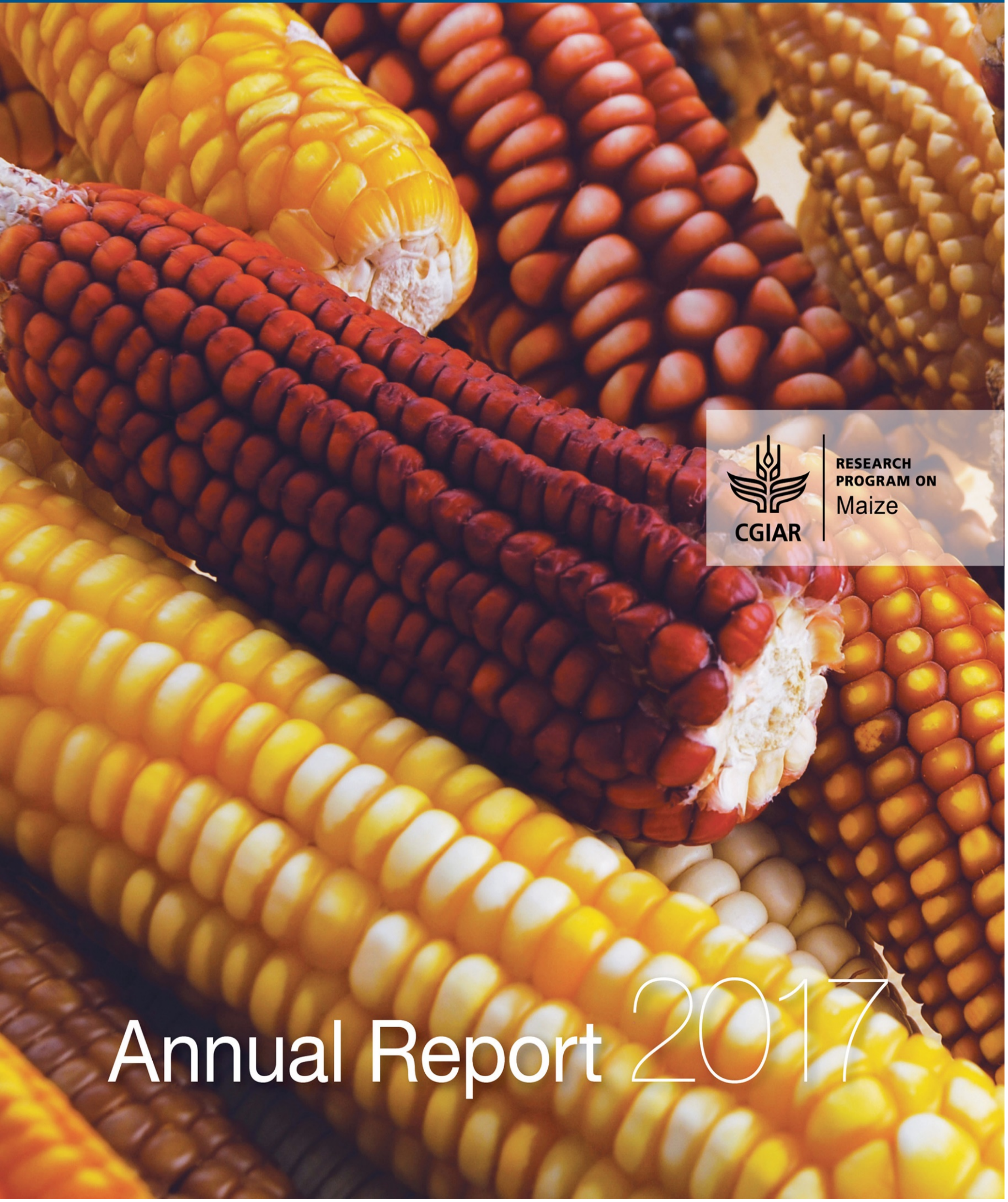
CGIAR Research Program on Maize

An Agri-Food System CGIAR Research Program



Annual Report 2017

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Acronyms and abbreviations

CGIAR System Institutions and Processes

A4NH	CGIAR Research Program on Agriculture for Nutrition and Health
AFS	Agri-food system
ARI	Advanced research institute
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security
CGIAR	CGIAR is a global research partnership for a food-secure future
CIMMYT	International Maize and Wheat Improvement Center
CRP	CGIAR Research Program
CSISA	Cereal Systems Initiative for South Asia
DTMA	Drought Tolerant Maize for Africa
DTMASS	Drought Tolerant Maize for Africa Seed Scaling
EiB	CGIAR Excellence in Breeding Platform
FP	Flagship project
FTA	CGIAR Research Program on Forests, Trees, and Agroforestry
GENNOVATE	Global comparative gender norms research initiative
GRiSP	Global Rice Science Partnership
IA	Impact assessment or intellectual asset
IDO	CGIAR intermediate development outcome
IEA	Independent Evaluation Arrangement of CGIAR
IITA	International Institute of Tropical Agriculture
IMIC	International Maize Improvement Consortium
IRRI	International Rice Research Institute
ISC	Independent Steering Committee
LMS	Learning Management System
MAIZE	CGIAR Research Program on Maize Agri-food Systems
MARLO	Managing Agricultural Research for Learning and Outcomes platform
MasAgro	Sustainable Modernization of Traditional Agriculture Program, Mexico
MC	Management committee
MELIA	Monitoring, Evaluation, Impact Assessment and Learning
ME&L	Monitoring, evaluation and learning (also MEL)
ORNL	Oak Ridge National Laboratory, USA
PIM	CGIAR Research Program on Policies, Institutions, and Markets
POWB	Plan of work and budget
RTB	CGIAR Research Program on Roots, Tubers, and Bananas
RICE	CGIAR Research Program on Rice Agri-food Systems
SeeD	Seeds of Discovery, CIMMYT
SRFSI	Sustainable Resilient Farming Systems Intensification
SIMLESA	Sustainable Intensification of Maize and Legume Systems for Food Security in Eastern and Southern Africa
SLO	CGIAR system level outcome
SMB	System Management Board
SRF	Strategy and results framework
STMA	Stress Tolerant Maize for Africa
TAMASA	Taking Maize Agronomy to Scale in Africa

WHEAT	CGIAR Research Program on Wheat Agri-food Systems

Research and Development Partners

ACIAR	Australian Centre for International Agricultural Research
AGRA	Alliance for a Green Revolution in Africa
DArT	Diversity Arrays Technology
DFID	Department for International Development, UK
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (German Corporation for International Cooperation)
GOBii	Genomic Open-source Breeding informatics initiative, Cornell University
GRIN-Global	Germplasm Resource Information Network
IBP	Integrated Breeding Platform
ICAR	Indian Council of Agricultural Research
IDS	Institute of Development Studies, University of Sussex, Brighton, UK
IFAD	International Fund for Agricultural Development
IIASA	International Institute for Applied Systems Analysis
IPNI	International Plant Nutrition Institute
IRAD	Institute of Agricultural Research for Development
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
JHI	James Hutton Institute, UK
KALRO	Kenya Agricultural & Livestock Research Organization
KIT	Royal Tropical Institute, the Netherlands
MSI	Management Systems International
NASECO	Nalweyo Seed Company
NARO	National Agricultural Research Organisation (Uganda)
NARS	National agricultural research system(s)
NARES	National agricultural research and extension systems
PPPLab	Public-private partnerships lab, the Netherlands
PROAGRO	Program for Productive Agriculture, Mexico
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WEnR	Wageningen Environmental Research
WUR	Wageningen University

Miscellaneous

ARI	Advanced research institute
BNI	Biological nitrification inhibition
CA	Conservation agriculture
CIM2GTAILS	CIMMYT second generation tropicalized haploid inducers (also 2GTAILS)
CoA	Cluster of activity
CSA	Climate smart agriculture
CSV	Climate smart village
DH	Doubled haploid
DT	Drought-tolerant
DTMV	Drought tolerant maize variety

ESA	Eastern and southern Africa
FAW	Fall armyworm
GES	Growth Enhancement Support Scheme
GHG	Greenhouse gas
GIS	Geographic information systems
GLS	Grey leaf spot
GS	Genomic selection
GWAS	Genome-wide association study
G x E	Genotype by environment interaction
G x E x M	Genotype by environment by management interaction
ha	Hectare
HIR	Haploid induction rate
HTPP	High-throughput plant phenotyping
IA	Intellectual assets
ICT	Information and communication technology
IMV	Improved maize variety
IP	Intellectual property
IPM	Integrated pest management
LA	Latin America
MARS	Marker Assisted Recurrent Selection
MAS	Marker assisted selection
MCMV	Maize chlorotic mottle virus
MLN	Maize lethal necrosis
MSV	Maize streak virus
NE	Nutrient expert
NGO	Non-government organization
NRM	Natural resource management
OPV	Open pollinated variety
PFSR	Post flowering stalk rot
PVA	Provitamin A
QFSA	Quantitative Farming Systems Analysis
QPM	Quality protein maize
QTL	Quantitative trait locus or loci
R4D	Research for development
SDG	Sustainable development goal
SI	Sustainable intensification
SNP	Single nucleotide polymorphism
SSA	Sub-Saharan Africa
SWI	Surface water irrigation
TLB	Turcicum leaf blight
TSC	Tar spot complex
UNFCCC NAP	United Nations Framework Convention on Climate Change National Adaptation Plans
WUE	Water use efficiency
ZN	Zinc
ZT	Zero tillage

Statistical analysis applications

ACBD-R	Generates and analyzes augmented designs
ADEL-R	Generates and analyzes standard experimental designs
AGD-R	Analysis of Genetic Designs
BGLR,BGLRR	Bayesian Generalized Linear Regression for prediction in genome selection
BIO-R	Molecular biodiversity
GEA-R	Genotype x Environment Analysis
META-R	Multi-Environment Trial Analysis
STAD-R	Descriptive statistics of experimental designs

CGIAR CRP Annual Reporting Template

COVER PAGE

Name of the CRP **MAIZE-AgriFood Systems**

Name of the Lead Center **CIMMYT**

List of participating Centers and other key partners: **IITA, ICAR (India), IDS (UK), KIT (NL), DArT (AU), JHI (UK), Monsanto, DuPont-Pioneer (now Corteva Agriscience), KALRO (Kenya), NARO (Uganda) and WUR (NL). The complete list/map of 251 partners (2017) is accessible** here.

List of donors (W1&2): See Table J

1. Key Results

1.1 CRP Progress Towards Intermediate Outcomes and SLOs:

The CGIAR Research Program (CRP) on Maize (MAIZE), an Agri-Food Systems CRP, focuses on tropical and sub-tropical maize-based systems in 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 smallholder farmers. Under section 2.1, we show which specific intermediate development outcomes MAIZE contributes to.

Germplasm improvement pillar (FP2 & 3)

- In 2017, 79 improved varieties, including 26 in Latin America, 44 in Sub-Saharan Africa and 9 in Asia, based on use of CGIAR (CIMMYT, IITA) lines, were released by MAIZE partners worldwide. Some of the special traits stacked in these varieties include drought and heat tolerance, nitrogen use efficiency, enhanced protein quality, high kernel zinc and resistance to diseases of regional or global importance, such as maize lethal necrosis (MLN), tar spot complex (TSC), and resistance to the parasitic weed, Striga. To view an interactive version of this map, click here.

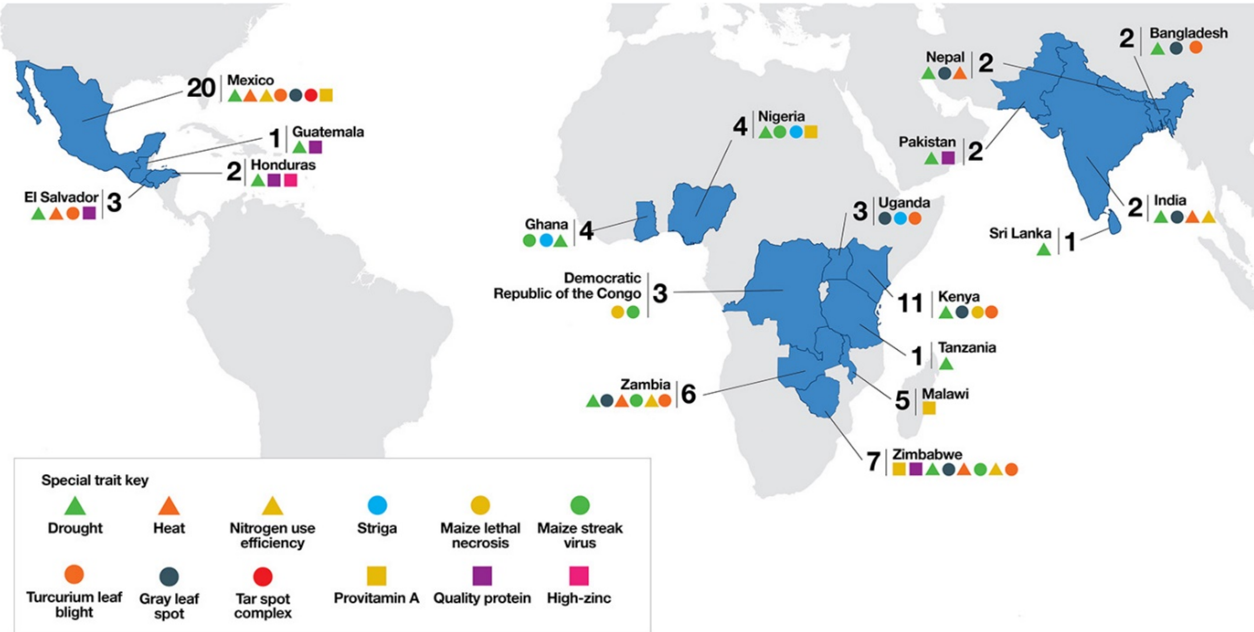


Figure 1: Elite maize varieties released by MAIZE CRP partners in 2017, with depiction of key traits.

MAIZE researchers documented genetic gain in grain yield through conventional breeding programs in eastern and southern Africa. The study found that, **genetic gain in grain yield in these areas was comparable with other regions of the world**. However, absolute yields remain lower, highlighting the need to increase productivity in the farmers' fields through various interventions, including improved seed, improved agronomy, and enabling policies - *for more detail, see under FP3 and FP4 below and see Table A-1, SLO 2.1.*

Over the next century, increasingly erratic weather patterns and environmental changes projected to result from climate change mean that maize will need to adapt at an unprecedented rate to maintain stable production globally. Scientists have unlocked evolutionary development of landraces through a comprehensive study of allelic diversity, revealing more about the genetic basis of flowering time and how maize adapts to variable environments. Farmers have been ingeniously adapting maize landraces to their local environments for thousands of years. In this study, over 4,000 landraces from across the Americas were analyzed. The study identified 100 genes, among the approximately 40,000 genes that make up the maize genome, influencing adaptation to latitude, altitude, growing season and the developmental point at which maize plants flower in the field.

The release of second-generation tropicalized haploid inducers (CIM2GTAILs) and the use of over 93,0000 doubled haploid (DH) lines in maize breeding programs in Latin America, Africa and South Asia have great potential to increase genetic gains.

The fall armyworm (FAW), a devastating insect- pest from the Americas, continues its march across sub-Saharan Africa. MAIZE has been working closely with international, regional and national partners to produce a comprehensive technical guide on the integrated FAW management. The MAIZE team is also working intensively to curb the spread and impact of MLN in sub-Saharan Africa through the development and deployment of MLN-resistant maize hybrids, besides strengthening the capacities of national plant protection organizations (NPPOs) across sub-Saharan Africa on MLN diagnostics and management. MAIZE is at the forefront in responding to the FAW challenge. The rapid response to MLN and ongoing intensive efforts against FAW highlight MAIZE's expertise and partnerships to counter the present and future pest/disease challenges in the tropics.

Policy, scaling and sustainable intensification

Invest in reviewing scaling pathways and approaches. MAIZE is an active partner in the GIZ-led, multi-CRP Scaling Task Force, which set up a Community of Practice with Dutch and CGIAR Center partners and joined the MSI/IFAD-led Scaling Up Community of Practice. In addition to building networks and relationships, the Senior Scaling Expert collaborated with select projects to build capacity for a new Scaling Tool.

Farmer decision support tools are all the rage, but how do you achieve sustainable scaling out, after projects are shut down? The 'Taking Maize Agronomy to Scale in Africa' project (TAMASA) has brought together 6 Ethiopian, 4 Nigerian and 3 Tanzanian partners, plus CCAFS and university partners, to find an answer. TAMASA focuses on adapting the web- and phone-based Nutrient Expert and Maize Variety Selector tools to local conditions and needs, for example, by filling a weather data gap. Such tailoring involved crowd-sourcing of agro-dealers, farmer schools and other interactive means of product design and, crucially, building business models and a market. TAMASA builds on lessons learnt from mega projects like DTMA/STMA, CSISA and SIMLESA's integrated scaling plan - *more details are under section 1.2, FP4, below*.

MAIZE researchers found compelling research evidence on the multiple benefits of conservation agriculture (CA) and argued that it should be included as one of the major technology packages in Ethiopia's national agricultural extension system. *Scaling efforts* need to be supported by appropriate national, regional and local policies and community by-law, as well as capacity development for all actors involved in extension. The policy brief "Scaling conservation agriculture-based sustainable intensification systems in Ethiopia" discusses how conservation agriculture (CA) could be used to address the numerous challenges to sustainable crop production in Ethiopia, including severe soil erosion, depletion of nutrients, declining soil fertility and health, and frequent droughts. Using the brief to influence policy-makers will require partners, networking and business cases. Similar research collaborations and high-level meetings to influence policy-making were performed in South Asia.

1.2 Progress by CRP Flagships:

See also Tables B, C and D. The list of 2017 MAIZE publications is found here.

FP1 Enhancing MAIZE's R4D Strategy for Impact

In 2017, MAIZE researchers generated new knowledge through numerous impact assessments, ex-ante evaluations and policy briefs that showed the value of MAIZE research for farmers and consumers around the world. In "Climate change impacts and potential benefits of heat-tolerant maize in South Asia," researchers found that under projected climate scenarios, heat-tolerant maize varieties such as those developed by MAIZE could minimize yield loss by up to 36% and 93% in 2030 and by 33% and

86% in 2050, under rainfed and irrigated conditions respectively. "Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia" showed that the adoption of a maize-soybean rotation by farmers in Zambia could reduce per-unit production costs by between 26% and 32% compared to maize monocropping - *see Table A-1, SLO 1.1*.

