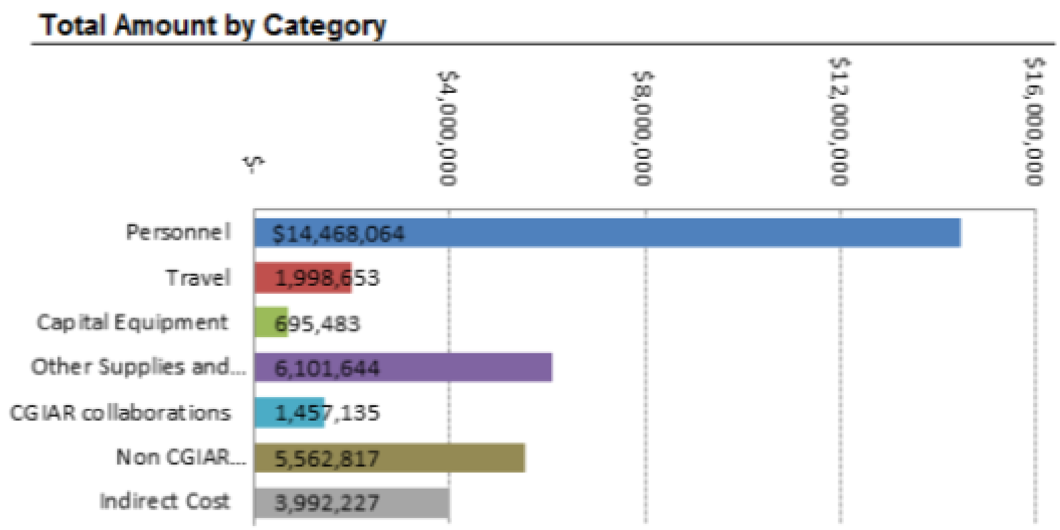
Expand/Collapse sections to see/hide the budget and actuals & projections →

Budget

Prepared by: Ramiro Tovar

	Period 1 Jan-17 - Dec-17 Budget	Period 2 Jan-18 - Dec-18 Budget	Period 3 Jan-19 - Dec-19 Budget	Period 4 Jan-20 - Dec-20 Budget	Period 5 Jan-21 - Dec-21 Budget	Period 6 Jan-22 - Dec-22 Budget	
Uses of Funds by Expense Category							
Category							TOTAL
Personnel	$ 2,127,058	$ 2,233,411	$ 2,345,082	$ 2,462,336	$ 2,585,453	$ 2,714,725	$ 14,468,064
Travel	293,837	308,529	323,956	340,146	357,159	375,025	1,998,653
Capital Equipment	102,248	107,361	112,729	118,363	124,283	130,500	695,483
Other Supplies and Services	897,050	941,902	988,997	1,038,425	1,090,364	1,144,905	6,101,644
CGIAR collaborations	214,225	224,936	236,183	247,986	260,390	273,415	1,457,135
Non CGIAR Collaborations	817,833	858,724	901,661	946,723	994,076	1,043,800	5,562,817
TOTAL DIRECT COST	**4,452,251**	**4,674,864**	**4,908,607**	**5,153,979**	**5,411,725**	**5,682,369**	**30,283,796**
Indirect Cost	586,928	616,274	647,088	679,435	713,412	749,090	3,992,227
TOTAL BUDGET	**$ 5,039,179**	**$ 5,291,138**	**$ 5,555,695**	**$ 5,833,415**	**$ 6,125,137**	**$ 6,431,459**	**$ 34,276,022**
Breakdown of Budget by Participating Partner							
							TOTAL
CIMMYT	$ 4,137,827	$ 4,344,719	$ 4,561,955	$ 4,790,000	$ 5,029,542	$ 5,281,071	$ 28,145,114
IITA	901,352	946,419	993,740	1,043,415	1,095,595	1,150,388	6,130,908
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
TOTAL BUDGET	**5,039,179**	**5,291,138**	**5,555,695**	**5,833,415**	**6,125,137**	**6,431,459**	**34,276,022**
Funding Plan							
Sources of Funding Needed							TOTAL
W1+W2	$ 1,867,255	1,960,618	2,058,648	2,161,534	2,269,648	2,383,177	$ 12,700,881
W3	1,526,284	1,602,598	1,682,728	1,766,826	1,855,198	1,947,996	10,381,628
Bilateral	1,645,640	1,727,923	1,814,319	1,905,054	2,000,291	2,100,286	11,193,513
Other Sources							-
TOTAL FUNDING PLAN	**5,039,179**	**5,291,138**	**5,555,695**	**5,833,414**	**6,125,137**	**6,431,459**	**34,276,022**
Sources of Funding Secured							TOTAL
W1+W2 (Assumed Secured)	1,867,255	1,960,618	2,058,648	2,161,534	2,269,648	2,383,177	$ 12,700,881
W3	194,812	-	-	-	-	-	194,812
Bilateral	1,024,857	268,098	-	-	-	-	1,292,955
Other Sources							-
TOTAL SECURED	**3,086,923**	**2,228,715**	**2,058,648**	**2,161,534**	**2,269,648**	**2,383,177**	**14,188,647**
TOTAL FUNDING GAP OVER/(UNDER)	**$ (1,952,255)**	**$ (3,062,423)**	**$ (3,497,047)**	**$ (3,671,880)**	**$ (3,855,488)**	**$ (4,048,281)**	**$ (20,087,375)**
W1+W2 (Required from SO)	-	-	-	-	-	-	-
W3 (Required from FC Members)	(1,331,472)	(1,602,598)	(1,682,728)	(1,766,826)	(1,855,198)	(1,947,996)	(10,186,816)
Bilateral (Fundraising)	(620,783)	(1,459,825)	(1,814,319)	(1,905,054)	(2,000,291)	(2,100,286)	(9,900,558)
Other Sources (Fundraising)	-	-	-	-	-	-	-

Analysis



Total Amount by Category
$-
$4,000,000
$8,000,000
$12,000,000
$16,000,000
Personnel
Travel
Capital Equipment
Other Supplies and...
CGIAR collaborations
Non CGIAR...
Indirect Cost
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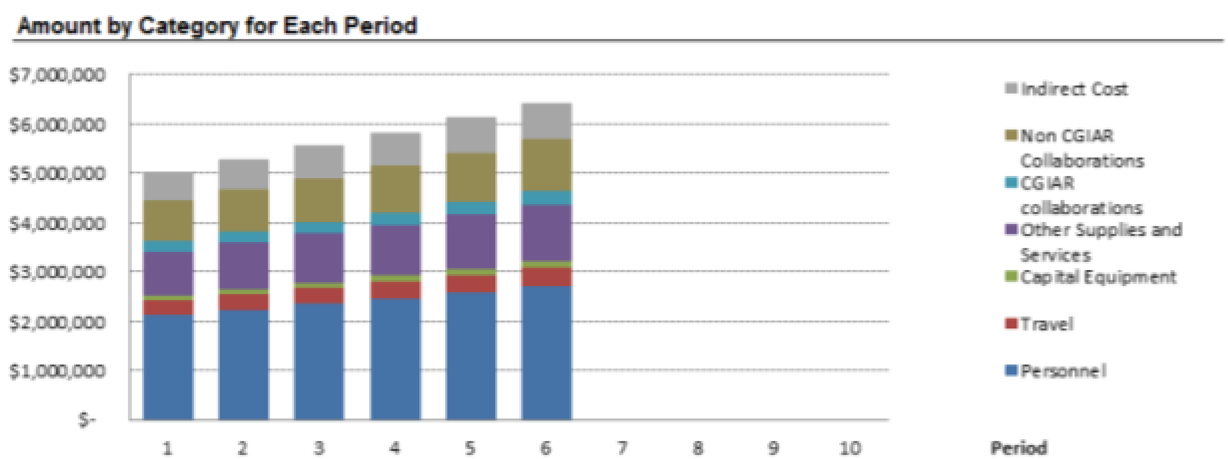
695,483
6,101,644
1,457,135
5,562,817
3,992,227



Amount by Category for Each Period
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$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$-
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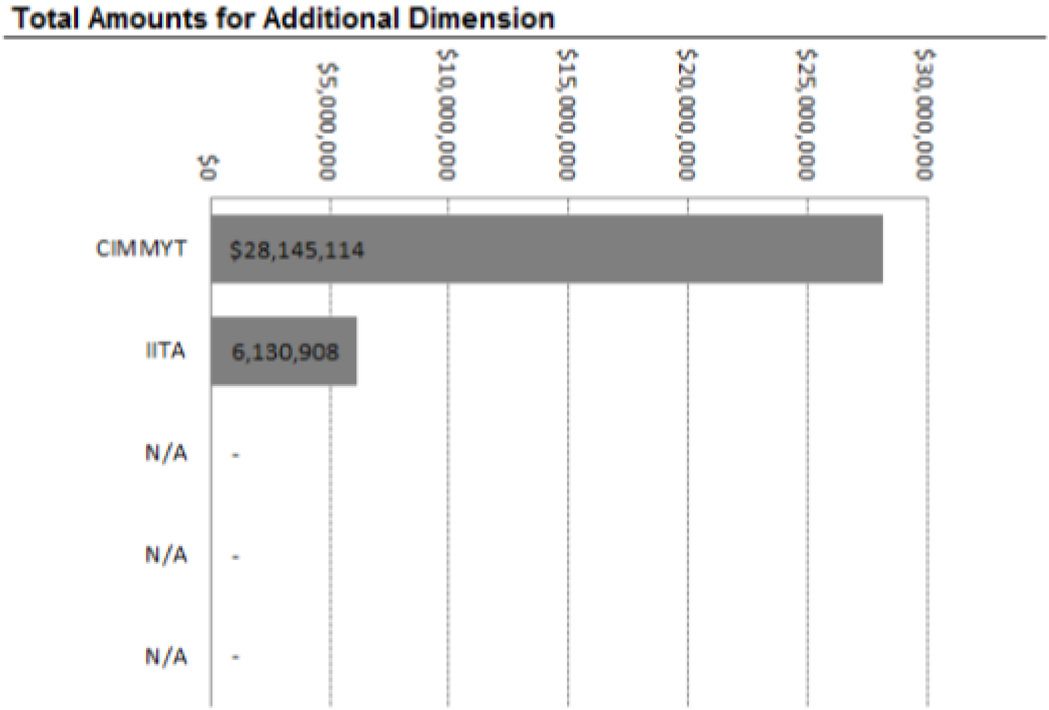
Period
Indirect Cost
Non CGIAR Collaborations
CGIAR collaborations
Other Supplies and Services
Capital Equipment
Travel
Personnel

Analysis



Total Amounts for Additional Dimension
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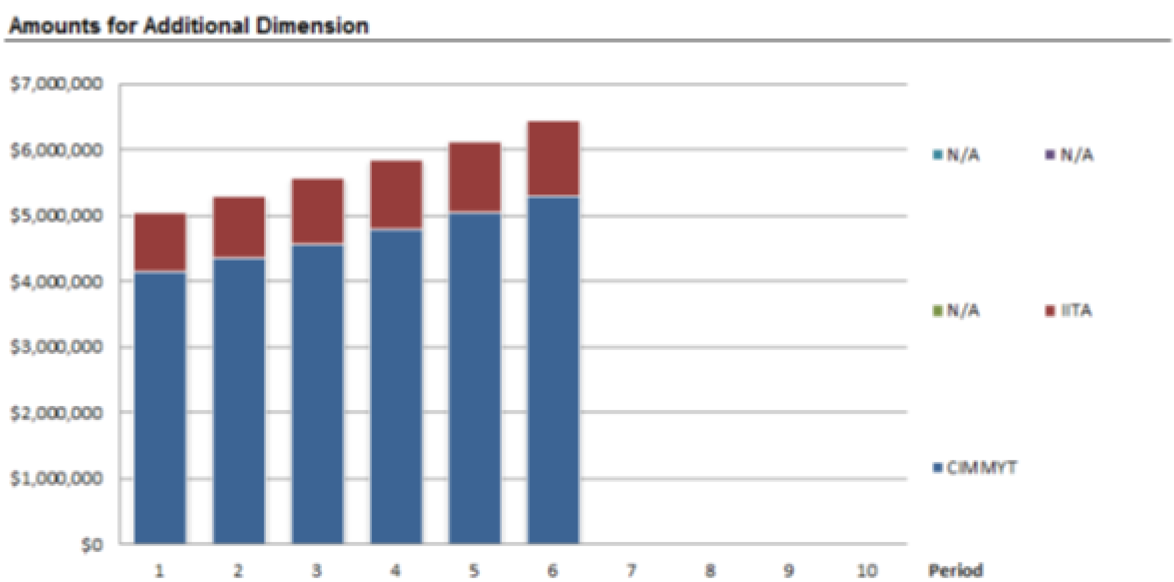
$5,000,000
$10,000,000
$15,000,000
$20,000,000
$25,000,000
$30,000,000
CIMMYT
$28,145,114
IITA
6,130,908
N/A
-
N/A
-
N/A
-



Amounts for Additional Dimension
$7,000,000
$6,000,000
$5,000,000
$4,000,000
$3,000,000
$2,000,000
$1,000,000
$0
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10
Period
N/A
N/A
N/A
IITA
CIMMYT

FP2 Budget

General Information

CRP on Maize
FP2 Novel Diversity and Tools for increasing Genetic Gains

Prepared by: Ramiro Tovar

Date submitted:

Template version 2015-01-14.1

Legend for cell formatting:
Enter information into light yellow cells
Enter actual expenditures into green cells
Blue cells will be populated by CO

GENERAL INFORMATION

Proposal Information

CRP Name	CRP on Maize
Flagship Title	FP2 Novel Diversity and Tools for increasing Genetic Gains
How are you using the template?	Consolidated Flagship
CRP Lead Center's Name	CIMMYT
Requested Amount	**$45,551,396**
Total Project Cost	**$50,953,774**

Budgeting & Reporting Periods

Anticipated Start Date	01-Jan-17
Anticipated End Date	31-Dec-22
Project Duration (months)	72.0

Reporting Periods	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period Start Date	**01-Jan-17**	**01-Jan-18**	**01-Jan-19**	**01-Jan-20**	**01-Jan-21**	**01-Jan-22**		
Period End Date	**31-Dec-17**	**31-Dec-18**	**31-Dec-19**	**31-Dec-20**	**31-Dec-21**	**31-Dec-22**		
Number of Months	12.0	12.0	12.0	12.0	12.0	12.0		

Other Budget Factors

Is this a new version of a previously approved budget? No

Participating Partners' information

	List of Participating Partners	Primary Indirect Cost (IDC) Rate	Pass-thru IDC Rate
1	CIMMYT	15.0%	5.0%
2	IITA	16.5%	16.5%
3			
4			
5			

← *unhide additional rows if needed*

Financial Summary

FINANCIAL SUMMARY & REPORTING

Expand/Collapse sections to see/hide the budget and actuals & projections →

Budget

Prepared by: Ramiro Tovar

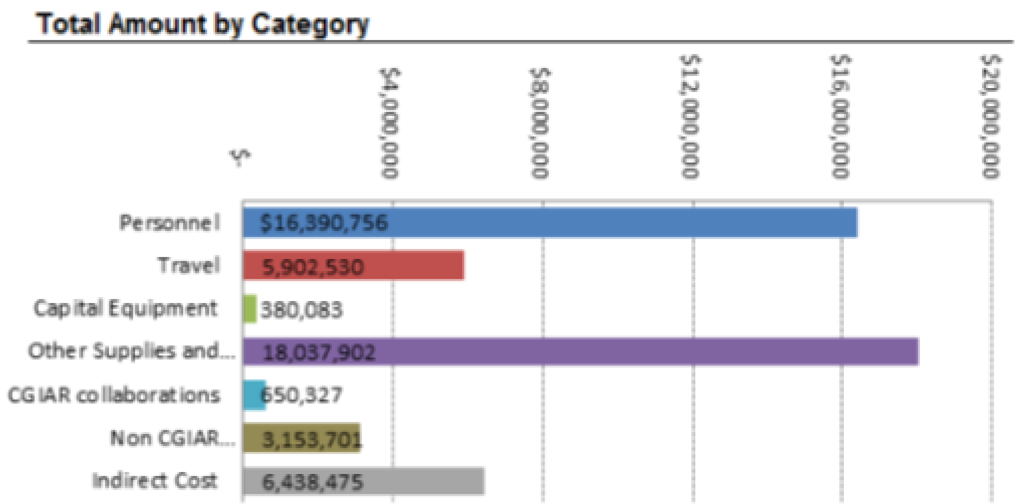
Uses of Funds by Expense Category Category	Period 1 Jan-17 - Dec-17 Budget	Period 2 Jan-18 - Dec-18 Budget	Period 3 Jan-19 - Dec-19 Budget	Period 4 Jan-20 - Dec-20 Budget	Period 5 Jan-21 - Dec-21 Budget	Period 6 Jan-22 - Dec-22 Budget	TOTAL
Personnel	$ 2,409,727	$ 2,530,214	$ 2,656,725	$ 2,789,561	$ 2,929,039	$ 3,075,491	$ 16,390,756
Travel	867,777	911,165	956,724	1,004,538	1,054,782	1,107,543	5,902,530
Capital Equipment	55,879	58,673	61,607	64,685	67,921	71,318	380,083
Other Supplies and Services	2,651,892	2,784,486	2,923,711	3,069,830	3,223,374	3,384,609	18,037,902
CGIAR collaborations	95,610	100,390	105,410	110,678	116,213	122,027	650,327
Non CGIAR Collaborations	463,650	486,832	511,174	536,721	563,567	591,756	3,153,701
TOTAL DIRECT COST	**6,544,534**	**6,871,761**	**7,215,349**	**7,576,013**	**7,954,896**	**8,352,745**	**44,515,299**
Indirect Cost	946,569	993,898	1,043,593	1,095,758	1,150,557	1,208,100	6,438,475
TOTAL BUDGET	**$ 7,491,104**	**$ 7,865,659**	**$ 8,258,942**	**$ 8,671,771**	**$ 9,105,454**	**$ 9,560,844**	**$ 50,953,774**

Breakdown of Budget by Participating Partner	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	TOTAL
CIMMYT	$ 6,620,881	$ 6,951,925	$ 7,299,521	$ 7,664,391	$ 8,047,695	$ 8,450,186	$ 45,034,599
IITA	870,223	913,734	959,421	1,007,380	1,057,759	1,110,658	5,919,175
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
TOTAL BUDGET	**7,491,104**	**7,865,659**	**8,258,942**	**8,671,771**	**9,105,454**	**9,560,844**	**50,953,774**

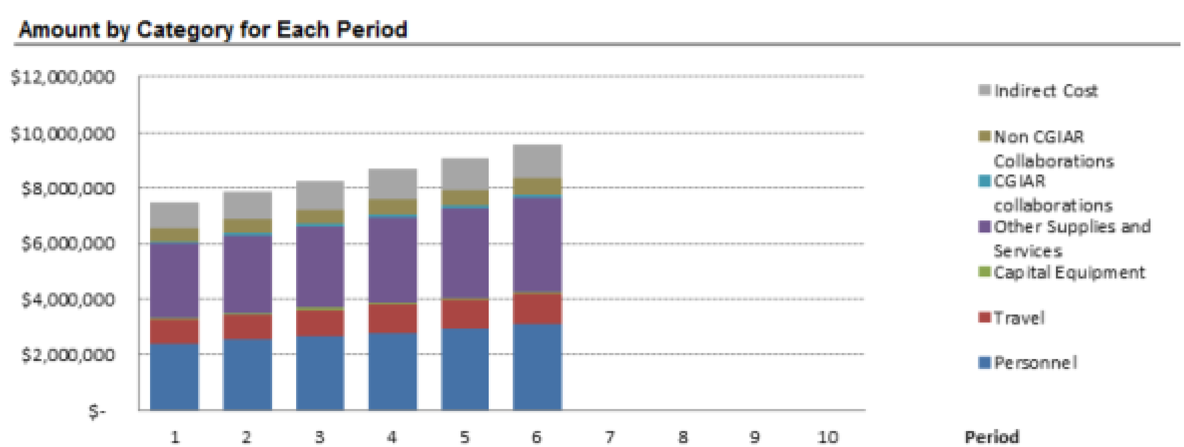
Funding Plan Sources of Funding Needed	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	TOTAL
W1+W2	$ 2,285,078	2,399,331	2,519,298	2,645,206	2,777,512	2,916,444	$ 15,542,869
W3	4,411,786	4,632,375	4,863,994	5,107,083	5,362,526	5,630,762	30,008,527
Bilateral	794,241	833,952	875,650	919,480	965,417	1,013,638	5,402,378
Other Sources							-
TOTAL FUNDING PLAN	**7,491,104**	**7,865,659**	**8,258,942**	**8,671,770**	**9,105,454**	**9,560,845**	**50,953,774**