Seed systems innovation approaches in Africa (ex ante). Researchers examined the productivity and welfare effects of Nigeria's innovative mobile phone-based input subsidy program that provides fertilizer and improved seed subsidies through electronic vouchers, known as the Growth Enhancement Support Scheme (GES)."Productivity and Welfare Effects of Nigeria's e-Voucher-Based Input Subsidy Program" found that farmers who participated in the GES were able to increase their maize yield by 26.3%, increasing their income from maize by ₦19,730 ($54). Similarly, in "Impact of adoption of drought-tolerant maize varieties on total maize production in south Eastern Zimbabwe," researchers found that households that grew DT maize were able to harvest 617 kilograms more maize per hectare than households that did not grow DT maize varieties. This translates into US$240 per hectare extra income for households that grow DT maize varieties, equivalent to 9 months' worth of additional food security. As 93 percent of surveyed households already grow improved maize varieties using seed purchased from local markets, by switching to DT varieties local farmers could greatly improve their livelihoods and food security at no additional cost - *see Table A-1, SLO 1.2.*

Home-grown improved varieties with highest impact on child nutrition. MAIZE scientists assessed the adoption of improved maize varieties (IMVs) on child nutrition outcomes in rural Ethiopia and found that the overall impacts of adoption on child height-for-age and weight-for-age z-scores are positive and significant, and largest among children with poorest nutrition profiles. The researchers determined that the increase in own-produced maize consumption is the major channel through which IMV adoption affects child nutrition. In late 2017, GeoNutrition, a new CIMMYT partner project received an $8.9 million grant from the Bill and Melinda Gates Foundation to work on reducing micronutrient deficiencies in Ethiopia and Malawi. - *see Table A-1, SLO 2.3.*

Niche markets a poverty-reducing option? In "Maize Diversity, Market Access, and Poverty Reduction in the Western Highlands of Guatemala," MAIZE researchers investigated whether facilitating the emergence of niche markets for local maize varieties in the western highlands of Guatemala could contribute to poverty reduction. The study found that the majority of smallholder farmers in western Guatemala had extremely small landholdings, with an average of 0.31 hectares of arable land per farming household. Farmers were often only able to produce enough maize to feed their families for 6.9 months of the year and would have to buy additional maize to eat. Given this large subsistence needs gap, the researchers suggested that other types of interventions would be more suited for poverty alleviation in the region.

Impact of gender on agricultural innovation. In "Gender and innovation processes in maize-based systems," a report from the GENNOVATE initiative to MAIZE, researchers interviewed 1,600 women and men from 27 villages of Ethiopia, Malawi, Mexico, Nigeria, Nepal, Tanzania, and Zimbabwe to examine the gender dimensions of agricultural innovation and wider social change. Overall, women interviewees considered improved maize central to maintaining household food security. Researchers found that both men's and women's innovation adoption is constrained by costs and seed market limitations. Improved maize seeds ranked as among the two most important agricultural innovations to have come into their communities - *see section 1.3 for more information*.

FP2 Novel diversity and tools for improving genetic gains

Gene editing and pre-breeding to increase resistance to MLN: Great strides were made in developing maize germplasm with resistance to maize lethal necrosis (MLN) disease in 2017, using both innovative technologies and novel maize genetic materials from around the world. MAIZE scientists have been working with Corteva Agriscience to identify one of the genes that confers strong resistance against MLN. With fine-mapping, a strategy that combines laboratory molecular tools with field phenotyping, scientists have narrowed their search to fewer than eight genes (from a total of ~40,000 in the maize genome). A promising candidate among these eight genes will be validated via gene editing directly in the MLN-susceptible parental lines to determine whether it confers resistance to MLN. Gene editing, compared to other breeding methods, will allow scientists to shave off one third of the time it would take to develop new MLN resistant lines; expediting development and release of improved varieties to farmers. Pre-breeding research, based on new sources of resistant alleles from native maize varieties in the germplasm bank transferred to early-generation lines for breeding use, is also used in the fight against MLN. Utilizing a broader range of disease resistant alleles in breeding helps to create varieties with durable resistance (capable of maintaining resistance over time). In 2017, 255 advanced pre-breeding lines developed from MAIZE were planted at the MLN screening site in Naivasha, Kenya for in situ evaluation for the first time.

Molecular Markers and Genomic selection: In 2017, two studies (Abdumalik et al., Bankole et al.) published by MAIZE researchers demonstrate the effectiveness of Marker Assisted Recurrent Selection (MARS) in increasing genetic gains for grain yield under stress conditions such as drought, Striga and maize streak virus (MSV). The studies found that MARS was effective in increasing the frequency of favorable alleles for tolerance to drought, without disrupting the level of resistance to Striga, and that the populations responded well to MARS for improvement of grain yield and other agronomic traits. Overall, IITA uses 22 markers linked to four traits (PVA, MSV, Aflatoxin resistance, QPM) for forward breeding. At CIMMYT, marker-assisted backcrossing (MABC) has been successfully implemented to convert 30 elite-but-MLN-susceptible lines into MLN-resistant versions, using 16 SNP markers associated with MLN resistance. Scientists practice MABC in parallel to forward breeding for resistance to MLN and MSV in elite Africa-adapted maize germplasm.

Doubled haploids for a faster breeding cycle: The use of doubled haploid (DH) technology and release of second generation tropicalized haploid inducers by CIMMYT have allowed breeders to greatly reduce the time and cost associated with the development of improved maize lines. DH lines have reduced the time it takes to develop inbred lines from 3-4 years to just one year. Over 93, 0000 DH lines were developed from 455 populations and delivered by CIMMYT in 2017 to maize breeding programs in Africa, Latin America and Asia. The second generation tropicalized haploid inducers (CIM2GTAILs) released in 2017 have a haploid induction rate (HIR) that is over 40% higher than the first-generation tropical inducers released by CIMMYT in 2012. The CIM2GTAILS were developed by CIMMYT using marker assisted selection (MAS). CIM2GTAILs are also superior in terms of agronomic performance. These improvements reduce DH development costs by at least 30%. The second generation inducers are already used for large-scale haploid inductions in CIMMYT DH facilities. MAIZE received 20 requests for 2GTAILS from public and private sector partners in 2017. In addition, 29 researchers were trained in various technologies that can enhance genetic gains in maize breeding, including DH.

Methods, tools and capacity development: Around 100 people were trained in statistical concepts and in the use of innovative software tools (META-R, GEA-R, ACBD-R, ADEL-R, BGLR, BGLRR, STAD-R, AGD-R, BIO-R) in courses held in El Salvador, Mexico and Tunisia, 50% of which were women. These tools are currently used in over 30 countries by students, scientists and private companies.

FP3 Stress tolerant and nutritious maize

Progress on fighting Fall Armyworm (FAW): As the FAW continues to spread across sub-Saharan Africa, MAIZE has intensively worked with partners on a variety of fronts to tackle the challenge. A Stakeholders Consultation Meeting was held in Nairobi, in April 2017 on the strategy for effective management of FAW in Africa, attended by 160 experts from 29 countries. The meeting, co-organized by CIMMYT, the Alliance for a Green Revolution in Africa (AGRA) and the UN Food and Agriculture Organization (FAO), in partnership with the government of Kenya, developed a framework document on the strategy to fight the fall armyworm. In late 2017 MAIZE, in partnership with USAID and other collaborators, produced a comprehensive manual on fall armyworm pest management in Africa. It was released in January 2018. The manual, "Fall

Armyworm in Africa: A Guide for Integrated Pest Management," provides tips on FAW identification as well as technologies and practices for effective and sustainable management. Two Regional Training and Awareness Creation Workshops, involving nearly 200 stakeholders, were organized by CIMMYT and USAID, in eastern Africa and southern Africa. MAIZE IITA researchers conducted surveys and collections of local strains of FAW. CIMMYT has initiated intensive screening of maize germplasm for native genetic resistance to FAW under artificial infestation in Kiboko, Kenya.

Without proper management, over the next one to two years (2018-19), FAW may cause up to six billion dollars' worth of damage across affected maize growing regions in sub-Saharan Africa (SSA). Though solutions for the short- and mid-term exist, strong multi-disciplinary and inter-institutional collaboration is required to develop and deploy integrated pest management (IPM) packages tailored to African agro-ecologies. For example, "**breeding** for fall armyworm resistant elite maize hybrids adapted to sub-Saharan Africa would require intensive germplasm screening and collaborative work with both the public and private sectors," said B.M. Prasanna, at an international stakeholders' meeting in Nairobi. Scientists estimate that Africa will need an investment of at least $150 to $200 million annually over at least the next five years to mitigate potential damage due to FAW, through the use of effective **IPM-based options**. Farmer awareness-raising and early detection are critical pieces in the solutions-mix. MAIZE and its partners are implementing regional train-the-trainer workshops, so that pest control and extension actors can effectively scout, determine the need for intervention, and appropriately apply specific practices to control the pest in maize and other crops.

Increasing Genetic Gains. "A high and sustained rate of genetic gain is a key component of agriculture transformation; the genetic gain delivered in farmers' fields is the key measure of effectiveness of a crop improvement system".[1] In 2017, MAIZE researchers have documented the genetic gain achieved in conventional maize breeding programs in eastern and southern Africa, in both hybrid and open pollinated breeding pipelines. The studies[2] found that, despite challenges, **genetic gain in yield in these areas was comparable with other regions of the world**, due to significant donor investment over the past decade in stress tolerant maize breeding for Africa. However, **absolute yields remain lower**, highlighting the need to increase yields at the farm level, including increase in varietal replacement rate to ensure farmers have continuous access to new varieties suitable for current climates. Further MAIZE investment to characterize genetic gain included planting 38,280 plots over six countries, showing significant yield gains for extra-early maize. These studies will provide the baseline for monitoring the impact of FP2 technologies on breeding programs and a benchmark for FP3 breeding research outputs and on-field outcomes.

Greater smallholder farmers' access to improved varieties. Timely replacement of older maize varieties is crucial to help smallholder farmers deal with emerging threats such as climate change related weather events, pests, diseases and more. A 2017 study found that the average maize variety being planted in Africa is at least 15 years old, compared to 3-5 years in North and South America and Asia. MAIZE researchers are working hard to not only fast-track development of new stress tolerant varieties, but also to get them to farmers faster through seed company partners. Production and availability of drought tolerant (DT) maize hybrids greatly increased in Uganda in 2017: Over 6,000 tons of 10 different DT maize varieties were produced by local seed companies, up from less than 2000 tons of only six different varieties in 2014. Some seed companies have begun to market DT maize certified seed beyond the border; for example Bazooka, a drought and MLN tolerant variety is marketed by NASECO in Burundi and Congo, besides Uganda. Similarly, seed companies working with IMIC in Latin America were able to increase their market share by 6% and grow their business by 32%, producing 1.1 million bags of MAIZE-derived seed under the MasAgro project in Mexico. This has been done in part by substituting obsolete hybrids and other varieties that kept farmers' maize yields low.

[1] Journal of Experimental Botany, doi:10.1093/jxb/erx135

[2] Two of these publications in Crop Science in 2017 have been downloaded a combined 1,352 & cited 20 times (status March 2018).

The second phase of IMIC-Asia's India chapter was launched in 2017 to deliver impact through public-private partnerships for targeted market segments; IMIC-Asia India Chapter includes 25 seed companies, besides the national maize program.

Impacts through adoption of improved maize varieties. 24.5% of maize producing farmers in Nigeria have adopted drought tolerant maize varieties, including 44% of those with access to seed. This has led to increased maize yields of 13.3% and reduced the level of variance by 53%. Researchers identified greater positive impacts on female-headed, compared to male-headed households. Productivity and risk reduction gains reduced the incidence of poverty: The probability of food scarcity among adopters fell by 83.8%. About 2.1 million Nigerians have been lifted out of poverty *– see Table A-1, SLO 1.2.*

FP4 Sustainable intensification of maize-based systems for improved smallholder livelihoods

Global reach maintained. MAIZE continues to support 168 innovation platforms and other multi-stakeholder interaction mechanisms across Africa, South Asia and Latin America. The platforms enhance interaction, relationships, confidence, and trust among stakeholders involved in R4D, development and market chains of target crops. *Looking at Latin America*, in 2017 MasAgro reached nearly 10,000 new participant farmers in Mexico, also via the 345 technicians that have been certified since 2011 (40 during 2017) . Over 700 users logged 3,187 extension areas covering over 11,000 ha into the MasAgro electronic log. On this basis, MasAgro could determine that participant maize farmers harvest twice the average yield compared to other farmers in their regions.

Maize-based systems in South Asia under improved technologies. Under CSISA Phase III, MAIZE, RICE and NARS researchers and extension practitioners worked together with 81,000 Bangladeshi and Nepalese farmers on nearly 27,000 ha. The farmers applied improved technologies or management practices on their land. The technologies and management practices contributed included new crop varieties (rice and maize hybrids), healthy rice seedlings, premium quality rice, improved weed management, and maize intensification. Strengthening of input and output markets is a pre-condition for maize intensification and income generation. CSISA facilitated more than 300 contracts signed between feed mills and producer groups to supply maize in 2 Nepali districts. To ensure inputs supply, seed dealers like NIMBUS supplied more than 200 tons of hybrid maize seed through retailers' networks, compared to a base near zero prior to CSISA's efforts. Another improvement in the solutions mix was integrated weed management. Farmers piloted improved practices, avoiding the high costs of manual weed control, which gave them increased grain yields by 30–35% with marked gains in profitability. This turned farmers' maize production from a (near) loss-making proposition (US$ 38/ha) to a business with attractive returns of US$ 582/ha if the farmers used herbicides or US$ 438/ha with mechanical control. In Odisha state (India), CSISA researchers tested a two-part ex post subsidy approach to rapidly increase the number of machinery service providers.

As part of the CSISA program, women from tribal lands in Odisha continued to make profits by growing improved maize varieties under improved agronomic practices in fallow land during monsoon season, despite challenges such as access to land and markets. The project will continue to work with the women to improve their maize yields and income in 2018.

Similarly to CSISA's approach in its other target regions, in Nepal, CSISA staff developed partnerships for market-based mechanization between 7 local agro-dealers and a range of exporters from India and China. CSISA's involvement included providing introductions, facilitating tours to launch linkages, providing advice, and nudging both parties along the way to implementing their partnership. In Bangladesh, 33,335 farmers on 9,986 hectares took up and tested new technologies and crop management practices that strengthen cereal production systems, that are profitable, and that confer improved potential for resilience and employment opportunities during the reporting year.

With regard to water management, CSISA has delivered results that include better targeting of a national irrigation scheme and irrigation equipment scaling for maize and wheat-based systems. The government of Bangladesh is promoting surface water irrigation (SWI) for sustainable intensification. Remotely sensed, geospatial, and farmers' yield data integrated to target SWI show the practice could benefit more than 100,000 hectares of fallow and rainfed cropland, substantially increasing maize and wheat productivity. A new online tool can help the development of irrigation schemes. Axial flow pumps, reapers, and seed fertilizer drills to support sustainable intensification were also widely scaled: 2,000 agricultural machines were obtained and used by 1,800 service providers, reaching 90,000 farmers.

Farmer Decision Support Systems for piloting and scaling: In many countries, there is a single blanket recommendation for fertilizer use that does not take into account variations in soil or climate. The Taking Maize Agronomy to Scale in Africa project (TAMASA), in collaboration with the International Plant Nutrition Institute (IPNI), has been working with partners to calibrate and validate Nutrient Expert (NE), decision-support tool to help farmers use the right amount of fertilizer at the right time. Scientists set up Nutrient Omission Trials (NOTs) to calibrate existing models or algorithms, Performance Trials to test recommendations and training for service providers/extension agents to use NE to generate recommendations for individual farmers. MAIZE researchers observed across Ethiopia, Nigeria and Tanzania that recommendations generated by NE maintained high grain yield with lower amounts of fertilizer, reducing costs to farmers. For example, in Nigeria the regional recommendation is 120 kgha-1 nitrogen (N), 60 kgha-1 phosphorus (P) and 60 kgha-1 potassium (K) compared with 110, 35 and 15 kgha-1 respectively for the NE recommendation. Yields were similar, between 4 and 4.5 tons/ha, while fertilizer costs were <$100 for the NE recommendation and $170 for the regional recommendation. Fertilizer-use efficiency (agronomic efficiency) increased by 50%. In 2017, extension agents in the public and private sector generated nearly 6,000 fertilizer recommendations for individual farmers in Ethiopia, Ghana, Nigeria, Tanzania and Togo. Developing business models and hosting arrangements is a major challenge that will be addressed in 2018. TAMASA scientists are optimizing models that support farmers in different environments when best to plant. Results of 25 years sensitivity analysis in the Sudan Savanna, for example, showed that planting intermediate maize varieties in early June produced the highest grain yields, ranging from 3.2 to 3.5 t/ha. Delaying planting beyond this date consistently decreases grain yield.

Improved targeting of innovations: Quantitative Farming Systems Analysis (QFSA) is a set of analytical tools that allow agricultural research and development agents to identify the diversity of farming systems and sustainable intensification (SI) alternatives. It also helps to assess the contribution of these alternatives to resource use efficiency, sustainability and resilience of different types of small scale farming systems - and to envisage options for their implementation and scalability. In 2017, MAIZE researchers worked to develop and apply methodologies based on QFSA for better targeting innovations, as well as work on QFSA tools and their application to different contexts and for different purposes. One of the main accomplishments has been the institutionalization and capacity building to foster use of QFSA tools. More than 60 research and development agents have participated in courses and workshops about QFSA in India and Guatemala, in which the participants were 75% male and 25% female, with 90% younger than 30 years old. Several post-graduate students have integrated some of these tools within their research. To identify the features that are most relevant to monitoring progress towards sustainability goals for agricultural landscapes, MAIZE researchers conducted a review of agricultural sustainability assessment frameworks (ASAF) in 2017. The review, to be published in 2018, found that assessment results should identify relationships among ecosystem services and socio-economic activities related to agricultural landscapes, and that visualization tools can facilitate understanding of trade-offs and synergies among sustainability goals, as reflected by individual indicators.