Sources of Funding Secured	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	TOTAL
W1+W2 (Assumed Secured)	2,285,078	2,399,331	2,519,298	2,645,206	2,777,512	2,916,444	$ 15,542,869
W3	746,354	-	-	-	-	-	746,354
Bilateral	756,476	339,233	300,179	-	-	-	1,395,888
Other Sources							-
TOTAL SECURED	**3,787,907**	**2,738,564**	**2,819,477**	**2,645,206**	**2,777,512**	**2,916,444**	**17,685,110**
TOTAL FUNDING GAP OVER/(UNDER)	**$ (3,703,198)**	**$ (5,127,094)**	**$ (5,439,465)**	**$ (6,026,564)**	**$ (6,327,943)**	**$ (6,644,400)**	**$ (33,268,663)**
W1+W2 (Required from SO)	-	-	-	-	-	-	-
W3 (Required from FC Members)	(3,665,432)	(4,632,375)	(4,863,994)	(5,107,083)	(5,362,526)	(5,630,762)	(29,262,174)
Bilateral (Fundraising)	(37,765)	(494,719)	(575,471)	(919,480)	(965,417)	(1,013,638)	(4,006,490)
Other Sources (Fundraising)	-	-	-	-	-	-	-

Analysis



Total Amount by Category
$-
$4,000,000
$8,000,000
$12,000,000
$16,000,000
$20,000,000
Personnel
Travel
Capital Equipment
Other Supplies and...
CGIAR collaborations
Non CGIAR...
Indirect Cost
$16,390,756
5,902,530
380,083
18,037,902
650,327
3,153,701
6,438,475



Amount by Category for Each Period
$12,000,000
$10,000,000
$8,000,000
$6,000,000
$4,000,000
$2,000,000
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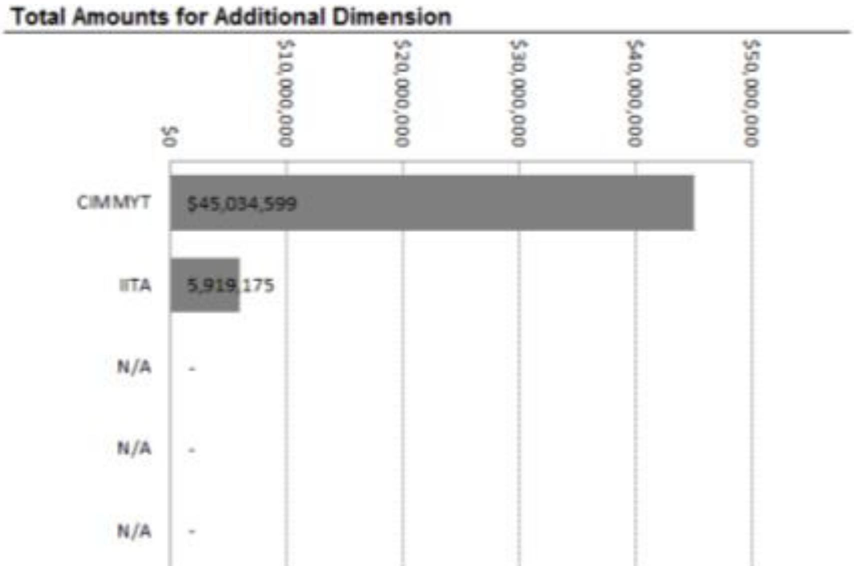
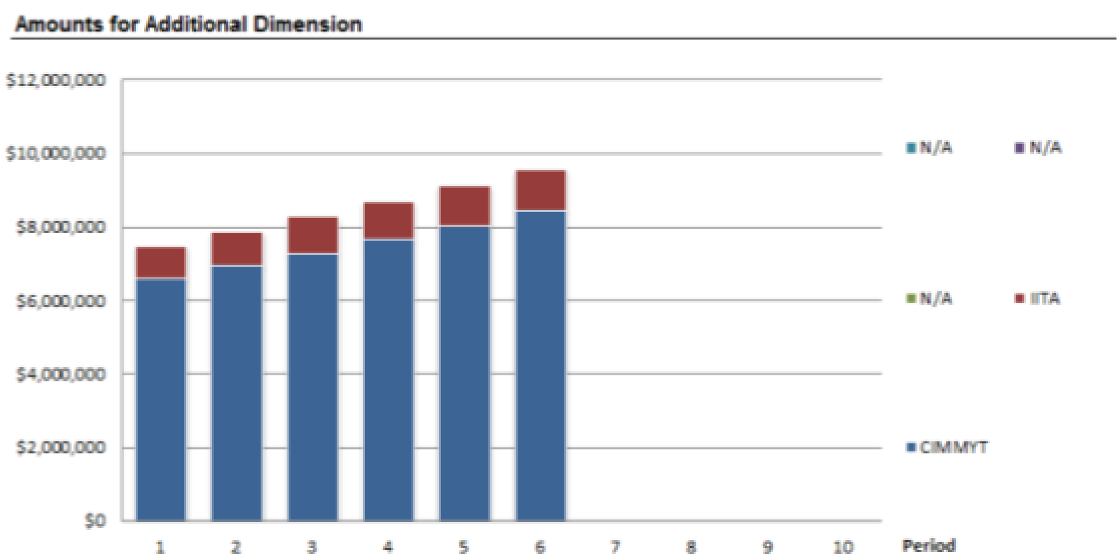
Period
Indirect Cost
Non CGIAR Collaborations
CGIAR collaborations
Other Supplies and Services
Capital Equipment
Travel
Personnel

Analysis



Total Amounts for Additional Dimension
$0
$10,000,000
$20,000,000
$30,000,000
$40,000,000
$50,000,000
CIMMYT
$45,034,599
IITA
5,919,175
N/A
-
N/A
-
N/A
-



Amounts for Additional Dimension
$12,000,000
$10,000,000
$8,000,000
$6,000,000
$4,000,000
$2,000,000
$0
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Period
N/A
N/A
N/A
IITA
CIMMYT

FP3 Budget

General Information

CRP on Maize
FP3 Stress Tolerant and Nutritious Maize

Prepared by: Ramiro Tovar

Date submitted:

Template version 2015-01-14.1

Legend for cell formatting:
Enter information into light yellow cells
Enter actual expenditures into green cells
Blue cells will be populated by CO

GENERAL INFORMATION

Proposal Information

CRP Name	CRP on Maize
Flagship Title	FP3 Stress Tolerant and Nutritious Maize
How are you using the template?	Consolidated Flagship
CRP Lead Center's Name	CIMMYT
Requested Amount	**$121,088,433**
Total Project Cost	**$189,857,993**

Budgeting & Reporting Periods

Anticipated Start Date	01-Jan-17
Anticipated End Date	31-Dec-22
Project Duration (months)	72.0

Reporting Periods	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period Start Date	**01-Jan-17**	**01-Jan-18**	**01-Jan-19**	**01-Jan-20**	**01-Jan-21**	**01-Jan-22**		
Period End Date	**31-Dec-17**	**31-Dec-18**	**31-Dec-19**	**31-Dec-20**	**31-Dec-21**	**31-Dec-22**		
Number of Months	12.0	12.0	12.0	12.0	12.0	12.0		

Other Budget Factors

Is this a new version of a previously approved budget? No

Participating Partners' information

	List of Participating Partners	Primary Indirect Cost (IDC) Rate	Pass-thru IDC Rate
1	CIMMYT	15.0%	5.0%
2	IITA	16.5%	16.5%
3			
4			
5			