Progress on Scaling approaches: MAIZE participates in the GIZ-led Scaling Task Force of 8 CIM experts that are embedded in 7 CRPs. Achievements include development of a scaling tool and building capacity on scaling in the MASAGRO/PROAGRO projects with Mexico. The tool is embedded in a training package, and four training events were conducted with Mexican partners, after being tested with 46 PROAGRO / MASAGRO trainers. The Sustainable Resilient Farming Systems Intensification (SRFSI) project’s phase 3 revolves around capacities for scaling. In late 2017, CGIAR and national partner researchers started a big Training of Trainers campaign in Nepal, Bangladesh and India. Third, MAIZE co-founded a CGIAR Scaling Community of Practice with the Royal Tropical Institute (KIT; NL), PPPlab (NL) and IITA, and joined the Scaling Up Community of Practice, coordinated by IFAD and with experts from the World Bank, MSI, USAID, DFID and others.

DTMASS (Drought- Tolerant Maize for Africa Seed – Scaling Project) conducted a workshop in Nairobi with 58 partners on Scaling Improved Ag Technologies to African farmers. Workshop outputs included maize seed system mapping at national level, to identify sectors, players and potential issues to be addressed, key indicators and data collection methods, as well as collaboration options for scaling.

1.3 Cross-Cutting Dimensions (at CRP level):

1.3.1 Gender:

In 2017, MAIZE continued with strategic and integrated gender research globally: In Latin America; MAIZE supported the projects 'Social Inclusion and gender dimensions of Buena Milpa in Guatemala', the social inclusion and gender dimensions of 'Modernizacion Sustentable de la Milpa en la Peninsula de Yucatan' and social inclusion and gender dimensions of MasAgro program (Mexico). For MasAgro, the gender team implemented awareness raising workshops, gender equity trainings and scaling activities, such as providing tools for farm advisors and agri-practitioners. In Africa, the MAIZE gender team developed case studies on Gender and Value Chain Analysis for Maize and Legumes in Tanzania and Ethiopia under the SIMLESA project, and a publication on gender and SI technology benefits and lessons learned submitted to ACIAR in November 2017. In Asia, publications such as 'Occupation Choice in the Agricultural and Non-agricultural sectors by Rural Youth and Females in Bhutan' contributed to a better understanding of rural females participating in the agricultural and non-agricultural sectors.

Under the GENNOVATE program, the report "Gender and innovation processes in maize- based systems" was published. Key findings are:

- The majority of men and women identified improved maize varieties among the top two agricultural innovations;
- Women are increasingly becoming key actors in local small-scale agriculture;
- Gender norms are changing, but men's agency, authority and resource control still predominate;
- There is more rapid and inclusive development in villages where both women and men report empowerment and take part in agricultural innovation.

MAIZE and WHEAT funded and promoted the CIMMYT Gender Capacity Strengthening Program roll-out in partnership with KIT (NL). Trainings on gender in agricultural research were delivered in 6 country offices and 2 parallel trainings at CIMMYT HQ. In total more than 170 CIMMYT-staff participated and gave very positive feedback (See Annex 1 for Flagship Project Contributions per Cross cutting topics).

1.3.2 Youth:

MAIZE is working on integrating youth into its R4D agenda, in particular to create conditions for young people to be interested in agriculture. With that purpose in mind, MAIZE and WHEAT co-funded a range of scoping discussions in collaboration with the Institute of Development Studies (IDS), University of Sussex, UK. The resulting scoping paper examined the potential opportunities that agricultural value chains, technology, and entrepreneurship offer for youth employment from a rural transformations perspective. Using cereal agri-food systems as an example, the authors propose an analytical framework built around key contextual factors that constrain or enable young people's economic activity. The authors warn against constructing youth as a new and supposedly homogeneous target group, whose concerns can be addressed independently of the rest of society.

MAIZE added a youth component to several of its bilateral projects. One example is the SIMLESA project: Three reports on youth's perception and participation in agriculture in Tanzania, Ethiopia and Mozambique were finalized, leading to a journal article. In South Asia, bilateral projects such as CSISA and SRFSI focus on appropriate-scale mechanization for smallholder farmers. CSISA has developed pilot projects to attract young rural entrepreneurs as service providers. They make a living by providing land preparation, crop establishment, irrigation and harvesting services to farmers, on an affordable fee-for-service basis. In Mexico, the project *Learning how to rescue a landrace: a study of the giant maize, Jala, and the community who grows it* found that Jala farmers are becoming older and there is no sign of a generational hand-over. The researchers pointed to the need to integrate young people and to develop commercially sustainable niche markets based on Jala maize. The project's second phase will include young women and men (aged 15-29) interested in conserving and revaluing native maize as a principal element of their way of life (See Annex 1 for Flagship Project Contributions per Cross cutting topics).

1.3.3 Other Aspects of Equity / "Leaving No-one Behind":

After the devastating hurricane Stan had hit Guatemala in 2005, a number of indigenous communities were unable to harvest seed from their traditional maize varieties (landraces). Generations of selection by farmers under local conditions has endowed these varieties with resistance to drought, heat, local pests and diseases. As the country struggled to rebuild and replant, it turned out that the entire maize seed collection in Guatemala's national seed bank had been damaged by humidity-induced seed rot. Seeds were vulnerable to insects and fungus and could not be regenerated. Thanks to the bilateral project 'Buena Milpa', CIMMYT'S Germplasm bank sent seed of more than 700 native Guatemalan maize varieties, including some of the varieties that have been lost.

Guatemalan scientists planted seed from those historic samples, to ensure the varieties will grow well under local conditions. The best materials will be returned to local and national seedbanks in Guatemala, once again available for farmers and researchers. So far, Buena Milpa has enabled 1.800 farmers to access community seed reserves. In addition, 13.000 farmers have applied improved practices and technologies.

As a follow-up, MAIZE researchers investigated "MAIZE diversity, market access and poverty reduction in the western highlands of Guatemala", to determinate whether selling native maize at a higher premium to niche markets could support in-situ conservation and provide higher returns for farmers. The study concluded that farmers had extremely small landholdings, are not able to produce enough maize. Given the large maize deficit, researchers proposed other types of interventions for poverty alleviation in the region. Based on these findings, MAIZE is planning a series of workshops aimed at extension agent collaborators that will address social inclusion issues.

Six maize populations and 42 inbred lines bred and released in Cameroon, with the support of USAID were lost, due to unexpected break down of the cold store at Institute of Agricultural Research for Development (IRAD). The materials were recovered from the USDA gene bank that maintains duplicate samples, multiplied and repatriated to IRAD.

Other examples of MAIZE engaging in least developed countries are featured under FP4, above (Bangladesh, Nepal).

1.3.4 Capacity Development:

CGIAR and partner researchers trained 46,790 scientists, technicians, and other participants from 17 countries, of which 11,688 were women (See Annex 2 for more details). They participated in workshops, field days, seminars and other learning events, such as regional training workshops on FAW management in Zimbabwe and Ethiopia. Besides the training courses, in 2017 MAIZE supported 110 MAIZE- funded Students in reaching their BSc, MSc, and PhD degrees, in 26 countries (See Annex 3 for more details).

Scaling out small-scale mechanization in the Ethiopian Highlands: CGIAR and partner scientists provided training and technical backstopping to 238 service providers (199 male; 39 female), to enable them to provide small-scale mechanization services. During the 2017 growing season, service providers were monitored and received both technical and agribusiness support in implementing their activities. 106 farmers (16 female; 90 male) attended field days to learn more about mechanized Sustainable Intensification technologies and see the two-wheel tractor and its different accessories in action.

MAIZE and WHEAT co-funded a project to establish, pilot and implement a *Learning Management System (LMS).* External experts in 2016 designed it after the fact-finding mission. The LMS with its functionalities was developed based on 13 pilot courses that represent the different training formats and environments at CIMMYT locations (offices & field). The System will be launched end of January 2018. Processes and workflows were defined and staff trained in the use of LMS, so that all training activities will be managed systematically through this system. The developers have connected with IITA and ICARDA from the outset and during 2018, the LMS will be presented to other CGIAR centers (See Annex 1 for Flagship Project Contributions per Cross cutting topics).

1.3.5 Open Data:

MAIZE-related Open Data Resource content has grown, but in 2017, no *additional* resources or tools were made available to a larger audience. Key challenges to Open Data Access implementation, which also apply to MAIZE, were aptly summarized in 2017. Bilaterally funded Open Data resources include the CSISA Open Data repository, with currently 17 datasets.

In 2017, the CIMMYT data repository that hosts open access MAIZE datasets was migrated to Dataverse 4.7.1. CIMMYT set up a partnership with the Dataverse development team at Harvard University, resulting in the release of version 4.6.2, which was featured during the 2017 Dataverse Community Meeting.

CIMMYT started in 2017 a full revamp of its digital repositories, including Dataverse, with the main objective of making MAIZE's Open Access assets available through the Mexican National Science Repository, which will be harvested by the Latin-American Regional Science Repository "La Referencia" in the near future.

A growing number of scientists are depositing data sets, as the graph below documents. Researchers' downloads of the increased number of Open Access datasets grew faster since November 2017 (35k file downloads). The trend has been positive since then, now at above 45k.

1.3.6 Intellectual Assets:

(a) How have intellectual assets been strategically managed by the CRP in order to maximize their global accessibility and/or impact in line with the CGIAR Principles on the Management of Intellectual Assets? E.g. taking out intellectual property rights, licensing, new innovative practices, etc.

CIMMYT, participating CGIAR Centers, and partners manage MAIZE CRP Intellectual Assets ('IA') in accordance with the CGIAR Principles for the Management of Intellectual Assets and the CGIAR Open Access and Data Management Policy. MAIZE is not a legal entity and thus, IAs are managed across the research portfolio of each Lead or Participating Center, without specific regard to how projects are matched to CRPs (or not) and funded.

Every year, CGIAR Centers submit an Intellectual Asset report to the CGIAR System Management Board, in which Centers describe the most relevant IA management strategies and practices and a summary that describes in detail intellectual property arrangements for Limited Exclusivity Agreements and Restricted Use Agreements. The 2017 report is found here. MAIZE does not duplicate IA Report information in this Annual Report.

During 2017, CIMMYT, as MAIZE Lead Center, strategically managed its IAs generated through MAIZE research projects, with a focus on revising current dissemination pathways for two main outputs:

Germplasm and research data. With respect to germplasm, CIMMYT updated its germplasm policy (currently under upper management review), to be finalized during 2018. This policy now includes new licensing schemes intended to recoup, under certain commercialization scenarios, a portion of the R&D investment in the development of the germplasm being commercialized, including scaling up and out through IA management. CIMMYT also standardized and maintained transparency of its maize product allocation principles, referenced in its Germplasm Policy. With respect to research data, CIMMYT continued to define data management standards that allow dissemination of datasets in the broadest possible way: through public repositories and data sharing agreements. At the same time, these standards respect all Centers' obligations under (i) the International Treaty on Plant Genetic Resources for Food and Agriculture; (ii) the privacy of individuals; (iii) confidential obligations acquired; and/or (iv) intellectual property rights of third parties.

(b) Indicate any published patents and/or plant variety right applications (or equivalent) associated with intellectual assets developed in the CRP and filed by Centers and/or partners involved in the CRP (please fill out or update the Table E);

CIMMYT has not filed, nor has any CIMMYT partner informed CIMMYT, of any application for patent or plant variety protection associated with intellectual assets developed in MAIZE.

(c) List any critical issues or challenges encountered in the management of intellectual assets in the context of the CRP.]

Most critical challenges encountered in IA management in the context of MAIZE were identified in the Phase II Full Proposal (listed below for reference). Two additional challenges were added in the light of recent developments, in the field of datasets (related to digital sequence data and datasets with personal, private information). The full list of challenges are:

- Ensure sufficient funding (including sufficient human resources), to implement on a timely basis all actions needed for a proper IA management.
- Lack of IP policies in some NARS; lack of knowledge among NARS of IA management practices at CGIAR Centers and/or insufficient capacity to conduct adequate IA management.
- Collecting, exporting and licensing seed in view of the ITPGRFA and the Nagoya Protocol.
- Some IP policies or practices from certain MAIZE partners are not aligned with CGIAR IA management Policies;
- Harmonization of licensing practices to disseminate digital sequence data with the Open Access obligation, in light of concerns raised among some ITPGRFA stakeholders in relation to the use of such datasets;
- The rising bar for Centers' privacy protection and accountability in the context of dealing with datasets, wherein such data include personal information that carry with them accompanying dissemination obligations under Open Access.

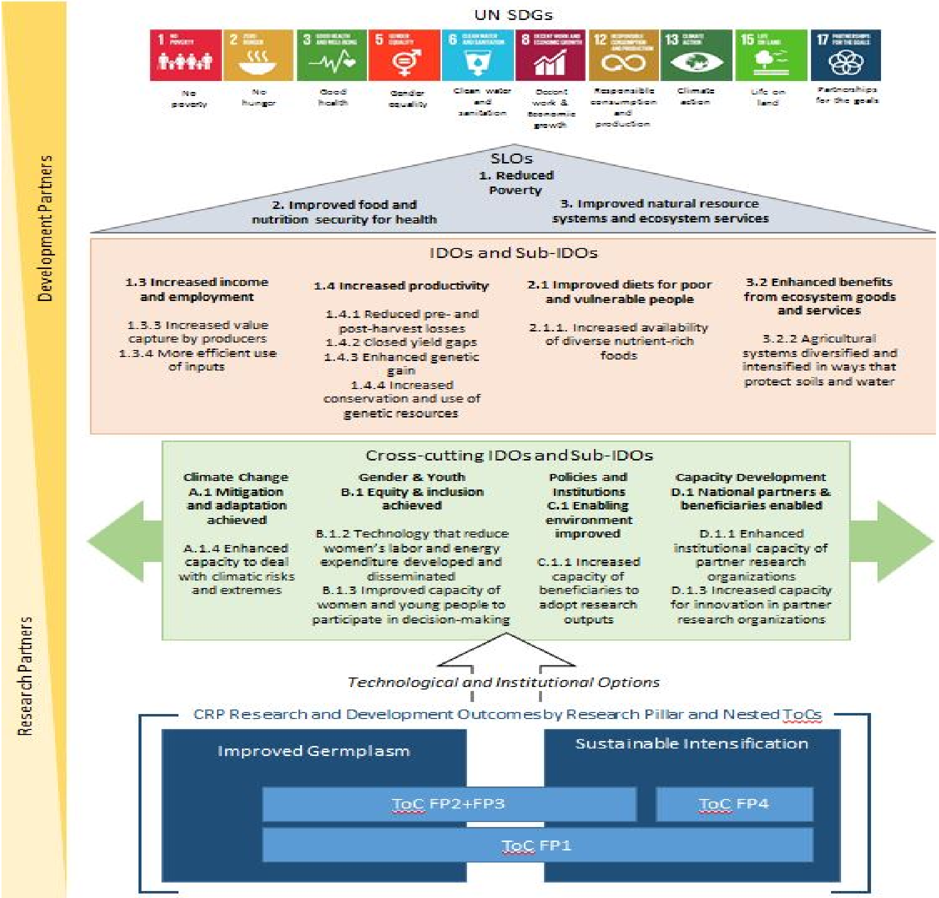
2. CRP Effectiveness and Efficiency

2.1 Variance from Planned Program:

During Phase II, MAIZE re-structured into 4 Flagship Projects (FPs), down from initially proposed five FPs into 4 strategically interlinked FPs:

FP1 Enhancing MAIZE's R4D strategy for impact;
FP2 Novel diversity and tools for improving genetic gains;
FP3 Stress tolerant and nutritious maize;
FP4 Sustainable intensification of maize-based systems for improved smallholder livelihoods.

MAIZE is committed to contributing to intermediate development outcomes and impacts that relate to IDO's 1, 2, 4 and 9, as shown. MAIZE contributes to these second tier IDOs: IDO3, 5, 6, 7, 11.



Program research scope. No significant change to overall and per FP research scope. FAW represents a challenge, in terms of capacity for partnership, fundraising and coordination.

Program delivery. Minor delays in delivery.

Learning at CRP/FP-levels. The FP4 Sustainable Intensification Program implemented three regional Retreats. The key Lessons Learnt were 1) it is important to offer range of locally adaptable technologies that can be layered to smallholder farmers, 2) implementing partners need to invest in their own capacity development and 3) a flexible and accommodating approach to partnership and project implementation can make a large and positive difference to impact on the ground. Underscoring the latter, especially in the context of MAIZE aligned bilateral projects, is crucial.

2.2 Use of W1-2 Funding:

W1&2 constitutes <20% of the overall MAIZE budget and serves an important, catalytic function by way of strategic and complementary investments to W3/bilateral projects in specific MAIZE R4D areas and target geographies. W1&2 helps in setting strategic direction and creating coherence across the MAIZE FPs, especially through:

a) proof-of-concept work;
b) seed investment on emerging research priorities leading to funding of W3/bilateral projects (e.g., precision agriculture and geospatial research; invasive insect-pests like Fall Army worm);
c) building new strategic partnerships for scaling, and for better understanding scaling processes;
d) Cross- regional and cross institutional learning on methods and approaches
e) MAIZE management functions: planning, monitoring and reporting; coordination among implementing centers and partners; open access and open data management; intellectual assets management; communications; knowledge management (e.g., MAIZE Atlas), and capacity development.

	Strategic, longer-term research, seed invests	Rapid response (incl flexibility)	Cross-Portfolio, -CRP learning for impact	CRP Gov. & Mgmt.
Discovery (upstream)	FP1, 4: *ex ante* IA & ex post IA / adoption studies for new knowledge for better targeting, prioritizing; ARI, national partners FP2-4: Generate new knowledge for R-to-D pipeline: New alleles for heat and drought, other climate change-related traits identified; GS models using high throughput phenotyping and environmental data	FP3 new diseases & pests: FAW, MLN, Spittlebug	FP2-3: Germplasm improvement methodologies, methods, data mgmt (e.g. Genetic gain, cross-crops) FP4: Research on scaling out, innovation pathways	MAIZE ISC, MAIZE -MC. SMB Board Member (DG), CRPs Rep in SMB, MEL CoP co-leadership
Validation	FP3: New traits into elite lines: Heat and Drought. Precision Phenotyping Platforms with NARS partners; expanded yield testing FP1: draw out the lessons from the previous MAIZE years and across MAIZE W3/bilateral studies and geographies to actively shape and coordinate the implications and priorities for enhancing the impact of MAIZE in Phase-II		FP4: Country coordination, systems research approaches; , strategic support to national research programs, private-sector led scaling FP2: development of decision support tools to enhance genetic gains in breeding programs, in partnership with EiB Platform	
Scaling out (downstream)	FP1, 4: Research on adoption dynamics, scaling out, targeting, prioritizing, M&E approaches FP3: Research on farmer adoption, seed systems innovation	FP3-4: post-conflict emergency support	FP3.7, 4.4: Country coordination, companion crops into maize- based systems, capacity development	
CGIAR-SRF Cross-cutting themes	Gender / social inclusion applied to 2 to 4 MAIZE innovation pipelines and assessments rapid value chain assessments with proper gender lens		FP1, 4: AFS-CRPs & CCAFS FP3: MAIZE & A4NH on improved nutrition Inter-CRP: How to improve gender mainstreaming into research	

2.3 Key External Partnerships:

In September 2017, MAIZE Participant Centers CIMMYT and IITA signed a memorandum of understanding to partner with AGRA to strengthen maize production in Africa. The three institutions share a vision of improving the lives of smallholder farmer and transforming African Agriculture. This collaborative partnership between the three institutions will ensure scaling up and delivery of seeds of improved high-quality maize varieties in 11 African countries.

MAIZE continued to strengthen strategic up- and down-stream partnerships with W1&2 funding, in particular by deploying MAIZE competitive partner grants:

Assure continuity for maize R4D on spittlebug incidence, diversity, ecology and control in Ghana and Togo: Final survey results were published on December 2016. In 2017, MAIZE continued investing in the partnership with the Laboratoire de Biosecurite et Biotechnologie, in conjunction with IITA, to develop bio-pesticides for the control of spittelbugs Poophilus Walker. Researchers investigated how endophytic isolates of Beauverya bassiana can control spittelbugs on maize plants and thus improve livelihoods of farmers, consumers and other stakeholders, by avoiding unsuitable side effects due to the use of chemicals pesticides. Final results will be available by December 2018.

HTPPs and open-source image processing tools for maize foliar disease assessments were developed in partnership with the University of Barcelona, KALRO and the KALRO/CIMMYT Maize Lethal Screening (MLN) Center at KALRO-Naivasha. In addition to the developing leaf- and canopy-level digital RGB high throughput plant phenotyping (HTPP) activities, the research partners created a combination of software tools to identify and score maize foliar diseases at the leaf and canopy level. The tools use open-source image and statistical analyses. MSc and PhD students used the tools to generate and process phenotyping data, resulting in knowledge sharing products.

Foshan University and CIMMYT signed a collaboration agreement (China-CIMMYT Tropical Maize Research Center, or CCTMRC), to partner on Specialty MAIZE R4D, including germplasm exchange and evaluation of tropical maize germplasm resources, genomics and genetics research on tropical fresh/sweet maize, molecular breeding and deployment of Improved Sweet Corn Hybrids. This collaboration is building on China-CIMMYT partnerships since the early 80’s, which has led to more than 40 key maize hybrids released in China, honored with 3 National Science and Technology Progress Awards.

See Table G for 5 top Partnerships per FP and click here for a comprehensive 2017 MAIZE partners list, based on all funding sources.

2.4 Cross-CGIAR Partnerships (other CRPs and Platforms):

In 2017 MAIZE worked in close collaboration with several CRPs and Platforms, for example mainstreaming modern maize breeding technologies with EiB, or the promotion of the “10 best bet innovations for adaptation in agriculture” in a supplement to the UNFCCC NAP Technical Guidelines, in collaboration with CCAFS. MAIZE had provided the inputs for a CCAFS policy paper on stress tolerant maize (see CCAFS working paper number 215). This has led to the inclusion of stress tolerant maize technology in two papers on risk reduction and CSA (both submitted to Agricultural Systems). For more information, see Table H.

2.5 Monitoring, Evaluation, Impact Assessment and Learning (MELIA):

- Due to budget restrictions, MAIZE was not able to commission its planned evaluation of FP2: Novel Tools and Diversity. This was part of the Phase-II Rolling Evaluation Plan as contained in the MAIZE Proposal and has been rescheduled for 2018, budget permitting.
- MAIZE continued to build capacity in terms of project management, conducting five four day trainings on MELIA at regional offices and at HQ in 2017. These trainings include sections to strengthen project-level monitoring, evaluation and learning and feed into institutional decision making and learning.
- MAIZE reviewed and reflected on FP theories of change at the end of 2017 based on performance data collected and lessons learned. Best practices have been taken into account for next year. In 2017, FP teams are coming together to collectively develop indicators, targets, data sources, data collection frequencies and data collection responsibilities for each output, outcome and assumption for the duration of Phase-II.

- MAIZE has also conducted regular follow-ups on evaluation recommendations from the 2015 Evaluation of the CGIAR Research Program on MAIZE, and the 2014 IEA Review on CRP Governance and Management, in compliance with the CGIAR Policy for Independent External Evaluation. MAIZE is progressing strongly towards full implementation of these recommendations and is transferring responsibilities and delegating where appropriate.
- In 2017, MAIZE began to roll out use of the MARLO platform (Managing Agricultural Research for Learning and Outcomes) in order to more strongly link individual projects and areas of research to 2022 outcomes and the MAIZE impact pathway, as well as more easily plan and budget its work, monitor research progress, and report on CRP results in coming years.

2.6 Improving Efficiency:

Due to past years' budget uncertainty and shifting donor priorities, MAIZE has been challenged to operate within budget and at adequate output quality levels. MAIZE has adopted Project Management practices and monitoring and learning tools, to operationalize the following principles:

- Avoid duplication (redundant overlap) with existing projects/ programs;
- Operate within budget even with W1&2 budget volatility and uncertainty;
- Continuous efforts to increase process efficiency and cost effectiveness;
- MAIZE competitive partner grants as an alternative approach for value for money, building partnership and deliver more efficiently.

Some examples of efficiency gains are described in below.

Flagship Project	Cluster of Activity	Improving Efficiency Examples
FP1 Enhancing MAIZE'S R4D strategy for Impact	1.1. Informing R4D strategies through foresight and targeting	Adaptation and potential benefit of stress tolerance maize varieties quantified under current and future climates across tropical environments achieved using data collected through PIM support and this reduced cost of the activity by at least 25%.
FP1 Enhancing MAIZE'S R4D strategy for Impact	1.2 Adoption Impact & Learning	Making use of student internships helped reduce research costs by at least 10-20%. Also strengthens collaboration with ARIs and Universities in Africa and beyond.
FP2 Novel Diversity and Tools for Increasing Genetic Gains	2.4 Pre- breeding: Development of germplasm resources	We have been able to identify 3 partners in the private sector that are interested in tar spot complex (TSC) resistant maize germplasm and willing to give space and manage TSC evaluation sites. This has reduced costs for land rental, chemical inputs and travel.
FP3 Stress tolerant and Nutritious Maize	3.3 Introgressing nutritional quality and end-user traits	1. Use of DH breeding technique has helped to shorten breeding cycle by about 60% and cost by about 30% 2. Use of various testing platforms has significantly facilitated to develop superior hybrids. 3. Use of testing network across region facilitated evaluation of products from partners, have cut germplasm phenotyping cost significantly, and aided in adaptation of products in wider environments.
FP3 Stress tolerant and Nutritious Maize	3.4 Precision phenotyping and mechanization of breeding operations	Collaboration with ARIs needs to be strengthened, because several of them work in the area of new field phenotyping tools, with significantly higher budget and larger groups. This can create synergies and help intensify the deployment of high-throughput field-based phenotyping tools (both proximal and remote sensing) in breeding programs.

		New phenotyping tools reduce the time taken key breeder preferred traits by up to 90%. The cost saving around labour allows greater resources to be diverted to the generation and management of larger populations, allowing selection intensity to be increased within a fixed budget.
FP4 Sustainable Intensification of Maize- based systems …	4.3 Multi-criteria evaluation and participatory adaptation of cropping systems	Bilateral W3 projects that focus on developing and extension of improved agronomic practices implemented in Latin America, Sub-Saharan Africa, and South Asia are mapped to MAIZE. This has enabled efficiencies of scale and synergies that has permitted scaling-out and –up of research products in aligned W3 projects, and helped to overcome some of the budget deficits experienced in 2017 under the CRPs. Leveraging private sector funding and sharing of training costs was one of the major achievements of the CIMMYT-MoANR partnership in 2017 in Ethiopia. In addition to in-kind contribution by providing two wheel tractors and their accessories, the Ministry also contributed funds towards technical and agribusiness training sessions conducted in 2017. This significantly reduced the financial burden on CIMMYT, enabling a refresher training in October 2017 for service providers. The MoANR contributed up to 50% of the training budget that was required to successfully run the first round of training sessions. The refresher training in October 2017 was funded by CIMMYT. In Bangladesh, CIMMYT has leveraged more than $3.6 million of in-kind support from the private sector to scale out smart farm machinery for smallholder farmers.

3. CRP Management

3.1 CRP Management and Governance:

With the integration of certain components of the HumidTropics CRP into MAIZE Phase-II, the MAIZE-Management Committee brought it an additional representative from IITA, to strengthen sustainable intensification R4D under FP4. MAIZE-MC changed its membership composition to include all FP leaders from CIMMYT and IITA responsible for day-to –day management of the CRP, besides representatives of the lead center providing key inputs/advice.

The MAIZE Independent Steering Committee (MAIZE-ISC) remained unchanged during 2017. Updated Terms of Reference and changes to membership composition were approved by the Lead Center Board of Trustees. The changed MAIZE-ISC will start operating from 2018 onwards.

3.2 Management of Risks to Your CRP:

During Phase I, MAIZE applied a risk management matrix to regularly assess and manage risks related to delivery of results. The three major risks identified remained unchanged during Phase II:

- W1&W2 budget insecurity and delayed transfer of W1&2 funds, which directly affects CRP research and development operations;
- Unfulfilled obligations by the partners for commissioned and competitive grants;
- Lack of a systematic and integrated approach for monitoring and evaluation at the outcome level.

To mitigate risk (1), the CRP Management Committee gives priority to multi-year investments of centers and partners, and uses the issuing of new partner grants as the most flexible component of the budget. MAIZE continues to sign only one-year partner grant contracts, to manage partner expectations and minimize any delays of payments to them. For risk (2), MAIZE regularly monitors the fulfillment of obligations by partners and intervenes when necessary to ensure proper completion of grant requirements. As for risk (3), the MAIZE and WHEAT counts with the support of a shared Senior Monitoring, Evaluation and Learning Specialist to strengthen the CRP monitoring and evaluation system. A number of CIMMYT/ MAIZE initiatives were also identified to contribute to minimizing risk, including the implementation of MARLO.

3.3 Financial Summary: [See also **Table J**.]

The System Council-approved budget (100%) is shown below (POWB2017):

Flagship	**Planned Budget 2017 (USD)**		
	W1/W2	**W3/bilateral**	**Total**
FP1: Enhancing MAIZE's R4D Strategy for Impact	1,330,260	3,171,924	4,502,184
FP2: Novel Diversity and Tools for Increasing Genetic Gains	1,841,463	5,206,026	7,047,489
FP3: Stress Tolerant and Nutritious Maize	3,978,090	24,789,300	28,767,390
FP4: Sustainable Intensification of Maize-based Systems	1,585,554	21,134,093	22,719,647
MAIZE Commissioned/Competitive Partner Grants	1,163,433	Above figures include Partner sub-grants	1,163,433
CRP Management & Support Cost (including MEL, Communications, Knowledge management, OA/OD, etc.)	1,401,200	-	1,401,200
Total	**11,300,000**	**54,301,343**	**65,601,343**

Given USAID and DFID contributions uncertainty, MAIZE-MC agreed to budget based on 80% ($9.040 M, see table below) of SC-endorsed 2017 allocation ($11.3 M). The 2017 W1&2 budget was adjusted in December 2017, when DFID contributions were confirmed and received, to $11.023 M, against expenditure of $10.414 M (see Table J). MAIZE-MC intends to deploy all carry-over from 2017 during 2018.

	2017
	80%
CRP Management	950,000
IITA	1,672,028
CIMMYT	5,667,972
Partners	750,000
Total	9,040,000

Tables

Table A: Evidence on Progress towards SLOs

From MAIZE Phase II Proposal: **Table 1.2** below presents the value proposition of MAIZE in terms of target contributions to the CGIAR SLOs, (see **Table A** of the **MAIZE Performance Indicator Matrix** document, for more details).

SRF indicators and targets	**MAIZE contribution indicators**	MAIZE 2022	MAIZE 2030
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

Table A-1: Evidence on progress towards the SLOs (sphere of interest)

SLO Target (2022)	Brief summary of new evidence of CGIAR contribution to *relevant* targets for this CRP (with citation)	Expected additional contribution before end of 2022 (if not already fully covered).
1.1. 100 million more farm households have adopted improved varieties, breeds, trees, and/or management practices	*Ex ante Impact Assessment (IA)*: Climate change impacts and potential benefits of heat-tolerant maize in South Asia: Under projected climate scenarios, heat-tolerant maize varieties such as those developed by MAIZE could minimize yield loss by up to 36/93% in 2030 and 33/86% in 2050 under rainfed/irrigated conditions, respectively. *Ex post IA:* Measuring the impacts of adaptation strategies to drought stress: the case of drought tolerant maize varieties where results showed that adoption of DTMVs increased maize yields by 13.3% and reduced the level of variance by 53% and downside risk exposure by 81% among adopters. This suggests that adoption had a "win-win" outcome by increasing maize yields and reducing exposure to drought risk. The gains in productivity and risk reduction due to adoption led to a reduction of 12.9% in the incidence of poverty and of 83.8% in the probability of food scarcity among adopters. *Ex ante*: Without proper management, over the next one to two years (2018-19), fall armyworm may cause up to six billion dollars' worth of damage (2 seasons with an estimated $3bn loss; April 2017) across affected maize growing regions in sub-Saharan Africa (SSA). See also Sept 2017 evidence note here.	No
1.2. 30 million people, of which 50% are women, assisted to exit poverty	*Ex ante IA:* Without proper management, over next years (2018-19), fall armyworm may cause up to 6 billion dollars' worth of damage across affected maize growing regions in sub-Saharan Africa (SSA). *Ex-ante* welfare impacts of adopting maize-soybean rotation in eastern Zambia: Adoption of maize-soybean rotation by farmers in Zambia could reduce per-unit production costs by between 26 and 32% compared to continuous maize production. (publication here) "Impact of adoption of drought-tolerant maize varieties on total maize production in south Eastern Zimbabwe": Households that grew DT maize able to harvest 617 kilograms more maize per hectare than households that did not grow DT maize varieties. Translates into	No

	US$240 per hectare extra income, equivalent to 9 months' worth of additional food security. *Ex post IA*: Productivity and welfare effects of Nigeria's innovative mobile phone-based input subsidy program (GES) that provides fertilizer and improved seed subsidies through electronic vouchers: Farmers who participated in the GES were able to increase their maize yield by 26.3%, increasing their income from maize by ₦19,730 ($54). *Ex post adoption* study: 24.5% of maize producing farmers in Nigeria adopted drought tolerant maize varieties, including 44% of those with access to seed; increased maize yields by 13.3% , reduced level of variance by 53%, even greater positive impacts on female-headed households compared to male-headed households. 12.9% reduction incidence of poverty, 83.8% reduced probability of food scarcity among adopters. Ca 2.1 million individuals lifted out of poverty.	
2.1. Improve the rate of yield increase for major food staples from current <1% to 1.2-1.5% per year	*Ex post IA*: MAIZE researchers documented genetic gain in grain yield in conventional maize breeding programs in eastern and southern Africa (OPV's, 1999-2011). Genetic gain in yield in these areas was comparable with other regions of the world. However, absolute yields remain lower, highlighting the need to increase yields.	No
2.2. 30 million more people, of which 50% are women, meeting minimum dietary energy requirements	Biofortified vitamin A "orange" maize can help address the adverse health effects of vitamin A deficiency. By 2016, HarvestPlus (under A4NH) and its partners had developed six orange maize varieties and delivery efforts have reached more than 100,000 farming households in Zambia. HarvestPlus has established the proof of concept, that vitamin A maize varieties can be developed without compromising yield levels and that these varieties can deliver sufficient quantities of vitamin A to improve nutrition.	No
2.3. 150 million more people, of which 50% are women, without deficiencies in one or more essential micronutrients	*Ex post IA*: Adoption of improved maize varieties (IMVs) on child nutrition outcomes in rural Ethiopia suggests the overall impacts of adoption on child height-for-age and weight-for-age z-scores positive and significant, largest among children with poorest nutrition outcomes. Agricultural technology adoption and child nutrition enhancement: improved maize varieties in rural Ethiopia: Increase in own-produced maize consumption is major channel through which IMV adoption affects child nutrition.	No

3.1. 5% increase in water and nutrient efficiency in agroecosystems	*Ex ante IA (under development)*: Mobile phone applications for nutrient recommendations, variety selection and seed area/plant density: Change in user volume, satisfaction.	No
3.2. Reduction in 'agriculturally'-related greenhouse gas emissions by 5%	*Genetic mitigation strategies to tackle agricultural GHG emissions:* the case for biological nitrification inhibition technology: Accelerated soil-nitrifier activity and rapid nitrification are the cause of declining nitrogen-use efficiency (NUE) and enhanced nitrous oxide (N2O) emissions from farming. Biological nitrification inhibition (BNI) is the ability of certain plant roots to suppress soil-nitrifier activity, through production and release of nitrification inhibitors. Transformative biological technologies designed for genetic mitigation are needed, so that BNI-enabled crop-livestock and cropping systems can rein in soil-nitrifier activity, to help reduce greenhouse gas (GHG) emissions and globally make farming nitrogen efficient and less harmful to environment.	No
3.3. 55 M ha degraded land area restored	*Adoption and farm-level impact of conservation agriculture in Central Ethiopia* - Soil erosion and degradation is an important agro-ecological challenge in the highlands of Ethiopia. Conservation agriculture (CA) has a long time been identified as one of the key interventions that could abate the current trend of physical and chemical erosion of soil. This study analyzed adoption of the different components of CA (minimal disturbance of soil, permanent organic soil cover, and crop rotation) and herbicide application in two districts of Ethiopia using a multivariate probit model.	No
3.4. 2.5 M ha forest saved from deforestation	*Ex ante, proxy*: Field scale, a 3-seasons experiment, Ethiopia: *F. albida* trees increase soil mineral N, wheat water use efficiency, reduce heat stress, increasing yield significantly. *To be investigated*: Impact of forest proximity on food security, dietary diversity, and agricultural productivity.	No