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Financial Summary

FINANCIAL SUMMARY & REPORTING

Expand/Collapse sections to see/hide the budget and actuals & projections →

Budget

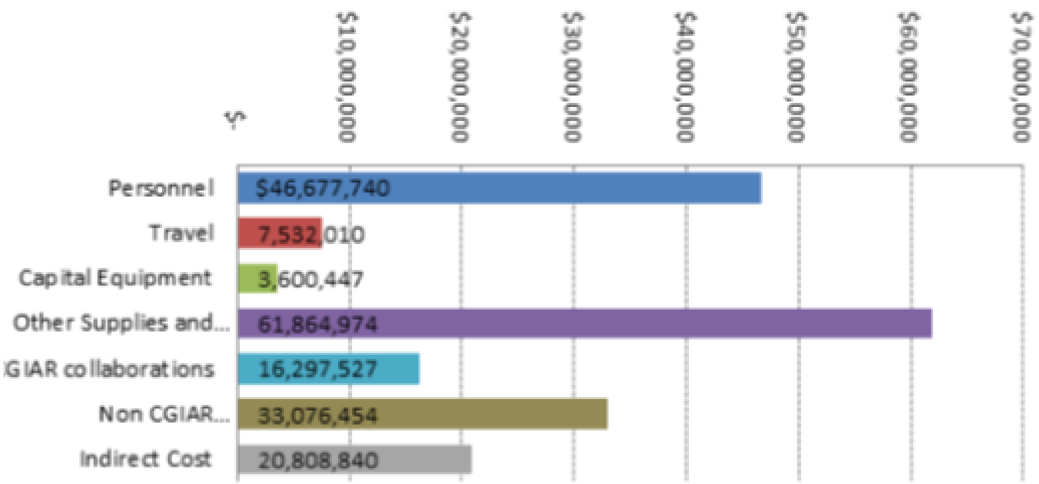
Budget

Prepared by: Ramiro Tovar

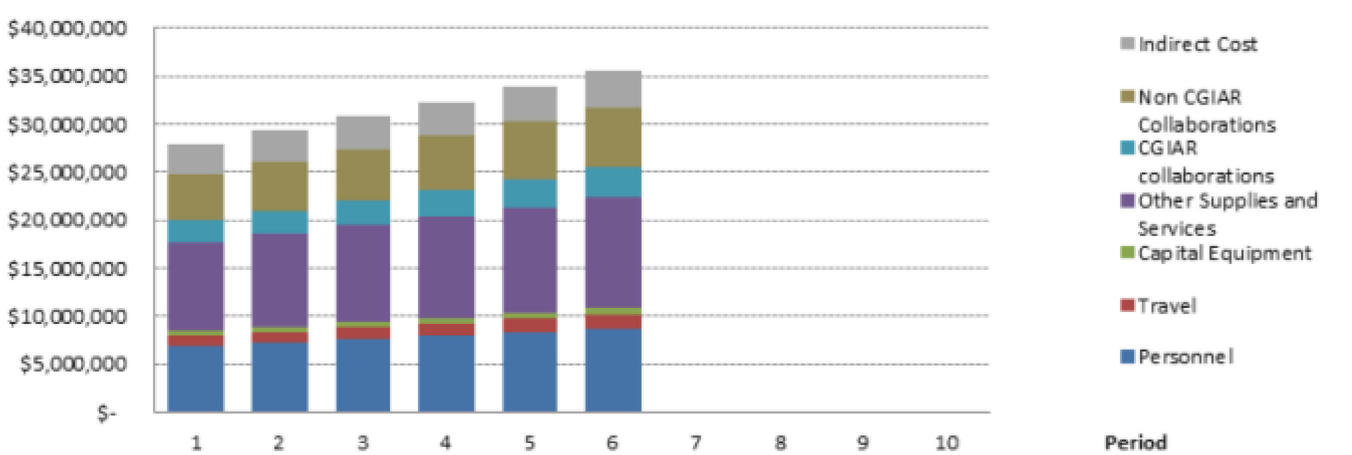
	Period 1 Jan-17 - Dec-17 Budget	Period 2 Jan-18 - Dec-18 Budget	Period 3 Jan-19 - Dec-19 Budget	Period 4 Jan-20 - Dec-20 Budget	Period 5 Jan-21 - Dec-21 Budget	Period 6 Jan-22 - Dec-22 Budget	
Uses of Funds by Expense Category							
Category							TOTAL
Personnel	$ 6,862,443	$ 7,205,565	$ 7,565,844	$ 7,944,136	$ 8,341,342	$ 8,758,410	$ 46,677,740
Travel	1,107,339	1,162,706	1,220,841	1,281,856	1,345,971	1,413,297	7,532,010
Capital Equipment	529,330	555,796	583,586	612,752	643,400	675,583	3,600,447
Other Supplies and Services	9,095,249	9,550,011	10,027,512	10,528,660	11,055,275	11,608,266	61,864,974
CGIAR collaborations	2,396,026	2,515,827	2,641,618	2,773,639	2,912,369	3,058,048	16,297,527
Non CGIAR Collaborations	4,862,826	5,105,967	5,361,265	5,629,207	5,910,765	6,206,424	33,076,454
TOTAL DIRECT COST	**24,853,212**	**26,095,873**	**27,400,667**	**28,770,250**	**30,209,122**	**31,720,028**	**169,049,152**
Indirect Cost	3,059,267	3,212,230	3,372,842	3,541,433	3,718,545	3,904,523	20,808,840
TOTAL BUDGET	**$ 27,912,479**	**$ 29,308,103**	**$ 30,773,508**	**$ 32,311,683**	**$ 33,927,668**	**$ 35,624,551**	**$ 189,857,993**
Breakdown of Budget by Participating Partner							TOTAL
CIMMYT	$ 25,982,789	$ 27,281,929	$ 28,646,025	$ 30,077,856	$ 31,582,125	$ 33,161,702	$ 176,732,426
IITA	1,929,690	2,026,174	2,127,483	2,233,827	2,345,543	2,462,850	13,125,567
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
TOTAL BUDGET	**27,912,479**	**29,308,103**	**30,773,508**	**32,311,683**	**33,927,668**	**35,624,551**	**189,857,993**
Funding Plan							
Sources of Funding Needed							TOTAL
W1+W2	$ 3,123,179	3,279,338	3,443,305	3,615,392	3,796,224	3,986,114	$ 21,243,552
W3	14,678,969	15,412,918	16,183,564	16,992,375	17,842,287	18,734,768	99,844,881
Bilateral	10,110,331	10,615,847	11,146,640	11,703,916	12,289,157	12,903,669	68,769,559
Other Sources							-
TOTAL FUNDING PLAN	**27,912,479**	**29,308,103**	**30,773,508**	**32,311,683**	**33,927,668**	**35,624,551**	**189,857,992**
Sources of Funding Secured							TOTAL
W1+W2 (Assumed Secured)	3,123,179	3,279,338	3,443,305	3,615,392	3,796,224	3,986,114	$ 21,243,552
W3	5,873,682	-	-	-	-	-	5,873,682
Bilateral	3,842,163	594,438	8,781	8,781	-	-	4,454,164
Other Sources							-
TOTAL SECURED	**12,839,025**	**3,873,777**	**3,452,086**	**3,624,173**	**3,796,224**	**3,986,114**	**31,571,398**
TOTAL FUNDING GAP OVER/(UNDER)	**$ (15,073,454)**	**$ (25,434,326)**	**$ (27,321,422)**	**$ (28,687,510)**	**$ (30,131,444)**	**$ (31,638,437)**	**$ (158,286,594)**
W1+W2 (Required from SO)	-	-	-	-	-	-	-
W3 (Required from FC Members)	(8,805,287)	(15,412,918)	(16,183,564)	(16,992,375)	(17,842,287)	(18,734,768)	(93,971,199)
Bilateral (Fundraising)	(6,268,167)	(10,021,409)	(11,137,859)	(11,695,135)	(12,289,157)	(12,903,669)	(64,315,395)
Other Sources (Fundraising)	-	-	-	-	-	-	-

Analysis

Total Amount by Category

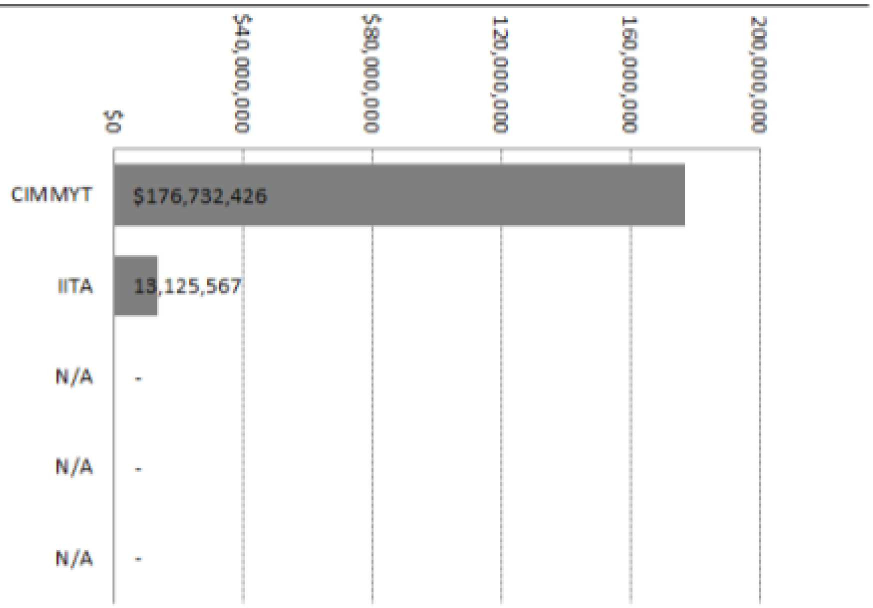


Amount by Category for Each Period

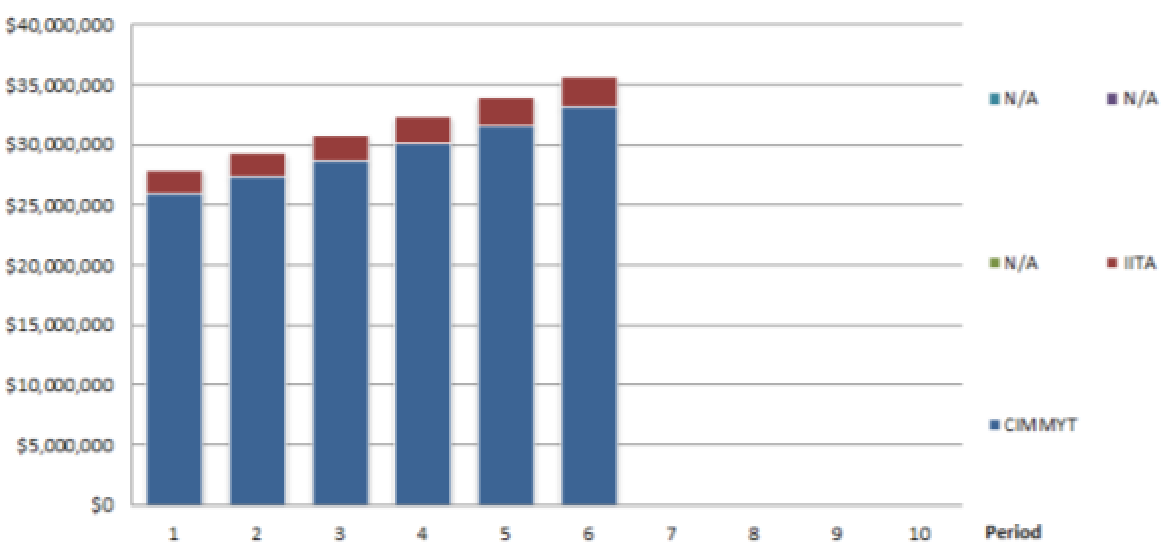


Analysis

Total Amounts for Additional Dimension



Amounts for Additional Dimension



FP4 Budget

General Information

CRP on Maize
FP4 Sustainable intensification of maize-based systems for better livelihoods of smallholders

Prepared by: Ramiro Tovar

Date submitted:

Template version 2015-01-14.1

Legend for cell formatting:
Enter information into light yellow cells
Enter actual expenditures into green cells
Blue cells will be populated by CO

GENERAL INFORMATION

Proposal Information

CRP Name	CRP on Maize
Flagship Title	FP4 Sustainable intensification of maize-based systems for better livelihoods of smallholders
How are you using the template?	Consolidated Flagship
CRP Lead Center's Name	CIMMYT
Requested Amount	$78,521,615
Total Project Cost	$161,187,980

Budgeting & Reporting Periods

Anticipated Start Date	01-Jan-17
Anticipated End Date	31-Dec-22
Project Duration (months)	72.0

Reporting Periods	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period Start Date	01-Jan-17	01-Jan-18	01-Jan-19	01-Jan-20	01-Jan-21	01-Jan-22		
Period End Date	31-Dec-17	31-Dec-18	31-Dec-19	31-Dec-20	31-Dec-21	31-Dec-22		
Number of Months	12.0	12.0	12.0	12.0	12.0	12.0		

Other Budget Factors

Is this a new version of a previously approved budget? No

Participating Partners' information

	List of Participating Partners	Primary Indirect Cost (IDC) Rate	Pass-thru IDC Rate
1	CIMMYT	15.0%	5.0%
2	IITA	16.5%	16.5%
3			
4			
5			