Table A-2: List of New Outcome Case Studies from This Reporting Year (Sphere of Influence)

Title of outcome case study	No. of Sub-IDO	Links to evidence*	Space for additional, very brief details, including on cross-cutting issues
Characteristics of maize cultivars in Africa: How modern are they and how many do smallholder farmers grow?	C.1.1	Click Here	Maize variety turnover in SSA is slower than what is practiced in the USA and other world regions such as Latin America and Asia. The substantial variations among regions and countries in all parameters measured suggest a tailored approach to mitigation interventions. Findings of this current study pave the way for replacing the old cultivars with more recent releases that are tolerant or resistant to multiple stresses and are more resilient.
Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan and Response to climate risks among smallholder farmers in Malawi	C.1.1 1.1.2 1.3.2	Here And Here	Results show that younger farmers and farmers with higher levels of education are more likely to use these adaptation practices, as do farmers that are wealthier, farm more land and have joint families. The number of adaptation practices used was found to be positively associated with education, male household heads, land size, household size, extension services, access to credit and wealth. Farmers adopting more adaptation practices had higher food security levels (8–13%) than those who did not, and experienced lower levels of poverty (3–6%). Climate change adaptation practices at farm level can thereby have significant development outcomes in addition to reducing exposure to weather risks. Using household and plot level data collected in 2011, we implement a multivariate probit model to assess the determinants of farmer adaptation behavior to climatic risks and the relative contribution of information, credit and education on the probability of adopting specific practices in response to adverse changes in weather patterns. We find that plot characteristics, credit constraints and availability of climate-related information explain the adoption of several of these practices. In relative terms, we also find that even when financial limitations are binding, making climate-related information available can still motivate farmers to adapt.
Hurdles to / ways to improve upon African farmers' adopting	1.3.2	Here	While there are issues with perceived benefit and relevance, the primary driver of negative evaluation of CA was found to be the feasibility of implementation. The required resources to

conservation agriculture practices: Enabling conditions, closing knowledge gaps, technologies' combination, role of subsidies (Eastern Zambia, Malawi)		And	implement CA (financial, physical, human and informational) are limited by community and institutional constraints which appear unlikely to be overcome through interventions targeted at addressing household resources. More positive evaluation of CA by smallholder farmers requires: (1) development of financially viable CA adoption pathways; (2) incorporation of wider livelihood objectives into a CA 'package'; (3) re-evaluation of current extension policy; and (4) development of CA-complementary agricultural policies. Without addressing these issues, the potential benefits of CA adoption are unlikely to be achieved in African smallholder systems.
	1.4.2	Here And	The current study focuses on conservation agriculture (CA) technology adoption dynamics among a small group of farmers who can be considered increasingly knowledgeable, as they have hosted CA demonstration-trials for at least 7 years. Management and performance of farmers' fields were compared with the CA demonstration-trials implemented on the same farm, focusing on yield gaps (YGs) between the two and the uptake of CA or some of its principles.
	1.3.2		Results show that a higher number of SIPs is associated with higher productivity which is more visible when commercial inputs are used in combination with cultural practices. Results have policy implication: Promoting an integrated use of technologies, instead of a single technology, would have a positive impact on farm productivity and farm household income.
	1.3.1	Here And	Farmers' access to markets and social capital empirically predicted minimum tillage combined with mulching (MTM) adoption. Policies that increased fertilizer subsidies and extension-staff-to-farmer ratios had similar effects, even if only modestly. Conceivably, subsidies specifically targeted at MTM could also be considered based on their potential environmental and social benefits. We conclude that adoption of MTM still faces the same micro- and macro-level hurdles common to all agricultural technologies. Long-term investments in agricultural extension and reductions in the costs of complementary inputs are critical for the diffusion of MTM.

	1.1.2	Here	Analysis of situation of Malawi's Farm Input Subsidy Program (FISP). Using panel data from smallholder farm households, we develop a multivariate probit model and examine how FISP participation affects farmers' decisions to adopt various NRM technologies, such as intercropping of maize with legumes, use of organic manure, water conservation practices and vegetative strips. As expected, FISP increases the use of inorganic fertilizer and improved maize seeds.
Enhancing Smallholder Access to Agricultural Machinery Services: Lessons from Bangladesh.	1.3.2	Here	Enabling adequate access through machinery services can thereby significantly contribute to food security and farm incomes. At the core of the service provision model is the lead farmer, who makes the initial investment in agricultural machinery, and provides services to others on a fee-for-service basis. Profiling the lead farmers can thereby provide important lessons and scaling implications. The present paper provides a case study of Bangladesh, using primary data to characterize the lead farmers. General education, credit availability and risk taking attitude play significant roles in whether or not a farm household will be a lead farmer in Bangladesh.
Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia	1.1.2	Here	Ex-ante welfare impact analysis showed significant potential income gains and poverty reduction following adoption of maize-legume rotation in eastern Zambia. Paper concludes with implications for policy to promote wider adoption of soil fertility management practices such as maize-soybean rotation for increased maize productivity in Zambia.
Adoption and farm-level impact of conservation agriculture in Central Ethiopia.	3.2.2	Here	Soil erosion and degradation is an important agro-ecological challenge in the highlands of Ethiopia. Conservation agriculture (CA) has a long time been identified as one of the key interventions that could abate the current trend of physical and chemical erosion of soil. This study analyzed adoption of the different components of CA (minimal disturbance of soil, permanent organic soil cover, and crop rotation) and herbicide application in two districts of Ethiopia using a multivariate probit model.
Productivity and Welfare Effects of Nigeria's e-Voucher-Based Input Subsidy Program.	1.1.2	Here	Nigeria has embarked on a potentially innovative mobile phone-based input subsidy program that provides fertilizer and improved seed subsidies through electronic vouchers. Results suggest that the program is effective in improving productivity and

			welfare outcomes of beneficiary smallholders. The size of the estimated effects suggests a large improvement in productivity and welfare outcomes.
Impact of Climate Change, Weather Extremes, and Price Risk on Global Food Supply.	1.4.1	Here	Using seasonal production data, price change and price volatility information at country level, as well as future climate data from 32 global circulation models, we project that climate change could reduce global crop production by 9% in the 2030s and by 23% in the 2050s. Climate change leads to 1–3% higher annual fluctuations of global crop production over the next four decades.
Improved (drought-tolerant) varieties adoption dynamics in SSA: Malawi, Zambia and Zimbabwe	C.1.1	Here And	This study assesses the maize adoption responses of food insecure farmers in Malawi, where drought-tolerant (DT) maize was recently introduced. More risk-averse households were more likely to have adopted DT maize, less likely to have adopted other improved maize varieties and less likely to have dis-adopted traditional local maize (LM). Exposure to past drought shocks stimulated adoption of DT maize and dis-adoption of LM.
		Here And	The results reveal drought tolerance, grain yield, covered cob tip, cob size, and semi-flint texture to be the most preferred traits by farm households in Zimbabwe. The WTP estimates show that farmers are willing to pay a premium for drought tolerance equal to 2.56, 7, 3.2, and 5 times higher than for an additional ton of yield per acre, bigger cob size, larger grain size, and covered cob tip, respectively. We suggest designing and implementing innovative ways of promoting DT maize along with awareness-raising activities to enhance contextual understandings of drought and drought risk to speed adoption of new DT maize varieties by risk-prone farming communities. Given the high level of rural literacy and the high rate of adoption of improved maize, trait-based promotion and marketing of varieties constitutes the right strategy.
		Here	Results showed that adoption of DTMVs increased maize yields by 13.3% and reduced the level of variance by 53% and downside risk exposure by 81% among adopters. This suggests that adoption had a "win-win" outcome by increasing maize yields and reducing exposure to drought risk. The gains in productivity and risk reduction due to adoption led to a reduction of 12.9% in the incidence of poverty and of 83.8% in the probability of food scarcity among adopters.

Farm production, market access and dietary diversity in Malawi.	1.3.1 2.1.1	Here	Farm production diversity is positively associated with dietary diversity. However, the estimated effects are small. Access to markets for buying food and selling farm produce and use of chemical fertilizers are shown to be more important for dietary diversity than diverse farm production. Results with household- and individual-level dietary data are very similar.
Agricultural technology adoption and child nutrition enhancement: improved maize varieties in rural Ethiopia.	1.3.1 2.1.1	Here	Increase in own-produced maize consumption is the major channel through which IMV adoption positively impacts child nutrition.

*Please submit outcome case studies in MARLO, MEL or other MIS, and provide links, using the outcome case study template.

Table B: Status of Planned Milestones

FP	Mapped and contributing to Sub-IDO	2022 CRP outcomes (from proposal)	Milestone*	2017 milestones status (Complete, Extended or Cancelled)	Provide evidence for completed milestones** or explanation for extended or cancelled
FP1	C.1.1 Increased capacity of beneficiaries to adopt research outputs	Outcome 1.1 Increased capacity of partner organizations through MAIZE foresight and ex-ante analysis	Milestone 1.1 Ex-ante impact assessments identify potential opportunities, threats and game changes for MAIZE	Extended	Manuscript to be submitted in 2018
	C.1.1 Increased capacity of beneficiaries to adopt research outputs	Outcome 1.2 Increased capacity of beneficiaries to adopt research outputs through better MAIZE learning from adoption studies and impact assessment	Milestone 1.2 Adoption and impact studies on technologies-rolling plan based on progress of technologies along the theory of change	Extended	The initial framework of the meta-analysis paper was developed. Data cleaning is completed and analysis started for Global MAIZE Germplasm Impact Study. Obtaining data on parentage of proprietary maize varieties and adoption rate were found highly difficult. The experts were approached and in-depth literature search was done for the data, which was time-consuming. The problems with staffing (recently filled the position of adoption-impact economist for the CRP) was another reason for timely completion of meta-analysis.

	1.3.4 More efficient use of inputs	Outcome 1.3 Improved capacity of women and young people to participate in decision-making through MAIZE's gender and social inclusiveness	Milestone 1.3 Gender/social inclusion lenses applied to 2-4 MAIZE innovation pipelines and assessments	Complete	Report on Gender and innovation processes in maize based – systems This report examines the gender dimensions of agricultural innovation and wider social change.
	1.3.4 More efficient use of inputs	Outcome 1.4 Increased capacity of partner organizations through MAIZE market/value chain opportunities prioritized for their livelihoods enhancing potential	Milestone 1.4 Preparation and roll-out of rapid value chain assessments with proper gender lens in selected countries to identify opportunities and bottlenecks in MAIZE.	Complete	
FP2	1.4.3 Enhanced genetic gain	Outcome 2.1 Efficiency and effectiveness of MAIZE partners and global research community enhanced by use of new data capture, storage, dissemination and analysis tools	Milestone 2.1 Most recent 5 years phenotypic, genotypic and genealogical data curated and stored in centralized data repositories.	Extended	CIMMYT is in the process of implementing several databases and data repositories for storing and accessing phenotypic, genotypic, and genealogical data, including the B4R breeding data management system and the GOBii Genotypic Data Manager while continuing to maintain historical resources, such as IMIS. CIMMYT is collaborating with IITA counterparts to deploy and load data into systems that support breeding and other germplasm research efforts. The process of receiving, curating, and

					loading current data into these resources as well as historical data for the last 4 years is on-going and will continue for the duration of this project.
	1.4.3 Enhanced genetic gain	Outcome 2.2 Increased use of doubled haploids by MAIZE partners, accelerating genetic gains	Milestone 2.2 Second-generation tropicalized haploid inducers with at least 10% haploid induction rate (HIR) developed and made available to maize researchers globally.	Complete	Over 93,000 DH lines were developed in 2017 for maize breeding programs in Africa, Latin America and Asia from 455 populations submitted. The 2nd generation tropicalized haploid inducers (2GTAILs) released in 2017 have a haploid induction rate (HIR) that is over 40% higher than the first generation tropical inducers that were being used in CIMMYT and partner DH production pipe lines. The 2GTAILs are also superior in terms of agronomic performance.
	1.4.3 Enhanced genetic gain	Outcome 2.3 New germplasm sources of genetic variation and molecular markers for prioritized traits used by MAIZE partners	Milestone 2.3 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	Complete	Marker-assisted Recurred Selection for Drought tolerance Two F2 mapping populations, Stb1 and Stb2 were genotyped by DArT platform. Raw data was processed and quality checked. For pop. Stb1 the linkage map was constructed using 292 F2 individuals and 3836 SNP markers, whereas for pop. Stb2 the linkage map was

					constructed using 2122 SNP markers against 287 F2 individuals. The data generated will be used for QTL analysis as soon as phenotype data is received.
	1.4.3 Enhanced genetic gain	Outcome 2.4 MAIZE partners and global research community use novel sources of useful genetic variance for drought, MLN, Tar spot complex, and other key traits	Milestone 2.4 Multi-location testing of at least 300 pre-breeding germplasm entries for at least two priority traits (MLN, Tar spot complex) and general hybrid performance	Complete	Over 250 lines sent to Naivasha, Kenya and planted in screen house for MLN evaluation. Over 500 backcross lines with novel alleles from landrace accessions evaluated in the field for tar spot resistance and genotyped.
	D.1.1 Enhanced institutional capacity of partner research organizations	Outcome 3.1 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 MAIZE FP2 and EiB Platform)	Milestone 3.1.1 At least 3% increase in genetic gain of Stage 4 hybrid advancement cohorts under targeted abiotic and biotic stresses in sub-Saharan Africa (SSA), Asia and Latin America (LA), as compared to benchmark commercial hybrids and internal genetic gain checks from previous years.	Complete	Genetic Gains in Grain Yield of a Maize Population Improved through Marker Assisted Recurrent Selection under Stress and Non-stress conditions in West Africa. Genetic Gains in yield and Yield related Traits under Drought Stress and favorable environments in a Maize population improved using marker assisted recurrent selection.
FP3			Milestone 3.1.2 At least 5 new MLN tolerant hybrids released or recommended	Complete	9 MLN, 3 in DRC and 6 in Kenya; MAIZE varieties released and commercialized by MAIZE partners (see interactive map here).

			for release, and at least 10 new MLN-tolerant hybrids under National Performance Trials (NPTs) in MLN-endemic countries in eastern Africa		
			Milestone 3.1.3 Germplasm diversity, yield potential, stress tolerance, input use efficiency and agronomic architecture of tropical MAIZE germplasm improved through temperate (Ex-PVP) germplasm introgression.	Complete	150 new breeding populations containing 25% and 50% temperate germplasm 150 inbreds lines with 25% temperate germplasm selected for drought, Grey Leaf Spot, and yield potential.
	1.4.1 Reduced pre- and post-harvest losses, including those caused by climate change, 1.1.2 Reduced production risk	Outcome 3.2 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	Milestone 3.2.1 MAIZE Atlas, along with a functional MLN Phytosanitary Community of Practice and MLN Web Portal, effectively disseminate latest updates on major transboundary pathogens and best management practices.	Complete	Maize Lethal Necrosis (MLN) information Portal
			Milestone 3.2.2 Systematic studies on seed transmission of MLN pathogens, especially	Complete	More than 1000 S1 lines derived form 28 bi-parental crosses involving CIMMYT MLN resistant maize inbred lines evaluated for

			MCMV, initiated in partnership with ARIs (USDA/Ohio State University, Univ. of Minnesota) and KALRO.		desirable agronomic features.
			Milestone 3.2.3 An integrated pest management strategy designed for effectively tackling two invasive pests on maize in SSA – Fall Army Worm and Spittlebugs.	Complete	To read "Fall Armyworm in Africa: A Guide for Integrated Pest Management," please click here.
	2.1.1 Increased availability of diverse nutrient-rich foods	Outcome 3.3 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	Milestone 3.3.1 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.	Complete	446 Pro VA rich QPM inbred lines (of various generation) adapted to mid- and highland agro-ecologies developed. QPM inbred lines (362) adapted to mid- and highland agro-ecologies developed. 989 inbred lines maintained. 61 high zinc inbred lines adapted to highland agro ecology selected from 88 CIMMYT introductions. 10 Inbred lines tolerant/resistant to major pest and disease identified. 34 Pro-vitamins A rich hybrids selected out of

					the 122 introduced from IITA. Nutritious maize hybrids / varieties with superior agronomic performance and desirable gender-informed traits (processing properties, palatability and storability) adopted in targeted geographies. Two publications submitted (Global Food Security, Food reviews international).
			Milestone 3.3.2 Robust, high-throughput tools/techniques for assessing different nutritional and end-use quality traits developed, validated and disseminated to increase cost-effectiveness and to speed-up the varietal development process.	Complete	QPM breeding nurseries: 430 inbred lines generated. 3 QPM population adapted to mid- and highland agro-ecologies developed 424 Pro-vitamins A rich QPM inbred lines developed 50-60 adapted QPM inbred lines from CIMMYT-Zimbabwe introduced. 10 disease (5) and pest (5) resistant. 88 high Zn inbred lines developed. 60 Pro-vitamins A rich hybrids introduced and selected.

	D.1.3 Increased capacity for innovations in partner research organizations	Outcome 3.4 Reduction in product development and elite line recycling time and costs through integration of novel tools/technologies in breeding programs.	Milestone 3.4.1 High throughput field-based phenotyping tools, high-throughput genotyping for trait-linked markers, doubled haploid technology, and decision support tools integrated into MAIZE breeding programs for increasing genetic gains, improving breeding efficiency, and reducing the cost of product development	Complete	P, Zou C, Lu Y, Xie C, Zhang X, Prasanna BM, Olsen MS: Enhancing genetic gain in the era of molecular breeding. J Exp Bot 2017, 68:2641-2666.
			Milestone 3.4.2 A new open-source image analysis program developed by University of Barcelona (MAIZE partner) for disease phenotyping validated in a range of field environments.	Complete	Araus JL, Kefauver SC, Zaman-Allah M, Olsen MS, Cairns JE: Translating high throughput phenotyping into genetic gain. Trend Plant Sci 2018, 23:451-466.
			Milestone 3.4.3 MAIZE partners' capacity for generating high-quality multi-location phenotyping data for major abiotic (drought; heat) and biotic	Complete	Phenotypic and genotypic evaluation and line development of maize genetic resources for novel resistance to MLN and Tar Spot Complex QTL.

			stresses improved.		
	1.4.2 Closed yield gaps	Outcome 3.5 Reduced cost of seed production (= reduced "cost of goods sold or COGS") of newly developed and released maize varieties.	Milestone 3.5.1 Parental lines of at least 200 improved MAIZE pre-commercial hybrids (Stage 4) evaluated for flowering synchronization, seed producibility, herbicide sensitivity, and other desirable agronomic traits.	Complete	3700 tons of certified drought tolerant seed produced and marketed by seed companies.
			Milestone 3.5.2 Gender and socio-economic considerations included when designing crosses for developing products, seed production research and determining recommendation domains.	Complete	
	1.1.2 Reduced production risk	Outcome 3.6 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	Milestone 3.6.1 Availability and affordability of MAIZE-derived novel varieties improved in target geographies in partnership with an array of seed companies in SSA, Asia and LA.	Complete	Evaluation and deployment of stress resilient hybrids in lowland tropics of LA, Drought, heat and pests and diseases in Africa and Asia (See MAIZE varieties release map above).
			Milestone 3.6.2 Targeted efforts by MAIZE seed systems teams	Complete	MAIZE organized field days, workshops, and provided technical backstopping to

			lead to replacement of at least 10-15 obsolete (15/20+ year old) varieties with recently derived improved MAIZE varieties.		farmers in collaboration with NARS, Extension agents and Private Sector (seed companies, agro dealers, etc.).
			Milestone 3.6.3 Selected Mexican maize landraces improved through participatory breeding, and special landrace-growing farming communities benefited through fair trade markets	Complete	17 tons directly sold from 4 areas of Mexico and approximately 100 tons through directed linkages to exporters. ProMaizNativo legal constituted and registered as an Asociacion Civil in Mexico. This group consists of native maize experts, farmer representatives, sociologists, food scientists, marketing specialists. Clear objectives and set and agreed upon, committees formed and officers elected.
FP4	C.1.1. Increased capacity of beneficiaries to adopt research outputs (4.7)/B.1.2 Technologies that reduce women's labour and energy expenditure developed and disseminated (4.8)	Outcome 4.1 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)	Milestone 4.1 Multi-criteria assessments taking into account environmental and social acceptability aspects, based on standardized protocols for multi-criteria assessments of advanced crop management packages (not individual technologies)	This review will be published in 2018	Methodological contribution to the development of sustainable intensification indicators and metrics at landscape level and upscaling of field/farm levels indicators, aiming at improving MAIZE MEL. The review found that assessment results should communicate relationships among ecosystem services and socio-economic activities related to

					agricultural landscapes, and that visualization tools can facilitate understanding of trade-offs and synergies among sustainability goals as reflected by individual indicators.
	1.4.5 increased access to productive assets, including natural resources	Outcome 4.2 Decision support systems for nutrient and water management used by development partners	Milestone 4.2 Innovative tools, methods and multi-media extension materials to enhanced soil quality, nutrient and water use efficiency through participatory approaches	Complete	Development of ICT based data collection tools (including crowdsourcing avenues) to improve M&E of FP4 work. Development of Agrotutor tool- mobile farm management application In collaboration with IIASA, Sustainable intensification in Mexico (Pilot Project) through Crowdsourcing
	1.4.2 Closed yield gaps through improved agronomic & animal husbandry practices	Outcome 4.3 Adoption of productivity enhancing technologies by smallholder farming communities through participatory methods	Milestone 4.3 Increased adoption of combinations of SI strategies, resource and labour saving technologies in specific target geographies compared to 2016.	Complete	Development and implementation of methodologies based on QFSA for better targeting innovations for sustainable intensification, as well as work on QFSA tools and their application to different context for different The app interface was tested at field days in 2017 with 16 farmers, both male and female. Ground cover assessment app is currently being tested in Bangladesh, and will be deployed in other countries in the future.

	A.1.4 Enhanced capacity to deal with climate risks and extremes	Outcome 4.4. Impact at scale through adoption of SI technical innovation and practices and technical capacity reinforcement of scaling partners	Milestone 4.4 Existing scaling approaches including public/ private partnership and context specific business models evaluated in target geographies leading to improve scaling models and critical scaling factors defined.	Complete	Scaling tool developed and applied in several project contexts.

* Milestones include both outputs, output use and outcomes along the impact pathways.
** Provide link to any relevant open accessible document.

Table C: Cross-cutting Aspect of Outputs (W1 & 2 funded)

Cross-cutting	Number (%) scored 2 (Principal)	Number (%) scored 1 (significant)	Number (%) scored 0	Total overall number of outputs
Gender	8%	25%	68%	145
Youth	8%	26%	66%	
CapDev	6%	44%	50%	

Table D: Common Results Reporting Indicators

Table D-1: Key CRP Results from 2017, in Numbers

Sphere	Indicators	Data	Comments
Influence	I1/I2*. Projected uptake (women and men) /hectares from current CRP investments (for innovations at user-ready or scaling stage only – see indicator C1)	N/A	N/A
	I3. Number of policies/ investments (etc.) modified in 2017, informed by CGIAR research	20 Policies Complete list of 2017 documents could be found here	The Ministry of Agriculture and Natural Resources of Ethiopia, accepted to include CA-based sustainable intensification in the national extension package based on the policy brief "Scaling conservation agriculture-based sustainable intensification systems in Ethiopia".
Control	C1. Number of innovations by phase - new in 2017	11 innovations at proof of concept 2 piloted successfully 14 available for uptake (includes policy recommendations) 2 taken up by next users (includes policy change) see Table D-2 for more details	
	C2. Number of formal partnerships in 2017, by purpose (ongoing + new)	251 research partnerships of Which: Piloting Partnerships: 28 Scaling up and out Partnerships : 103 Research Partnerships (Discovery /Proof of concept): 120 Click here for more details	W1 & 2 funded competitive partner grants in addition to W3 and bilateral agreements between CIMMYT and IITA.
	C3. Participants in CGIAR activities 2017 (new +ongoing)	44,714 'end-users' (24% women) in on-farm trials, farmer field days and similar 4,937 'next users' (68% women) in innovation platforms, policy workshops and similar	

	C4. People trained in 2017	Long term (new + ongoing): 120 (41% Women) Short term: 46,666 (25% women)	Long Term includes, MAIZE funded students in addition to Visiting Scientists and non-degree students
	C5. Number of peer-reviewed publications	163 in 2017 [full list of CRP publications here] of which 72 (44%) are Open Access	
	C6. Altmetrics	N/A	N/A

*Please note: I = Sphere of Influence and C = Sphere of Control

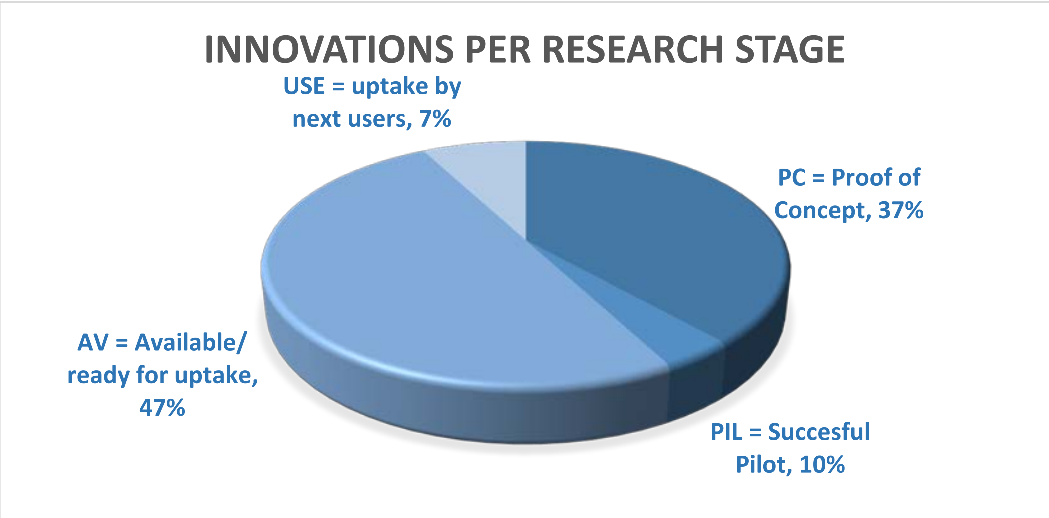
Table D-2: List of CRP Innovations in 2017 (From indicator #C1 in Table D-1)

Title of innovation (minimum required for clarity)	Phase of research * PC = Proof of Concept, AV = Available/ ready for uptake , PIL = Successful Pilot , USE = uptake by next users	Novel or adaptive research	Contribution of CRP (sole, lead, contributor)	Geographic scope: for innovations in phases AV* or USE* only (one country, region, multi-country, global)
Remote sensing for forage and Stover quality	PC	Adaptive	Contributor	NA
Genotyping of exotic germplasm for breeding	AV	Adaptive	Lead	Global
Genomic selection prediction in tropical maize	PIL	Novel	Contributor	
The use of unmanned aerial platform or vehicle (UAP/V) and sensors to collect crop phenotypic traits.	AV	Novel	Contributor	Multi-county
Development of an android application for yield estimation from harvested ears.	PC	Novel	Contributor	NA
Assessment of ear rot using digital ear phenotyping method.	PC	Novel	Contributor	NA
Develop improved maize germplasm through temperate introgressions, with selection for key traits relevant for smallholders in SSA	AV	Novel	Contributor	Global
Expand Regional Trials testing network in ESA	AV	Novel	Contributor	Region

Increasing yield potential and stress tolerance of QPM varieties for sub-Saharan Africa	AV	Novel	Sole	Region
Use of remote sensing techniques with drones to evaluate impact of Tar Spot Complex Disease on maize.	AV	Novel	Lead	Global
Early identification of haploid embryos in vitro	PC	Adaptive	Contributor	Region
Use of lime for nematodes control in maize systems on sandy soils	PC	Novel	Contributor	One country
Mobile phone applications for nutrient use	USE	Novel	Lead	Multi-county
Mobile phone application for variety selection	AV	Novel	Lead	Multi-county
Mobile phone application for seed rate	PC	Novel	Lead	Multi-county
Scaling tool	PC	Novel	Lead	Region
Development of a standard protocol for surface water irrigation pump testing (method)	USE	Adaptive	Contributor	One country
Integration of weather forecasting and crop modeling for irrigation scheduling advisories	PC	Adaptive	Contributor	One country
Zimplow direct seeder	AV	Adaptive	Lead	Region
Grownet direct seeder	AV	Adaptive	Lead	One country
Two wheel tractor based service provision of Sustainable Intensification technologies	AV	Adaptive	Contributor	One country
Atoxigenic strain identification	AV	Adaptive	Lead	One country
APSIM model validated for simulating maize response to N and climate change	AV	Adaptive	NA	Region
CERES-Model in DSATT calibrated and validated to simulate and predict performance of under changing crop management practices and environment	AV	Adaptive	NA	Region
Review comprised assessments of the impacts of the range of technologies (mostly improved maize varieties) and covered research conducted in 12 sub-Saharan African countries and published between January 2008 and January 2018.	NA	NA	NA	NA

We have assessed for the first time endophytic attributes of some *Beauveria bassiana* isolates and their effects on *Poophilus costalis*, a new maize insect pest	PC	Novel	Contributor	One country
Early haploid embryo identification and in vitro chromosome doubling protocols to enhance efficiency of doubled haploid production within mainstream maize breeding	PC	Novel	Sole	Global
Novel sources of tolerance to maize lethal necrosis incorporated from germplasm bank accessions to breeder-ready source lines via pre-breeding	PC	Novel	Sole	Sub-Saharan Africa
Linear selection indices for use in modern plant breeding (open access book completed 2017; will publish in 2018)	PIL	Novel	Contributor	Global
Environmental Genome-wide Association (GWAS) to identify useful sources of genetic diversity (published in Nature Genet 2017 - doi:10.1038/ng.3784)	AV	Novel	Contributor	Global

* Phases: PC - proof of concept, PIL - successful pilot, AV - available/ready for uptake, USE - uptake by next users.



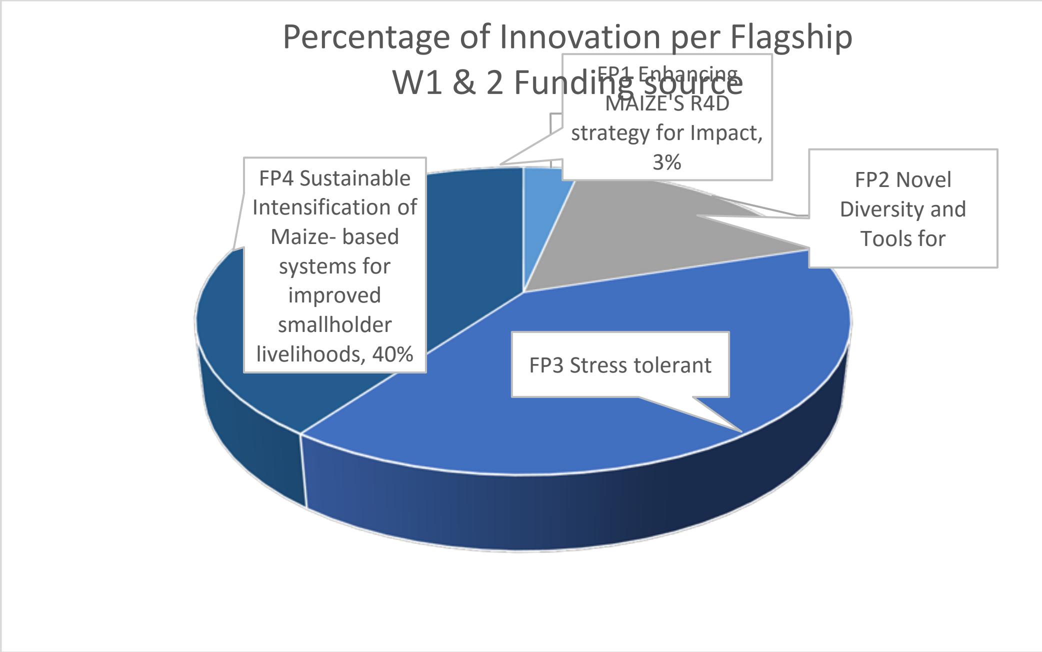


Table E: Intellectual Assets

Year reported	Applicant(s) / owner(s) (Center or partner)	Patent or PVP Title	Additional information *	Link or PDF of published application/ registration	Public communication relevant to the application/registration
2017	None	None	N/A	N/A	N/A

Table F: Main Areas of W1/2 Expenditure in 2017 [Optional]

Expenditure area *	Estimated percentage of total W1/2 funding in 2017**	Space for your comments [please remove notes below]
Planned research: principal or sole funding source	60%	Provide data curation support, software training and back-stopping for adoption and use of BMS and associated tools (especially KDExplore). Second generation haploid inducers with red root and R1-nj markers, and better agronomic characters. Increasing yield potential, stress tolerance, input use efficiency and agronomic architecture of tropical maize through temperate germplasm introgression Improve plant type, production potential and resistance to mycotoxin contamination in adapted maize through infusion of introduced germplasm Identification and quantification of the performance of drought tolerant and WUE maize hybrids Donor germplasm with high levels of resistance to multiple diseases, including MLN, MSV, GLS, TLB, mycotoxins, PFSR, downy mildew and other high priority regionally important diseases documented and disseminated to partners in SSA, Latin America and Asia
Planned research: Leveraging W3/bilateral funding	10%	Africa and Asia Regional trial hybrid advancement cohort having a 25% yield advantage under drought/heat stress compared to previous years benchmark hybrids. Tropical reference genome sequenced and published; HapMap 3 in use by MAIZE discovery community; Maize pan-genome analysis and marker-assisted breeding for abiotic and biotic stress tolerance
Catalyzing new research areas	15%	Gene editing research capacity with initial focus on MLN tolerance; transgenic expression and gene editing. Developing cold stress tolerant maize hybrids for Asia. Developing and deploying acid soil tolerant and disease resistant maize germplasm for the tropical/subtropical regions.
Gender	10%	Synthesis of strategic gender research in MAIZE target areas, including a write-up on lessons and implications for MAIZE from qualitative research on gender; 2) Implementation of new strategic gender studies in MAIZE target countries (in partnership with ARIs & NARES); and 3) Roll-out of Gender CapDev Framework and training of MAIZE researchers (in partnership with KIT).
Youth	5%	Efficient agricultural machinery appropriate for smallholder farmers focusses on developing young rural entrepreneurs as machinery service providers.
Capacity development	15%	Learning Management System (LMS) Implementation at CIMMYT, MAIZE Lead Center
Start-up or maintenance of		

partnerships (internal or external)		
Monitoring, learning and self-evaluation	Already included in the categories above	Add value to breeding and seed delivery, Provide Knowledge that will improve targeting and delivery of Maize varieties which objectives includes Targeting with GIS and HH surveys, Farmer Participatory evaluation, Gender research, M&E, Impact assessment in Angola, Benin, Ethiopia, Ghana, Kenya ,Malawi, Mali, Mozambique, Nigeria, Tanzania, Uganda, Zambia, Zimbabwe
Evaluation studies and Impact Assessment studies		Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia
Emergency/contingency	0	MAIZE-MC approved a 2017 W1&2 budget at 80% of System Council-endorsed. The 20% difference acted as contingency, carry –over will be deployed during 2018
Other	0	
TOTAL FUNDING (AMOUNT)	11,023	

Table G: List of Key External Partnerships

FP	Stage of research*	Name of partner	Partner type*	Main area of partnership*
FP1	PC	University of Minnesota	University	Foresight work
FP1	PC	Wageningen UR	University	Systems characterization and systems trajectories, synergies and trade-off analysis
FP1	PC	KIT	Research Institute	Gender and development work
FP1	PC	Oak Ridge National Laboratory (ORNL)	Research Institute	Big Data
FP2	PIL	Cornell University	University	High-density genotyping-by-sequencing (GBS), and genomic selection
FP2	PIL	University of Hohenheim	University	R4D on haploid inducers and DH technology
FP2	PIL	IBP, DArT and JHI	Private Sector	Database management, medium-density GBS, and breeding informatics
FP2	PIL	University of Barcelona	University	Field-based phenotyping
FP2	PIL	Monsanto, Pioneer, KALRO	Private Sector	Maize transgenic testing under CFTs and stewardship implementation
FP3	AV	wide array of NARES, seed companies and NGOs	NARS	Germplasm development and multi-location testing in SSA, LA and Asia.
FP3	PIL	KALRO and ARC	Research Institute	Elite germplasm for product development