← *unhide additional rows if needed*

Financial Summary

FINANCIAL SUMMARY & REPORTING

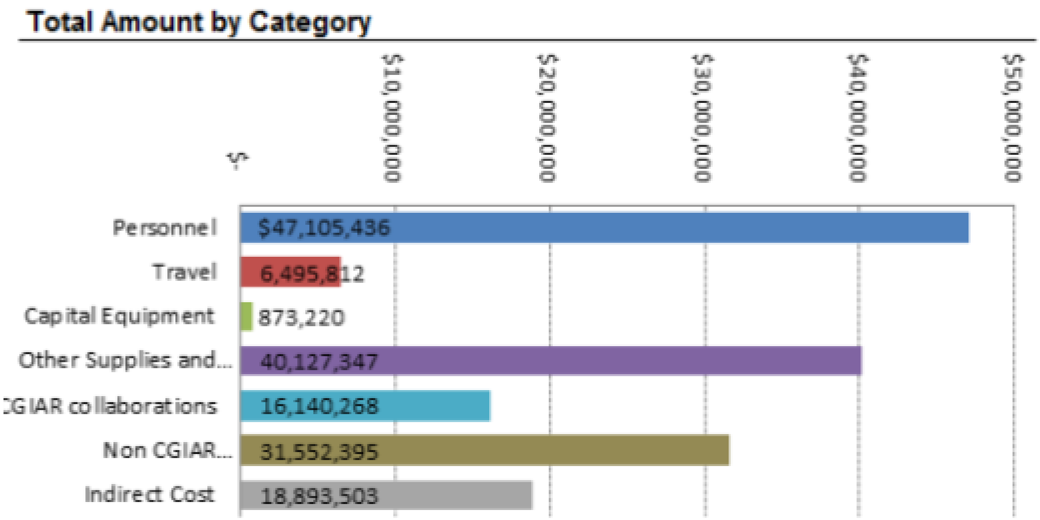
Expand/Collapse sections to see/hide the budget and actuals & projections →

Budget

Prepared by: Ramiro Tovar

	Period 1 Jan-17 - Dec-17 Budget	Period 2 Jan-18 - Dec-18 Budget	Period 3 Jan-19 - Dec-19 Budget	Period 4 Jan-20 - Dec-20 Budget	Period 5 Jan-21 - Dec-21 Budget	Period 6 Jan-22 - Dec-22 Budget	TOTAL
Uses of Funds by Expense Category							
Category							TOTAL
Personnel	$ 6,925,322	$ 7,271,588	$ 7,635,167	$ 8,016,926	$ 8,417,772	$ 8,838,661	$ 47,105,436
Travel	955,000	1,002,750	1,052,887	1,105,508	1,160,802	1,218,866	6,495,812
Capital Equipment	128,379	134,798	141,538	148,611	156,044	163,850	873,220
Other Supplies and Services	5,899,432	6,194,404	6,504,124	6,829,182	7,170,760	7,529,445	40,127,347
CGIAR collaborations	2,372,906	2,491,551	2,616,129	2,746,876	2,884,267	3,028,540	16,140,268
Non CGIAR Collaborations	4,638,762	4,870,700	5,114,235	5,369,831	5,638,415	5,920,452	31,552,395
TOTAL DIRECT COST	**20,919,800**	**21,965,790**	**23,064,080**	**24,216,934**	**25,428,060**	**26,699,813**	**142,294,477**
Indirect Cost	2,777,678	2,916,562	3,062,390	3,215,467	3,376,275	3,545,130	18,893,503
TOTAL BUDGET	**$ 23,697,478**	**$ 24,882,352**	**$ 26,126,470**	**$ 27,432,401**	**$ 28,804,335**	**$ 30,244,944**	**$ 161,187,980**
Breakdown of Budget by Participating Partner							TOTAL
CIMMYT	$ 11,907,687	$ 12,503,072	$ 13,128,225	$ 13,784,438	$ 14,473,819	$ 15,197,708	$ 80,994,950
IITA	11,789,791	12,379,280	12,998,244	13,647,963	14,330,516	15,047,235	80,193,030
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
TOTAL BUDGET	**23,697,478**	**24,882,352**	**26,126,470**	**27,432,401**	**28,804,335**	**30,244,944**	**161,187,980**
Funding Plan							
Sources of Funding Needed							TOTAL
W1+W2	$ 2,563,385	2,691,555	2,826,132	2,967,375	3,115,795	3,271,649	$ 17,435,891
W3	8,980,685	9,429,720	9,901,206	10,396,041	10,916,023	11,462,049	61,085,724
Bilateral	12,153,407	12,761,078	13,399,132	14,068,982	14,772,517	15,511,247	82,666,363
Other Sources							-
TOTAL FUNDING PLAN	**23,697,478**	**24,882,352**	**26,126,470**	**27,432,399**	**28,804,335**	**30,244,944**	**161,187,978**
Sources of Funding Secured							TOTAL
W1+W2 (Assumed Secured)	2,563,385	2,691,555	2,826,132	2,967,375	3,115,795	3,271,649	$ 17,435,891
W3	7,416,468	6,183,861	2,608,125	854,847	-	-	17,063,301
Bilateral	6,798,940	3,756,779	-	-	-	-	10,555,719
Other Sources							-
TOTAL SECURED	**16,778,793**	**12,632,196**	**5,434,258**	**3,822,222**	**3,115,795**	**3,271,649**	**45,054,911**
TOTAL FUNDING GAP OVER/(UNDER)	**$ (6,918,685)**	**$ (12,250,157)**	**$ (20,692,212)**	**$ (23,610,177)**	**$ (25,688,540)**	**$ (26,973,296)**	**$ (116,133,067)**
W1+W2 (Required from SO)	-	-	-	-	-	-	-
W3 (Required from FC Members)	(1,564,218)	(3,245,859)	(7,293,080)	(9,541,194)	(10,916,023)	(11,462,049)	(44,022,423)
Bilateral (Fundraising)	(5,354,468)	(9,004,299)	(13,399,132)	(14,068,982)	(14,772,517)	(15,511,247)	(72,110,644)
Other Sources (Fundraising)	-	-	-	-	-	-	-

Analysis



Total Amount by Category
$-
$10,000,000
$20,000,000
$30,000,000
$40,000,000
$50,000,000
Personnel
Travel
Capital Equipment
Other Supplies and...
CGIAR collaborations
Non CGIAR...
Indirect Cost
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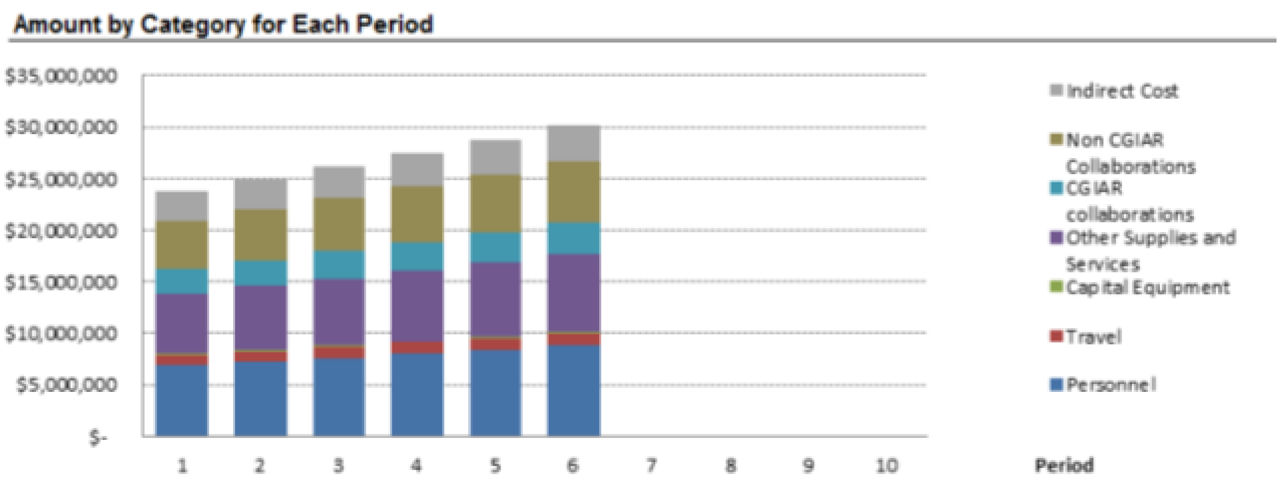
6,495,812
873,220
40,127,347
16,140,268
31,552,395
18,893,503



Amount by Category for Each Period
$35,000,000
$30,000,000
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$-
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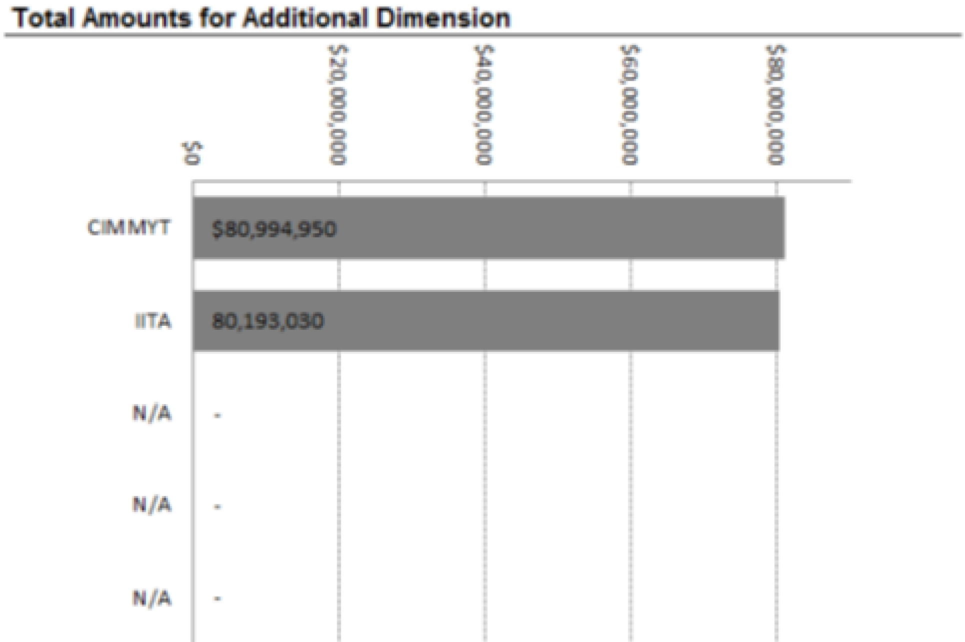
10
Period
Indirect Cost
Non CGIAR Collaborations
CGIAR collaborations
Other Supplies and Services
Capital Equipment
Travel
Personnel