FP3	PIL	Purdue University	University	Diverse yellow/orange maize germplasm for provitamin A enrichment
FP4	AV	Public Sector- NARES	NARS	Adaptive research
FP4	AV	IIASA	Private Sector	Co-invention of technologies

Table H: Status of Internal (CGIAR) Collaborations among Programs and between the Program and Platforms

Name of CRP or Platform	Brief description of collaboration (give and take among CRPs) and value added*	Relevant FP
PIM	Collaboration with IFPRI IMPACT team and all other CGIAR centers in the Global Futures and Strategic Foresight project. Strong synergies between PIM CoA 1.1 and Maize AFS CRP CoA 1.1	1
PIM	Collaboration with PIM CoA 1.2	1
Big Data	CIMMYT participates in a project led by WEnR to create weather and climate services using the European Space Agency satellites.	1
PIM	PIM provided resources for data collect phase of the project while resources from CRP Maize were used to generate outputs from the data collected in the early phase of the project.	1
Grain Legumes, FTA, WHEAT, GRiSP, Livestock and Fish	CGIAR Gender & Agricultural Research Platform	1
EiB	Identification of tools to be used in Enterprise breeding software	2
WHEAT	The MAIZE and WHEAT CRPs both operate in CIMMYT and the germplasm data management staff on these two CRPs interact extensively. The two teams share ideas, advice, and, when possible, software and data standards across these two CRPs.	2
GRiSP	IRRI and CIMMYT are jointly contributing to the development of the B4R breeding data management system. Each group requests features and helps to test new versions of the software. There are efforts to engage in joint prioritization. Scientists in the RICE, MAIZE, and WHEAT CRPs will benefit directly from all improvements made to this software in the short term whereas other CRPs, EiB-member programs, and other NARs will benefit from these improvements in the longer term.	2
EiB	Module 5 of the Excellence in Breeding Platform tries to organize the collaborative development of software and tools that are crucial for data management in the MAIZE CRP, such as B4R, a Sample Tracker, and the GOBII software. Module 5 of the EiB Platform receives requests and feedback from the MAIZE CRP data management team, and provides advice, organizing power, and communications fora in return.	2
Big Data	Module 1 (Organize) of the Big Data Platform seeks to promote shared, high quality data management standards to enhance the FAIR management of data in the CG. Module 1 of the Big Data Platform receives requests and feedback from the MAIZE CRP data management team, and provides advice, organizing power, and communications fora in return.	2

CCAFS	CCAFS were interested to promote the "10 best bet innovations for adaptation in agriculture" in a supplement to the UNFCCC NAP Technical Guidelines. I provided the inputs on stress tolerant maize (also published as CCAFS working paper number 215. This has also resulted in the inclusion of stress tolerant maize as a technology in two papers on risk reduction and CSA (both submitted to Agricultural Systems)	3
A4NH	Once atoxigenic strains are identified, Aflasafe activities under A4NH begin. These include atoxigenic strain selection, Aflasafe product testing, registration, commercialization, licensing, awareness campaigns, sensitization campaigns, product improvement, among others	3
EiB	Community of Practice, Working Group	3.3
EiB	Mainstreaming modern technologies in maize breeding pipelines in LA	3
CCAFS	Data sharing on climate change issues	4
RTB	Joint development of a spatial nutrient recommendation and analysis system through collaboration with ACAI (BMGF Cassava project implemented by IITA)	4
PIM	Keynote delivered at the 'South-South Knowledge Sharing on Agricultural Mechanization' workshop	4
CCAFS	CCAFS scientists collaborate in CoA 4.3 aligned bilateral project research on Integration of weather forecasting and crop modeling for irrigation scheduling advisories	4
WHEAT	WHEAT FP4 CoA 4.1 lead collaborates on research on targeting of appropriate mechanization and conservation agriculture options for different farmer typologies and at different scales across South Asia	4
Genebanks	The MAIZE data management team seeks to provide data curation support for the Maize Germplasm Bank at CIMMYT via the GRIN-Global database. Under the Genebanks Platform, the Seed Health Laboratory is also seeking to digitalize its data capture and storage efforts using tools endorsed	MAIZE

Table I: Monitoring, Evaluation, Impact Assessment and Learning

Table I-1: Status of Evaluations, Impact Assessments and Other Learning Exercises Planned in the 2017 POWB

Studies/learning exercises in 2017 (from POWB)	Status	Comments
Abate, T., Fisher, M., Abdoulaye, T., Kassie, G.T., Lunduka, R., Marenya, P., Asnake, W., 2017. Characteristics of maize cultivars in Africa: How modern are they and how many do smallholder farmers grow? Agriculture & Food Security 6, 30.	Complete	SSA
Ali, A., Erenstein, O., 2017. Assessing farmer use of climate change adaptation practices and impacts on food security and poverty in Pakistan. Climate Risk Management 16, 183-194.	Complete	Pakistan
Brown, B., Nuberg, I., Llewellyn, R., 2017. Negative evaluation of conservation agriculture: perspectives from African smallholder farmers. International Journal of Agricultural Sustainability 15, 467-481.	Complete	ESA
Cheesman, S., Andersson, J.A., Frossard, E., 2017. Does closing knowledge gaps close yield gaps? On-farm conservation agriculture trials and adoption dynamics in three smallholder farming areas in Zimbabwe. The Journal of Agricultural Science 155, 81-100.	Complete	ESA
Haile, M.G., Wossen, T., Tesfaye, K., von Braun, J., 2017. Impact of Climate Change, Weather Extremes, and Price Risk on Global Food Supply. Economics of Disasters and Climate Change 1, 55-75.	Complete	Global
Kassie, G.T., Abdulai, A., Greene, W.H., Shiferaw, B., Abate, T., Tarekegne, A., Sutcliffe, C., 2017. Modeling Preference and Willingness to Pay for	Complete	Zimbabwe

Drought Tolerance (DT) in Maize in Rural Zimbabwe. World Development 94, 465-477.		
Koppmair, S., Kassie, M., Qaim, M., 2017. Farm production, market access and dietary diversity in Malawi. Public Health Nutrition 20, 325-335.	Complete	Malawi
Koppmair, S., Kassie, M., Qaim, M., 2017. The influence of farm input subsidies on the adoption of natural resource management technologies. Australian Journal of Agricultural and Resource Economics 61, 539-556.	Complete	ESA
Kotu, B.H., Alene, A., Manyong, V., Hoeschle-Zeledon, I., Larbi, A., 2017. Adoption and impacts of sustainable intensification practices in Ghana. International Journal of Agricultural Sustainability 15, 539-554.	Complete	ESA
Manda, J., Alene, A.D., Mukuma, C., Chikoye, D., 2017. Ex-ante welfare impacts of adopting maize-soybean rotation in eastern Zambia. Agriculture, Ecosystems & Environment 249, 22-30.	Complete	Zambia
Marenya, P.P., Kassie, M., Jaleta, M., Rahut, D.B., Erenstein, O., 2017. Predicting minimum tillage adoption among smallholder farmers using micro-level and policy variables. Agricultural and Food Economics 5, 12.	Complete	ESA
Mottaleb, K.A., Rahut, D.B., Ali, A., Gérard, B., Erenstein, O., 2017. Enhancing Smallholder Access to Agricultural Machinery Services: Lessons from Bangladesh. The Journal of Development Studies 53, 1502-1517	Complete	Bangladesh
Mulwa, C., Marenya, P., Rahut, D.B., Kassie, M., 2017. Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. Climate Risk Management 16, 208-221.	Complete	Malawi
Tsegaye, W., La Rovere, R., Mwabu, G., Kassie, G.T., 2017. Adoption and farm-level impact of conservation agriculture in Central Ethiopia. Environment, Development and Sustainability 19, 2517–2533.	Complete	Ethiopia
Wossen, T., Abdoulaye, T., Alene, A., Feleke, S., Menkir, A., Manyong, V., 2017. Measuring the impacts of adaptation strategies to drought stress: The case of drought tolerant maize varieties. Journal of Environmental Management 203, 106-113.	Complete	SSA
Wossen, T., Abdoulaye, T., Alene, A., Feleke, S., Ricker-Gilbert, J., Manyong, V., Awotide, B.A., 2017. Productivity and Welfare Effects of Nigeria's e-Voucher-Based Input Subsidy Program. World Development 97, 251-265.	Complete	SSA
Zeng, D., Alwang, J., Norton, G.W., Shiferaw, B., Jaleta, M., Yirga, C., 2017. Agricultural technology adoption and child nutrition enhancement: improved maize varieties in rural Ethiopia. Agricultural Economics 48, 573–586	Complete	Ethiopia

Table I-2: Update on Actions Taken in Response to Relevant Evaluations

Name of the evaluation	Recommendation	Management response – Action Plan	By whom	By when	Status
2015 Evaluation of the CGIAR Research Program on MAIZE	Assess target smallholder groups, ecologies, geographies and commercial seed markets	Accepted in full- Undertake analyses to determine recommendation domains for germplasm outputs and technical support.	CRP Director, Abebe Menkir	Analyses every 3 years	Full implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	Review priorities in FP 4 and 5 and re-	Partially accepted- Undertake analyses of seed sector evolution in	MAIZE MC/ISC,	June 2015-	Full implementation

	consider efforts in final product delivery	target environments over 10-15 years The role of Aflatoxin and post-harvest storage research will be reviewed for the Phase II proposal.	FP1 Co-Leads	Dec. 2016	
2015 Evaluation of the CGIAR Research Program on MAIZE	MAIZE should establish pro-active research capability to provide foresight on emerging issues in diseases and support environmental characterization.	Partially accepted-Discuss importance of, and funding for establishing capacity in MAIZE for foresight on emerging issues. Recruitment of senior Foresight and targeting specialist to develop foresight portfolio for MAIZE	CRP Director, FP1 Lead	June 2015-Dec. 2016	Full Implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	Improve deployment of new phenotyping technologies into breeding and extend science into trait dissection, plant-based phenotyping and modelling	Accepted in full-Opportunities to do so will be reviewed on an annual basis by the FP2&FP3 team.	FP2 Lead	Annual	Full implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	Continue support for deployment of germplasm/ genetic resources and broaden funding base for high-value trait lines. More focused product design, network trial results and seed market assessments should be used. A study should explore options for funding support toward the development of parental lines.	Accepted in full - the role of fee-based consortia or other income mechanisms are being assessed to ensure they do not contradict CGIAR Intellectual Asset Principles. More focused product design; network trial results and seed market assessments will be included in the analyses for recommendation 1. Characterizing and utilizing an array of germplasm options and genetic resources, and discovery and use of high-value trait lines, are important components of strategy.	CRP Director, FP2 Co-Leads	Undertake analyses every 3 years	Full implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	MAIZE should institute management measures to ensure efficiency and effectiveness in management of staff and research	Partially accepted-Allocate more W1/W2 for cross-disciplinary learning activities and events. Develop and operationalize protocols for data collection and management.	MAIZE program manager, Knowledge Management, M-MC	2015-2017	Planning stage-budget constraints affected ability to implement

	activities over the long term.	Role specialization within breeding team and necessary links between stages of product development have been devised Review project alignment and suggest opportunities to improve.			
2015 Evaluation of the CGIAR Research Program on MAIZE	MAIZE should improve links in agronomy research with other CRPs to develop sustainable intensification indicators	Accepted in full- Expand work on indicators and metrics with commodity-focused CRPs to systems CRPs (Humid Tropics and Dry Land Systems). This is presently taking place under leadership of Africa Rising.	FP4 Lead	2018	Substantial Implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	MAIZE should take action to improve its gender orientation.	Accepted in Full- Implement new MAIZE gender strategy. Increase investment on gender analysis at project level. Continue to implement measures to employ female scientists. Operationalize key recommendations from Gender Competency Framework and Modular Capacity Strengthening Program Report (2015).	Gender Team	2017	Full Implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	MAIZE should develop a strategy for impact assessment.	Accepted in Full- Develop comprehensive strategy for MAIZE impact assessment.	FP1 Lead	2018	Substantial Implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	MAIZE should enhance the conduct and use of impact assessment.	Accepted in Full- Implement strategy for impact assessment. All new MAIZE proposals > $5,000,000 to propose impact assessment budget. Operationalize feedback mechanisms of the new strategy for impact assessment. Proactive use of gender lens in technology design and adoption studies. Commission additional gender studies	FP1 Lead	Ongoing	Substantial Implementation
2015 Evaluation of the CGIAR Research Program on MAIZE	CIMMYT and IITA should establish a single global maize	Accepted in full- Subject to ratification by IITA's DG and BoT, CIMMYT	MAIZE-MC	December 2015	Full Implementation

	program that integrates efforts of the two centers.	and IITA senior management have already agreed to establishment of a single maize programme.			
2014 IEA Review on CRP Governance and Management	Publish on CRP websites the names of members and their qualifications, posting meeting agendas and minutes, and otherwise sharing important information.	Making minutes available on-line would require having two versions of the minutes: an edited public version (without confidential personal or business information) and an unedited version restricted to internal purposes and information to boards, Center senior management and main partners.	MAIZE CRP Team	Ongoing	Substantial Implementation

Table J: CRP Financial Report

	Planned budget 2017			Actual expenditure 2017*			Difference		
	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total	W1/2	W3/bilateral	Total
FP1	1,388	10,342	11,729	1,263	8,026	9,289	124	2,316	2,440
FP2	2,174	10,689	12,864	2,004	10,102	12,106	171	587	758
FP3	3,840	37,205	41,045	3,678	32,027	35,705	162	5,178	5,340
FP4	2,387	37,515	39,902	2,350	32,807	35,158	37	4,708	4,745
							0	0	0
Strategic Competitive Research grant	0	0	0	0	0	0	0	0	0
CRP Management & Support Cost	1,234	0	1,234	1,119	0	1,119	115	0	115
CRP Total	11,023	95,752	106,775	10,414	82,962	93,377	609	12,789	13,398

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

MAIZE W1&2 History

Mio of USD	Fund	Donor	2011 Financial Plan	2011 Received Funds	2012 Financial Plan	2012 Received Funds	2013 Financial Plan	2013 Received Funds	2014 Financial Plan	2014 Received Funds	2012-2014 Financial Plan	2012-2014 Received 2014	2015 Financial Plan	2015 Received Funds	2016 Financial Plan	2016 Received Funds	Total Phase I Financial Plan	Total Phase I Received Funds
MAIZE (In Advance)	W1																	
MAIZE	W1		4.290	4.290	12.384	12.384	7.991	7.991	10.410	10.410	35.075	35.075	5.360	5.015	4.200	4.204	44.635	44.294
	Total W1		**4.290**	**4.290**	**12.384**	**12.384**	**7.991**	**7.991**	**10.410**	**10.410**	**35.075**	**35.075**	**5.360**	**5.015**	**4.200**	**4.204**	**44.635**	**44.294**
MAIZE	W2	Australia											0.650		0.650	0.607		
MAIZE	W2	UK											5.430		5.430	2.512		
MAIZE	W2	USA											1.260		1.260	1.470		
MAIZE	W2	SA	2.802	1.795	2.153	3.071	6.025	6.114	3.790	3.790	14.770	14.770	0.060	7.745	0.060		29.570	27.369
MAIZE	W2	China														0.020		
MAIZE	W2	Mexico														0.245		
MAIZE	W2	...																
	Total W2		**2.802**	**1.795**	**2.153**	**3.071**	**6.025**	**6.114**	**3.790**	**3.790**	**14.770**	**14.770**	**7.400**	**7.745**	**7.400**	**4.853**	**29.570**	**27.369**
	Total MAIZE		**7.092**	**6.085**	**14.537**	**15.455**	**14.016**	**14.105**	**14.200**	**14.200**	**49.845**	**49.845**	**12.760**	**12.760**	**11.600**	**9.058**	**74.205**	**71.663**
Dif. Vs Funds Received			***(1.007)***		***0.918***		***0.089***		-				-		***(2.542)***		***(2.542)***	

2017 W1 Donors

Million USD	Received & confirmed, 2017	%	CIMMYT		Total
			MAIZE	WHEAT	Total
Australia	4.15	4.11	0.282	0.292	0.574
Belgium	0.14	0.14	0.010	0.010	0.019
Canada	7.43	7.37	0.506	0.523	1.028
France	1.42	1.41	0.097	0.100	0.197
India	0.80	0.79	0.054	0.056	0.111
Japan	0.58	0.58	0.039	0.041	0.080
Korea	0.27	0.27	0.018	0.019	0.037
Netherlands	4.65	4.61	0.316	0.327	0.644
New Zealand	3.97	3.94	0.270	0.279	0.549
Norway	12.78	12.67	0.870	0.899	1.769
Sweden	22.44	22.25	1.527	1.579	3.106
Switzerland	8.57	8.50	0.583	0.603	1.186
UK	3.66	3.63	0.249	0.257	0.507
World Bank	30.00	29.74	2.041	2.111	4.152
Total	**100.86**	**100.00**	**6.863**	**7.096**	**13.959**

Gender Expenditure (W 1& 2)

Summary Report - by Flagships or Modules

		2017 Gender Expenses
MAIZE-FP1	FP1-Enhancing Maize's R4D Strategy for impact	4,945
MAIZE-FP2	FP2-Novel Diversity and Tools for increasing Genetic Gains	5,494
MAIZE-FP3	FP3-Stress Tolerance and Nutritious Maize	10,317
MAIZE-FP4	FP4-Sustainable Intensification of Maize- Systems for better livelihoods of SH	12,960
	Strategic Competitive Research grant	-
	Management and Support Cost	122
	Net	**33,838**