Analysis


Total Amounts for Additional Dimension
$0
$20,000,000
$40,000,000
$60,000,000
$80,000,000
CIMMYT
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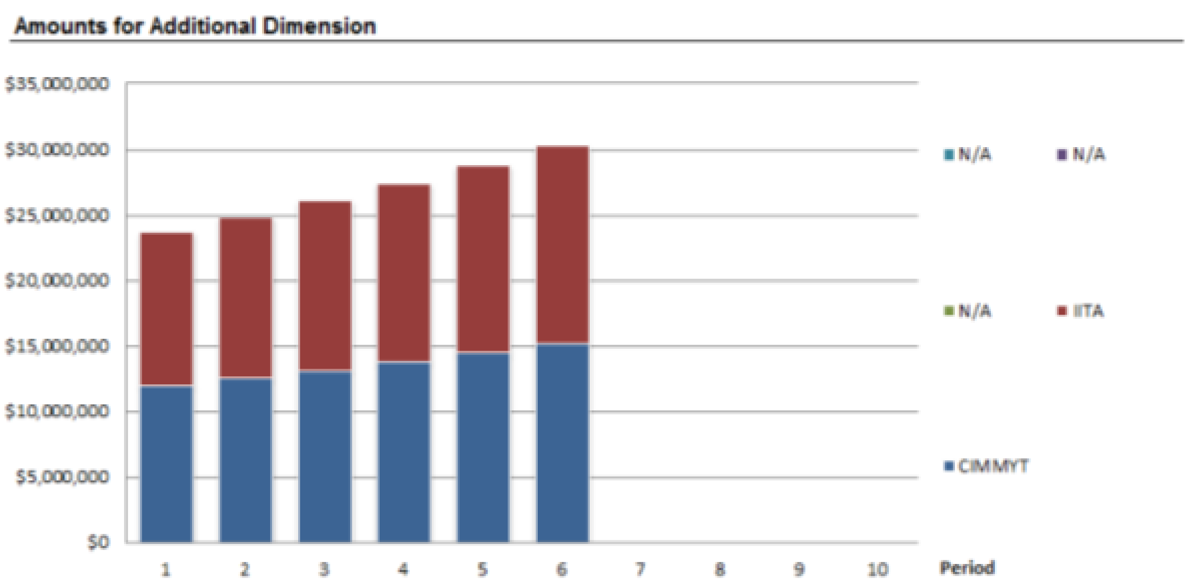
IITA
80,193,030
N/A
-
N/A
-
N/A
-


Amounts for Additional Dimension
$35,000,000
$30,000,000
$25,000,000
$20,000,000
$15,000,000
$10,000,000
$5,000,000
$0
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10
Period
N/A
N/A
N/A
IITA
CIMMYT

FP5 Budget

General Information

CRP on Maize

FP5 Adding Value for Maize Producers, Processors and Consumers

Prepared by: Ramiro Tovar

Date submitted:

Template version 2015-01-14.1

Legend for cell formatting:

Enter information into light yellow cells

Enter actual expenditures into green cells

Blue cells will be populated by CO

GENERAL INFORMATION

Proposal Information

CRP Name	CRP on Maize
Flagship Title	FP5 Adding Value for Maize Producers, Processors and Consumers
How are you using the template?	Consolidated Flagship
CRP Lead Center's Name	CIMMYT
Requested Amount	$9,553,507
Total Project Cost	$15,218,865

Budgeting & Reporting Periods

Anticipated Start Date	01-Jan-17
Anticipated End Date	31-Dec-22
Project Duration (months)	72.0

Reporting Periods	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period Start Date	01-Jan-17	01-Jan-18	01-Jan-19	01-Jan-20	01-Jan-21	01-Jan-22		
Period End Date	31-Dec-17	31-Dec-18	31-Dec-19	31-Dec-20	31-Dec-21	31-Dec-22		
Number of Months	12.0	12.0	12.0	12.0	12.0	12.0		

Other Budget Factors

Is this a new version of a previously approved budget? No

Participating Partners' information

	List of Participating Partners	Primary Indirect Cost (IDC) Rate	Pass-thru IDC Rate
1	CIMMYT	15.0%	5.0%
2	IITA	16.5%	16.5%
3			
4			
5			

Financial Summary

FINANCIAL SUMMARY & REPORTING

Expand/Collapse sections to see/hide the budget and actuals & projections →

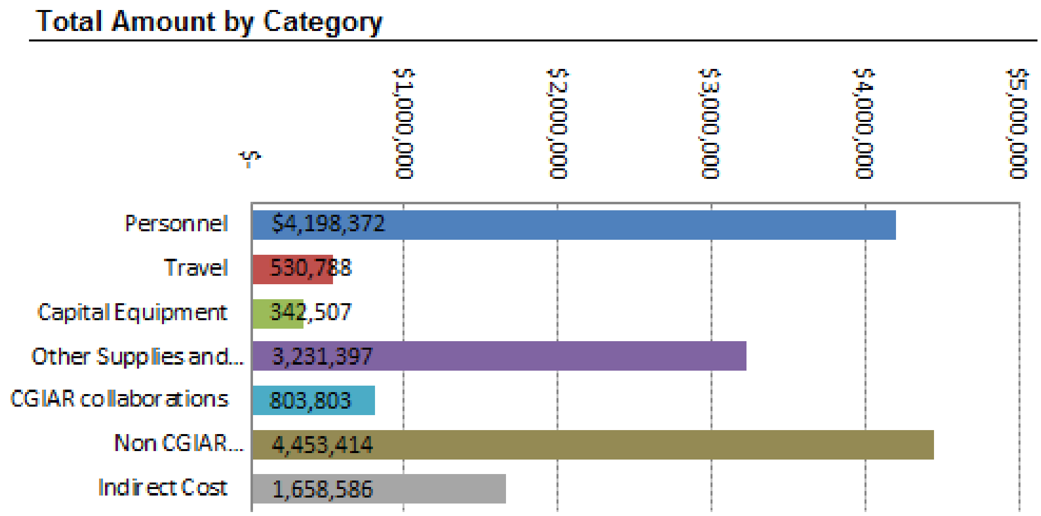
Budget

Budget

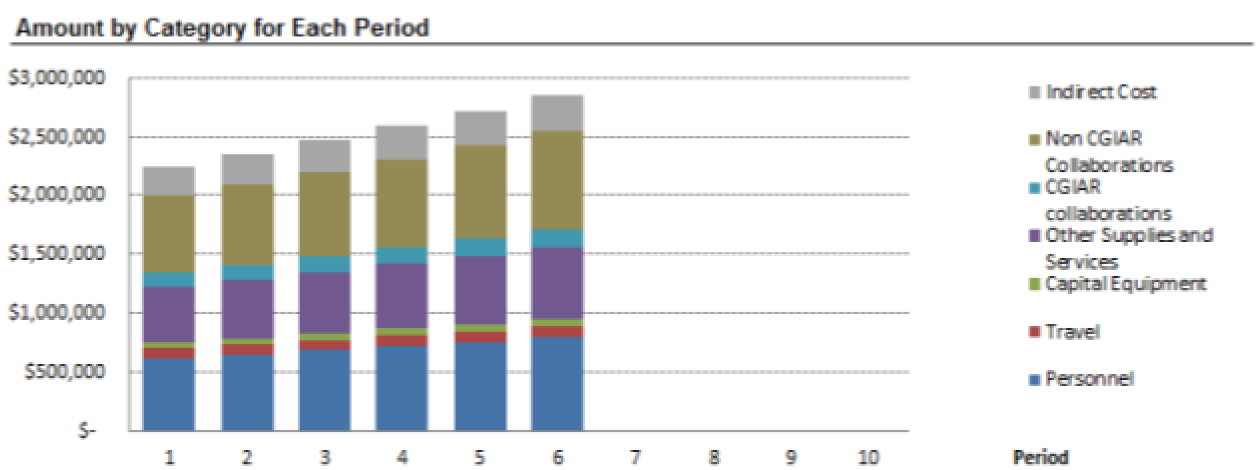
Prepared by: Ramiro Tovar

	Period 1 Jan-17 - Dec-17 Budget	Period 2 Jan-18 - Dec-18 Budget	Period 3 Jan-19 - Dec-19 Budget	Period 4 Jan-20 - Dec-20 Budget	Period 5 Jan-21 - Dec-21 Budget	Period 6 Jan-22 - Dec-22 Budget	
Uses of Funds by Expense Category							
Category							TOTAL
Personnel	$ 617,234	$ 648,096	$ 680,500	$ 714,525	$ 750,252	$ 787,764	$ 4,198,372
Travel	78,035	81,937	86,034	90,334	94,852	99,596	530,788
Capital Equipment	50,355	52,872	55,516	58,290	61,206	64,268	342,507
Other Supplies and Services	475,073	498,826	523,768	549,944	577,451	606,335	3,231,397
CGIAR collaborations	118,173	124,082	130,286	136,797	143,640	150,825	803,803
Non CGIAR Collaborations	654,731	687,467	721,841	757,916	795,825	835,633	4,453,414
TOTAL DIRECT COST	**1,993,601**	**2,093,281**	**2,197,945**	**2,307,807**	**2,423,225**	**2,544,421**	**13,560,280**
Indirect Cost	243,841	256,033	268,835	282,273	296,390	311,213	1,658,586
TOTAL BUDGET	**$ 2,237,442**	**$ 2,349,314**	**$ 2,466,780**	**$ 2,590,081**	**$ 2,719,615**	**$ 2,855,634**	**$ 15,218,865**
Breakdown of Budget by Participating Partne							TOTAL
CIMMYT	$ 1,302,924	$ 1,368,071	$ 1,436,474	$ 1,508,272	$ 1,583,706	$ 1,662,917	$ 8,862,364
IITA	934,518	981,243	1,030,306	1,081,809	1,135,909	1,192,717	6,356,501
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
TOTAL BUDGET	**2,237,442**	**2,349,314**	**2,466,780**	**2,590,081**	**2,719,615**	**2,855,634**	**15,218,865**
Funding Plan							
Sources of Funding Needed							TOTAL
W1+W2	$ 1,038,785	1,090,724	1,145,260	1,202,497	1,262,643	1,325,801	$ 7,065,709
W3	365,750	384,038	403,240	423,393	444,570	466,807	2,487,797
Bilateral	832,907	874,552	918,280	964,191	1,012,402	1,063,026	5,665,359
Other Sources							-
TOTAL FUNDING PLAN	**2,237,442**	**2,349,314**	**2,466,780**	**2,590,081**	**2,719,615**	**2,855,634**	**15,218,865**
Sources of Funding Secured							TOTAL
W1+W2 (Assumed Secured)	1,038,785	1,090,724	1,145,260	1,202,497	1,262,643	1,325,801	$ 7,065,709
W3	203,257	-	-	-	-	-	203,257
Bilateral	578,399	101,094	26,487	-	-	-	705,980
Other Sources							-
TOTAL SECURED	**1,820,440**	**1,191,818**	**1,171,747**	**1,202,497**	**1,262,643**	**1,325,801**	**7,974,946**
TOTAL FUNDING GAP OVER/(UNDER)	**$ (417,002)**	**$ (1,157,496)**	**$ (1,296,033)**	**$ (1,387,584)**	**$ (1,456,972)**	**$ (1,529,833)**	**$ (7,243,919)**
W1+W2 (Required from SO)	-	-	-	-	-	-	-
W3 (Required from FC Members)	(162,493)	(384,038)	(403,240)	(423,393)	(444,570)	(466,807)	(2,284,540)
Bilateral (Fundraising)	(254,508)	(773,458)	(891,793)	(964,191)	(1,012,402)	(1,063,026)	(4,959,379)
Other Sources (Fundraising)	-	-	-	-	-	-	-

Analysis



Total Amount by Category
$-
$1,000,000
$2,000,000
$3,000,000
$4,000,000
$5,000,000
Personnel
Travel
Capital Equipment
Other Supplies and...
CGIAR collaborations
Non CGIAR...
Indirect Cost
$4,198,372
530,788
342,507
3,231,397
803,803
4,453,414
1,658,586



Amount by Category for Each Period
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$-
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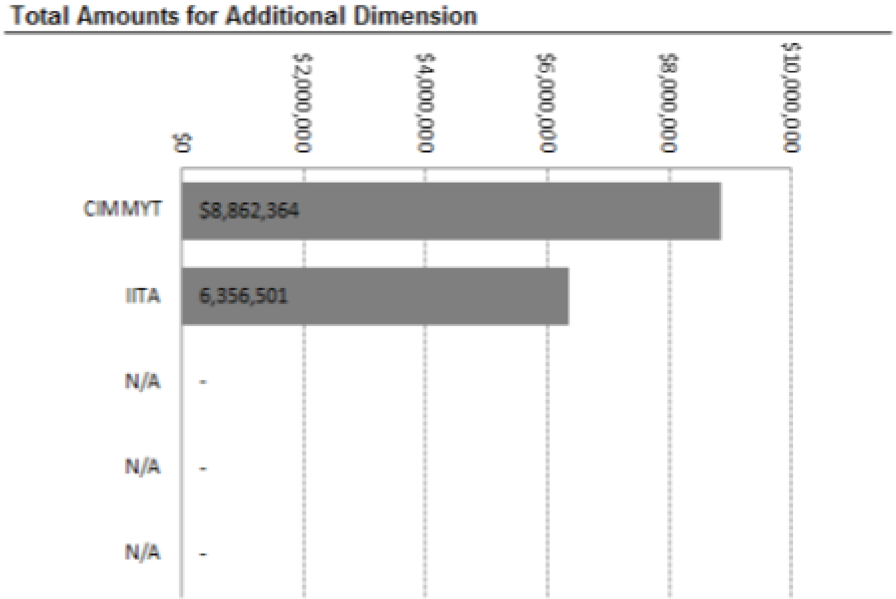
Period
Indirect Cost
Non CGIAR Collaborations
CGIAR collaborations
Other Supplies and Services
Capital Equipment
Travel
Personnel

Analysis


Total Amounts for Additional Dimension
$0
$2,000,000
$4,000,000
$6,000,000
$8,000,000
$10,000,000
CIMMYT
$8,862,364
IITA
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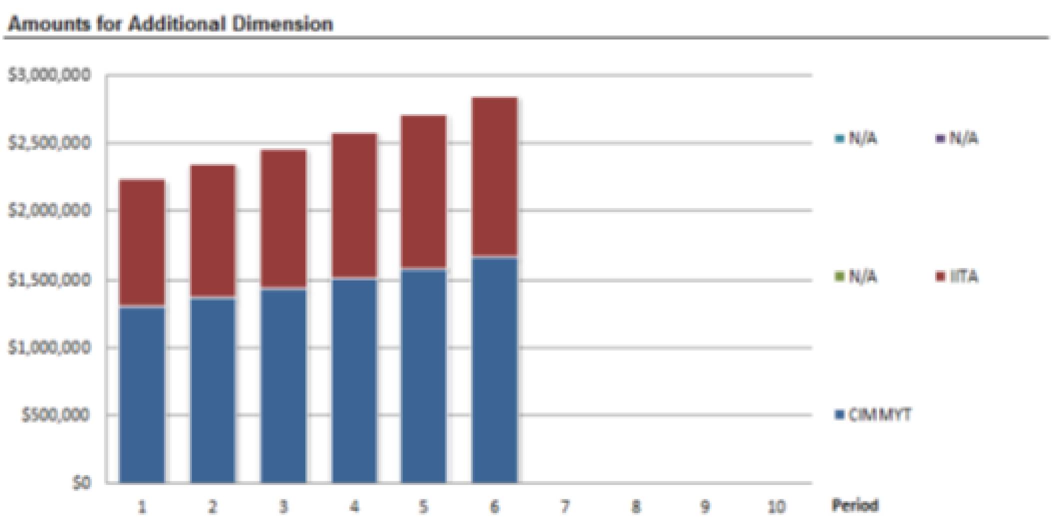
N/A
-
N/A
-
N/A
-


Amounts for Additional Dimension
$3,000,000
$2,500,000
$2,000,000
$1,500,000
$1,000,000
$500,000
$0
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Period
N/A
N/A
N/A
IITA
CIMMYT

MAIZE Management Budget

General Information

CRP on Maize Management

Prepared by: Ramiro Tovar

Date submitted:

Template version 2015-01-14.1

Legend for cell formatting:

Enter information into light yellow cells

Enter actual expenditures into green cells

Blue cells will be populated by CO

GENERAL INFORMATION

Proposal Information

CRP Name	CRP on Maize
Flagship Title	Management
How are you using the template?	Consolidated Flagship
CRP Lead Center's Name	CIMMYT
Requested Amount	**$11,034,855**
Total Project Cost	**$11,034,856**

Budgeting & Reporting Periods

Anticipated Start Date	01-Jan-17
Anticipated End Date	31-Dec-22
Project Duration (months)	72.0

Reporting Periods	Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	Period 7	Period 8
Period Start Date	**01-Jan-17**	**01-Jan-18**	**01-Jan-19**	**01-Jan-20**	**01-Jan-21**	**01-Jan-22**		
Period End Date	**31-Dec-17**	**31-Dec-18**	**31-Dec-19**	**31-Dec-20**	**31-Dec-21**	**31-Dec-22**		
Number of Months	12.0	12.0	12.0	12.0	12.0	12.0		

Other Budget Factors

Is this a new version of a previously approved budget? No

Participating Partners' information

	List of Participating Partners	Primary Indirect Cost (IDC) Rate	Pass-thru IDC Rate
1	CIMMYT	15.0%	5.0%
2	IITA	16.5%	16.5%
3			
4			
5			

← unhide additional rows if needed

Financial Summary

FINANCIAL SUMMARY & REPORTING

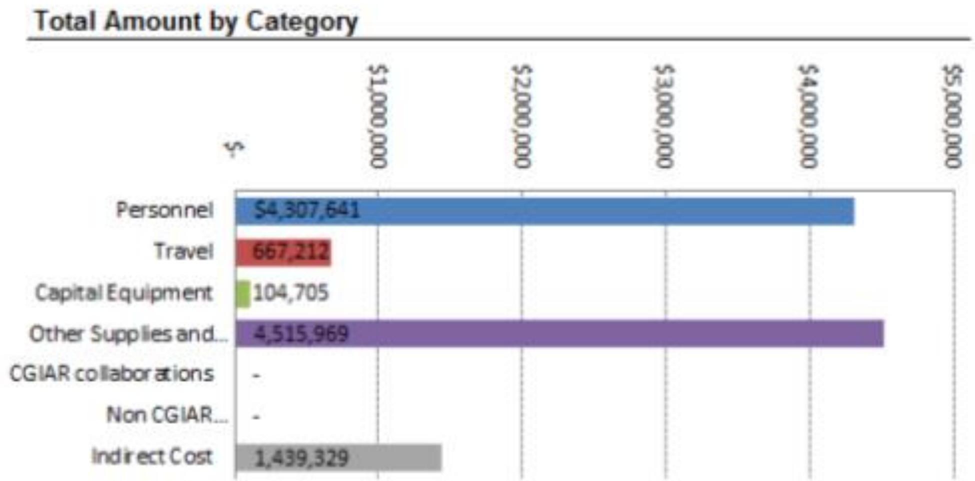
Expand/Collapse sections to see/hide the budget and actuals & projections →

Budget

Prepared by: Ramiro Tovar

	Period 1 Jan-17 - Dec-17 Budget	Period 2 Jan-18 - Dec-18 Budget	Period 3 Jan-19 - Dec-19 Budget	Period 4 Jan-20 - Dec-20 Budget	Period 5 Jan-21 - Dec-21 Budget	Period 6 Jan-22 - Dec-22 Budget	
Uses of Funds by Expense Category							
Category							TOTAL
Personnel	$ 633,298	$ 664,963	$ 698,212	$ 733,122	$ 769,778	$ 808,267	$ 4,307,641
Travel	98,092	102,997	108,146	113,551	119,231	125,195	667,212
Capital Equipment	15,394	16,163	16,971	17,820	18,711	19,647	104,705
Other Supplies and Services	663,928	697,124	731,980	768,563	807,004	847,371	4,515,969
CGIAR collaborations	-	-	-	-	-	-	-
Non CGIAR Collaborations	-	-	-	-	-	-	-
TOTAL DIRECT COST	**1,410,712**	**1,481,247**	**1,555,309**	**1,633,056**	**1,714,724**	**1,800,479**	**9,595,527**
Indirect Cost	211,607	222,187	233,296	244,958	257,209	270,072	1,439,329
TOTAL BUDGET	**$ 1,622,318**	**$ 1,703,434**	**$ 1,788,606**	**$ 1,878,014**	**$ 1,971,932**	**$ 2,070,551**	**$ 11,034,856**
Breakdown of Budget by Participating Partner							TOTAL
CIMMYT	$ 1,622,318	$ 1,703,434	$ 1,788,606	$ 1,878,014	$ 1,971,932	$ 2,070,551	$ 11,034,856
IITA	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
N/A	-	-	-	-	-	-	-
TOTAL BUDGET	**1,622,318**	**1,703,434**	**1,788,606**	**1,878,014**	**1,971,932**	**2,070,551**	**11,034,856**
Funding Plan							
Sources of Funding Needed							TOTAL
W1+W2	$ 1,622,318	1,703,434	1,788,606	1,878,014	1,971,932	2,070,551	$ 11,034,855
W3		-	-	-	-	-	-
Bilateral		-	-	-	-	-	-
Other Sources							-
TOTAL FUNDING PLAN	**1,622,318**	**1,703,434**	**1,788,606**	**1,878,014**	**1,971,932**	**2,070,551**	**11,034,855**
Sources of Funding Secured							TOTAL
W1+W2 (Assumed Secured)	1,622,318	1,703,434	1,788,606	1,878,014	1,971,932	2,070,551	$ 11,034,855
W3							-
Bilateral							-
Other Sources							-
TOTAL SECURED	**1,622,318**	**1,703,434**	**1,788,606**	**1,878,014**	**1,971,932**	**2,070,551**	**11,034,855**
TOTAL FUNDING GAP OVER/(UNDER)	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
W1+W2 (Required from SO)	-	-	-	-	-	-	-
W3 (Required from FC Members)	-	-	-	-	-	-	-
Bilateral (Fundraising)	-	-	-	-	-	-	-
Other Sources (Fundraising)	-	-	-	-	-	-	-

Analysis



Total Amount by Category
$-
$1,000,000
$2,000,000
$3,000,000
$4,000,000
$5,000,000
Personnel
$4,307,641
Travel
667,212
Capital Equipment
104,705
Other Supplies and...
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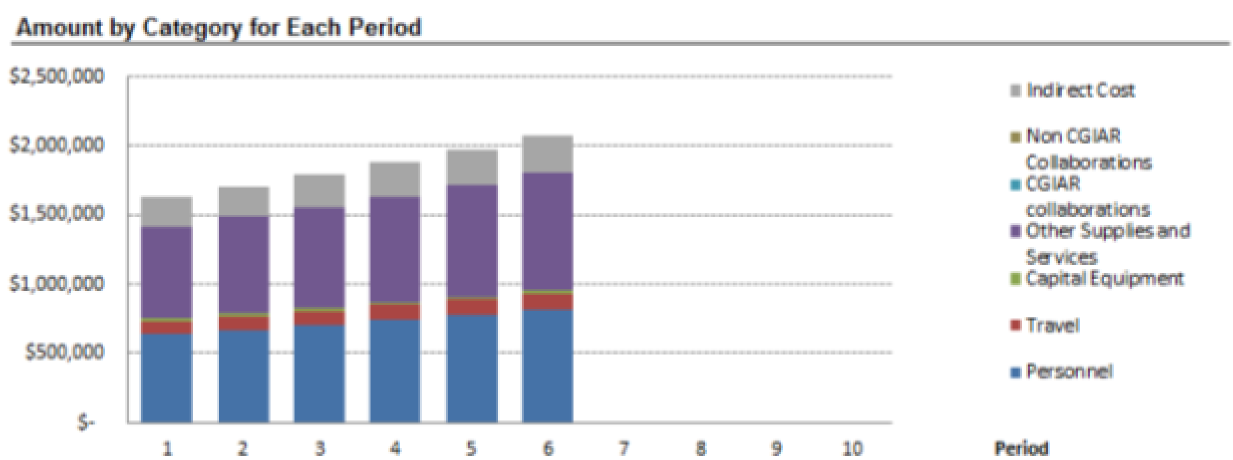
CGIAR collaborations
-
Non CGIAR...
-
Indirect Cost
1,439,329



Amount by Category for Each Period
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$2,000,000
$1,500,000
$1,000,000
$500,000
$-
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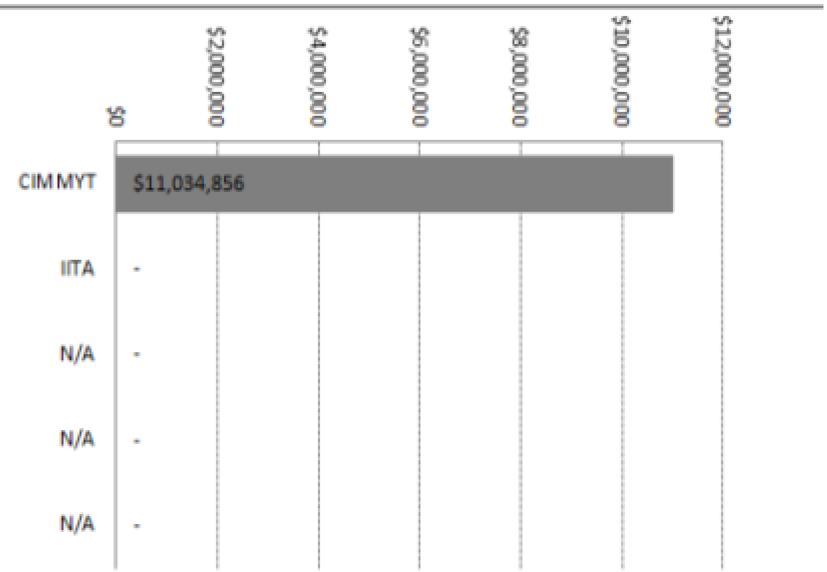
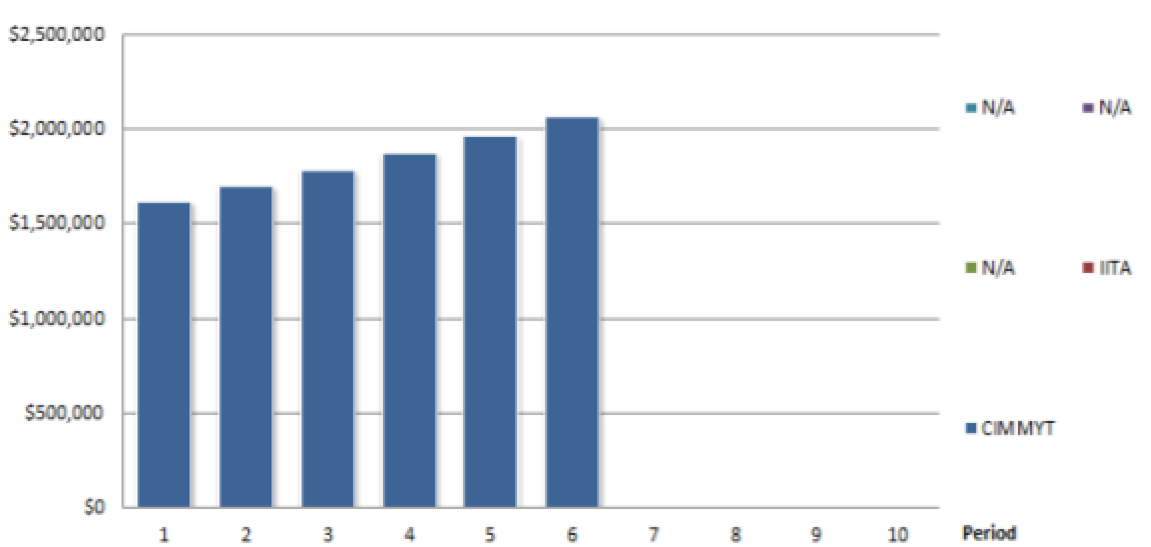
Period
Indirect Cost
Non CGIAR Collaborations
CGIAR collaborations
Other Supplies and Services
Capital Equipment
Travel
Personnel

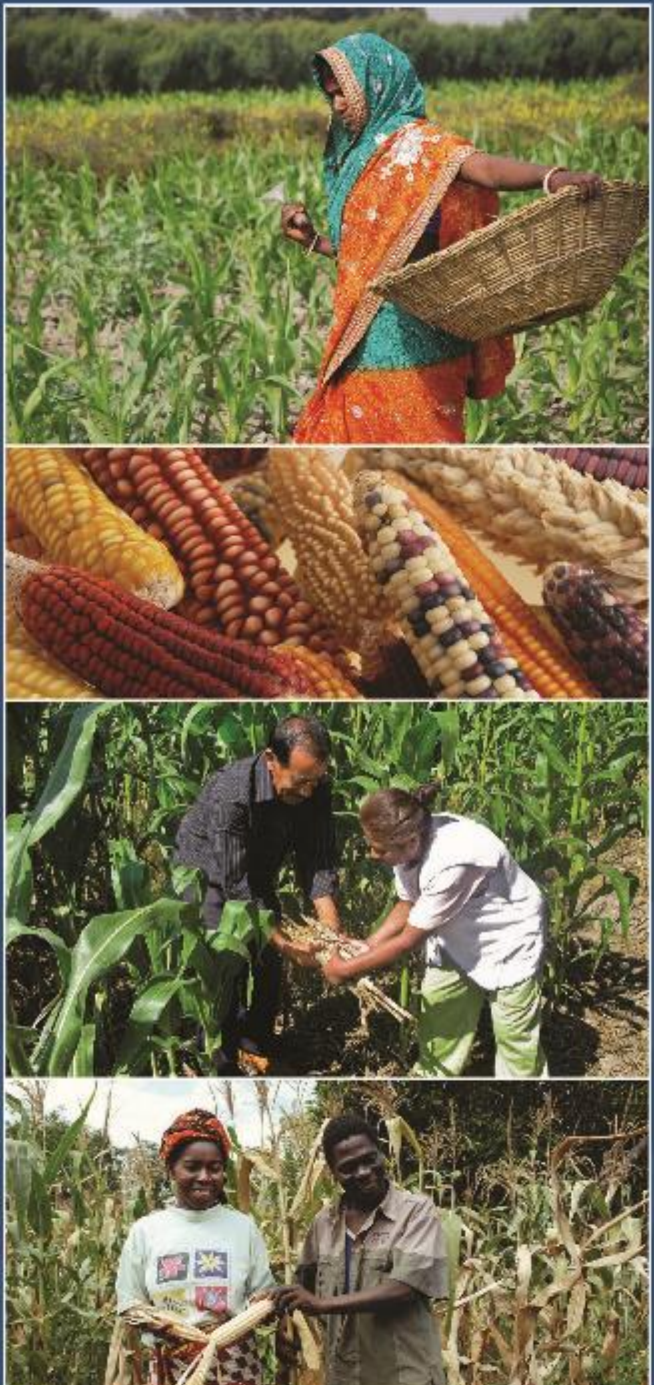
Analysis

Total Amounts for Additional Dimension



Amounts for Additional Dimension





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CGIAR

RESEARCH PROGRAM ON Maize