Participating Centers

CIMMYT

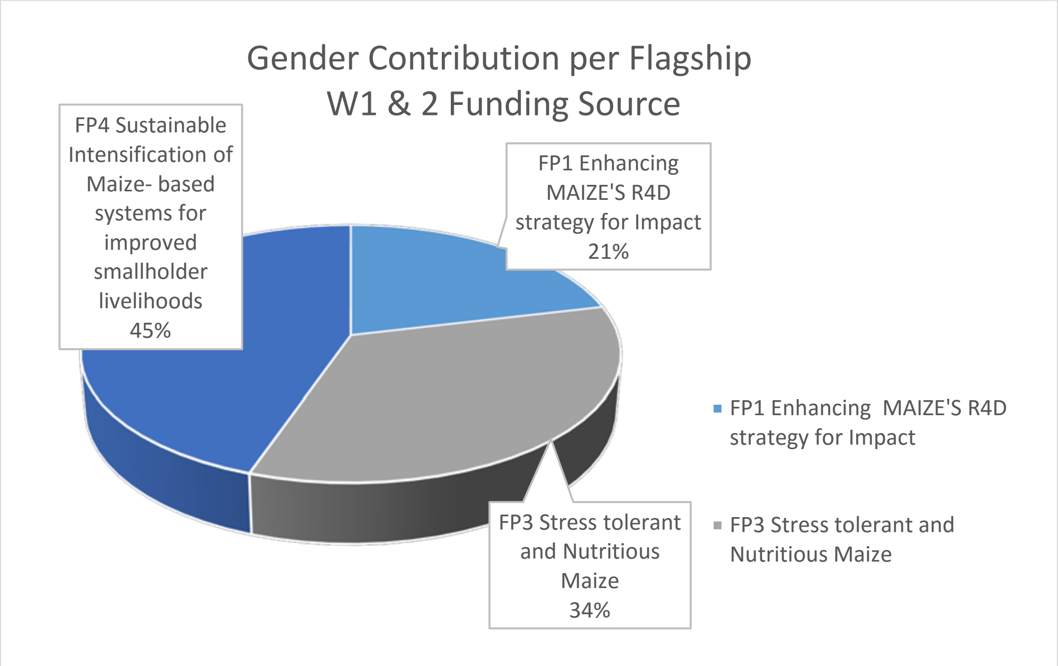
		2017 Gender Expenses
MAIZE-FP1	FP1-Enhancing Maize's R4D Strategy for impact	1,173
MAIZE-FP2	FP2-Novel Diversity and Tools for increasing Genetic Gains	465
MAIZE-FP3	FP3-Stress Tolerance and Nutritious Maize	3,612
MAIZE-FP4	FP4-Sustainable Intensification of Maize- Systems for better livelihoods of SH	3,218
	Strategic Competitive Research grant	-
	Management and Support Cost	-
	Net	**7,295**

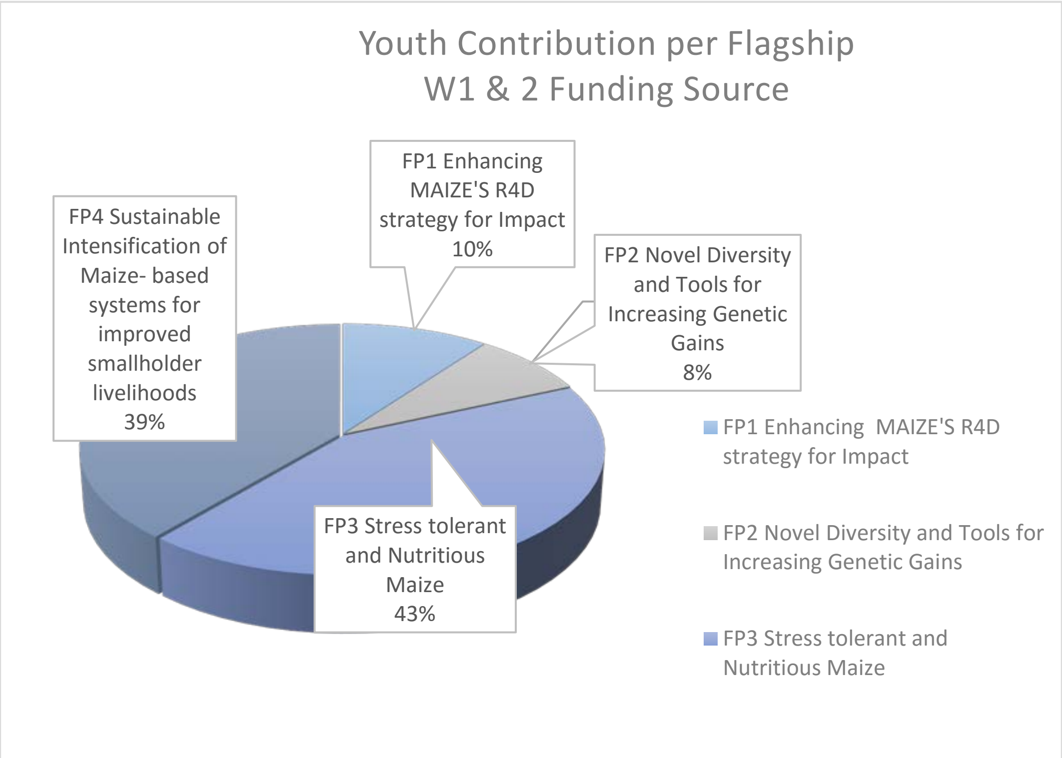
IITA

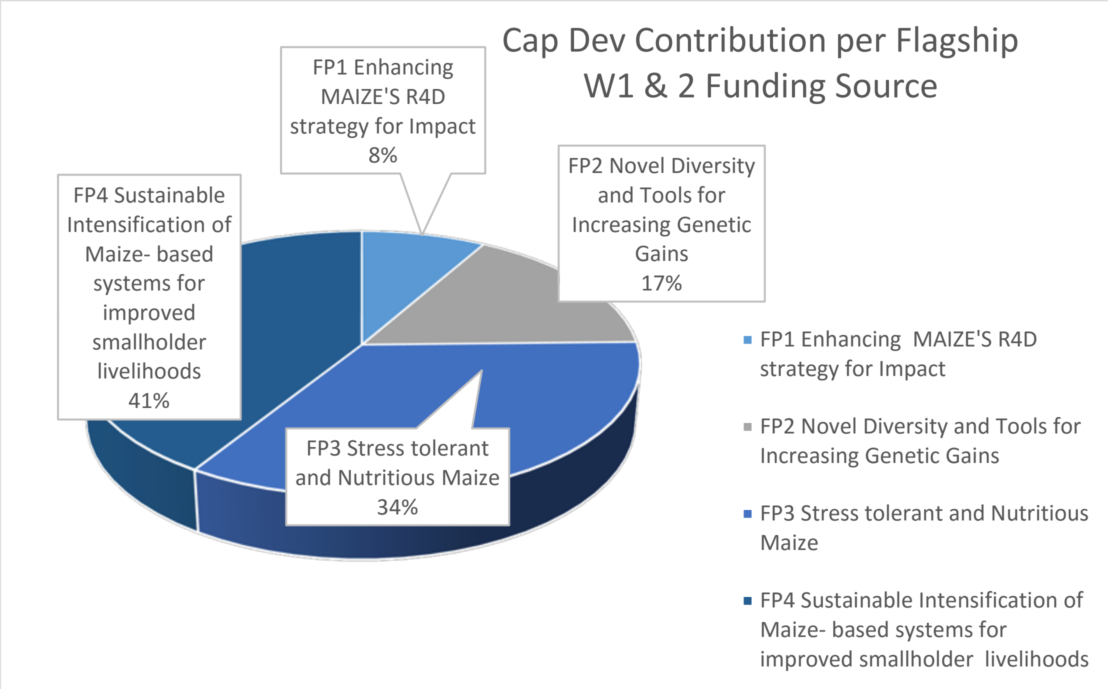
		2017 Gender Expenses
MAIZE-FP1	FP1-Enhancing Maize's R4D Strategy for impact	3,772
MAIZE-FP2	FP2-Novel Diversity and Tools for increasing Genetic Gains	5,029
MAIZE-FP3	FP3-Stress Tolerance and Nutritious Maize	6,705
MAIZE-FP4	FP4-Sustainable Intensification of Maize- Systems for better livelihoods of SH	9,742
	Strategic Competitive Research grant	
	Management and Support Cost	122
	Net	**21,598**

Annexes 1 & 2

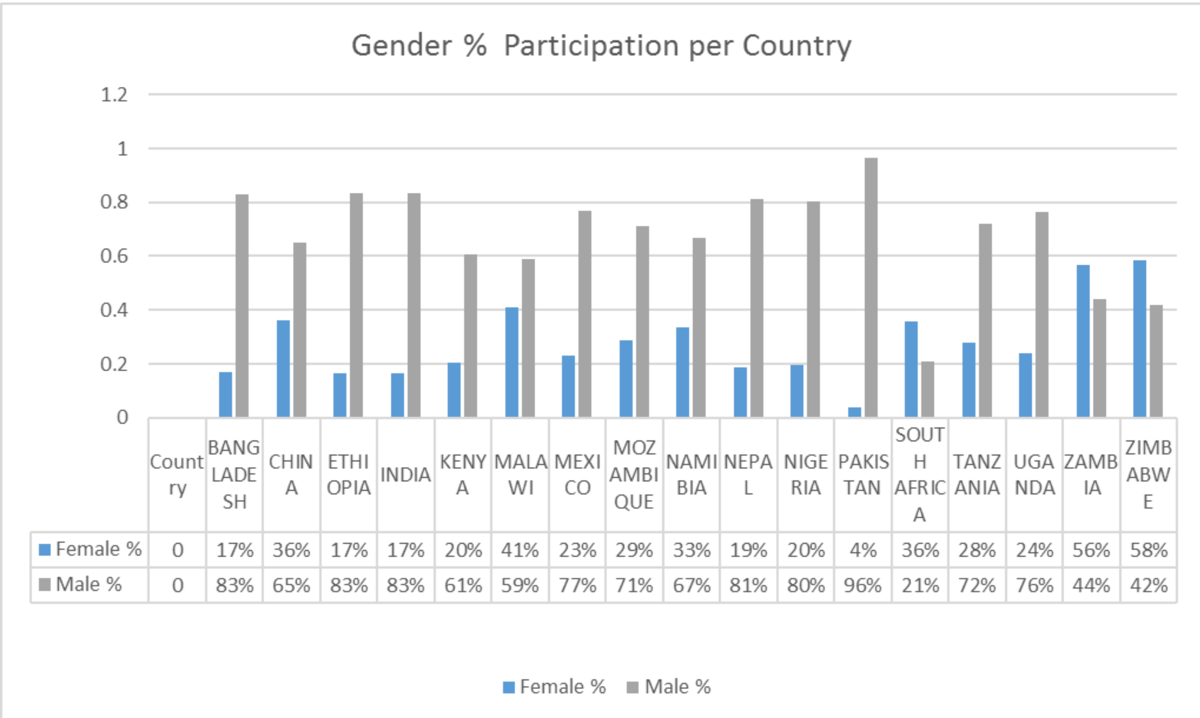
Annex 1: Flagship Project Contributions per Cross cutting topics (W1&2)



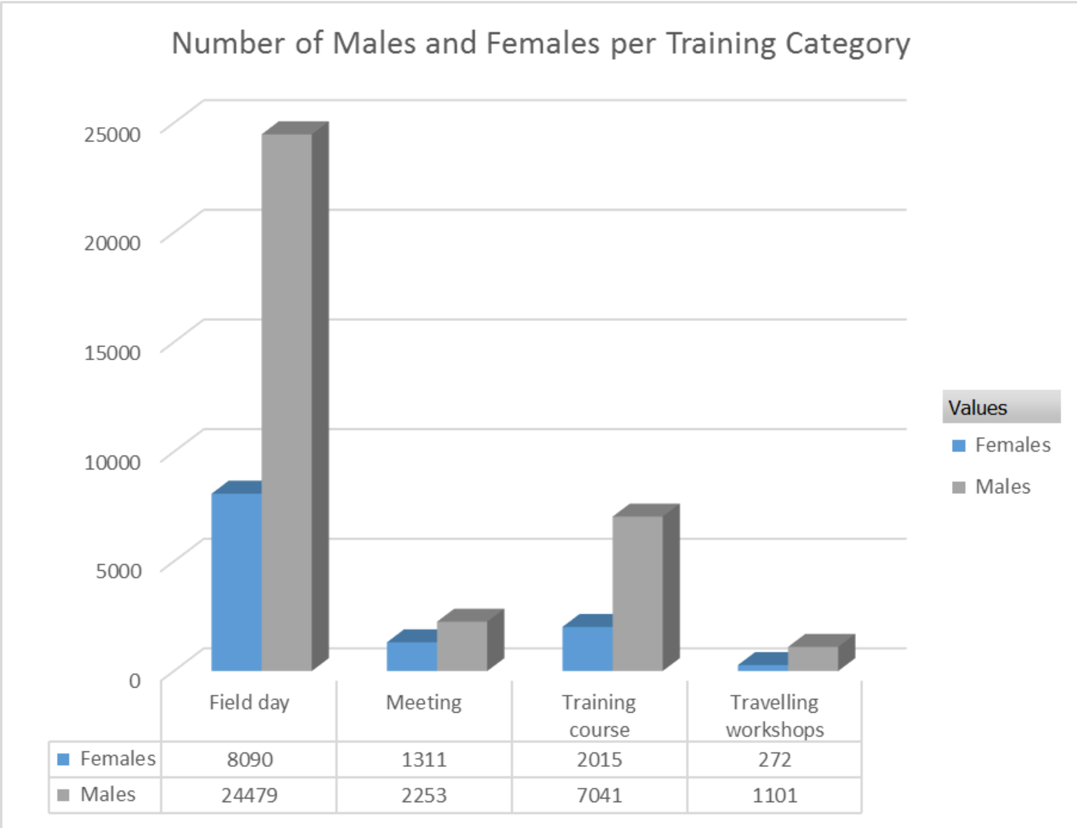


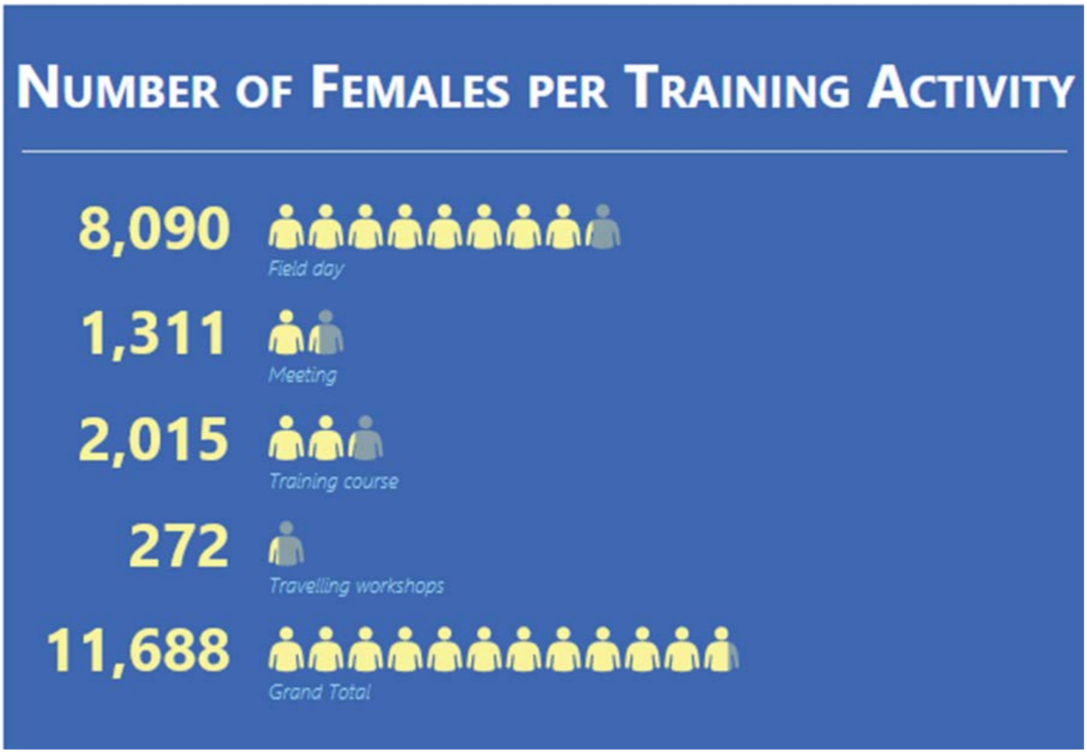


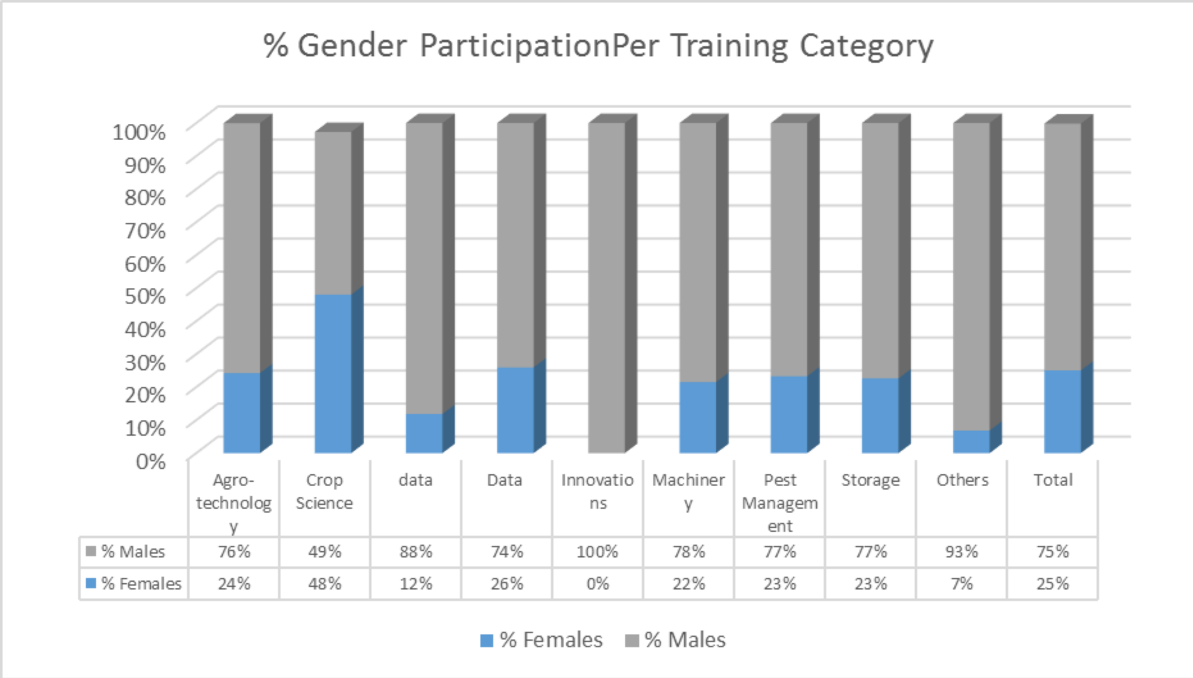
Annex 2: Training Figures and Graphs

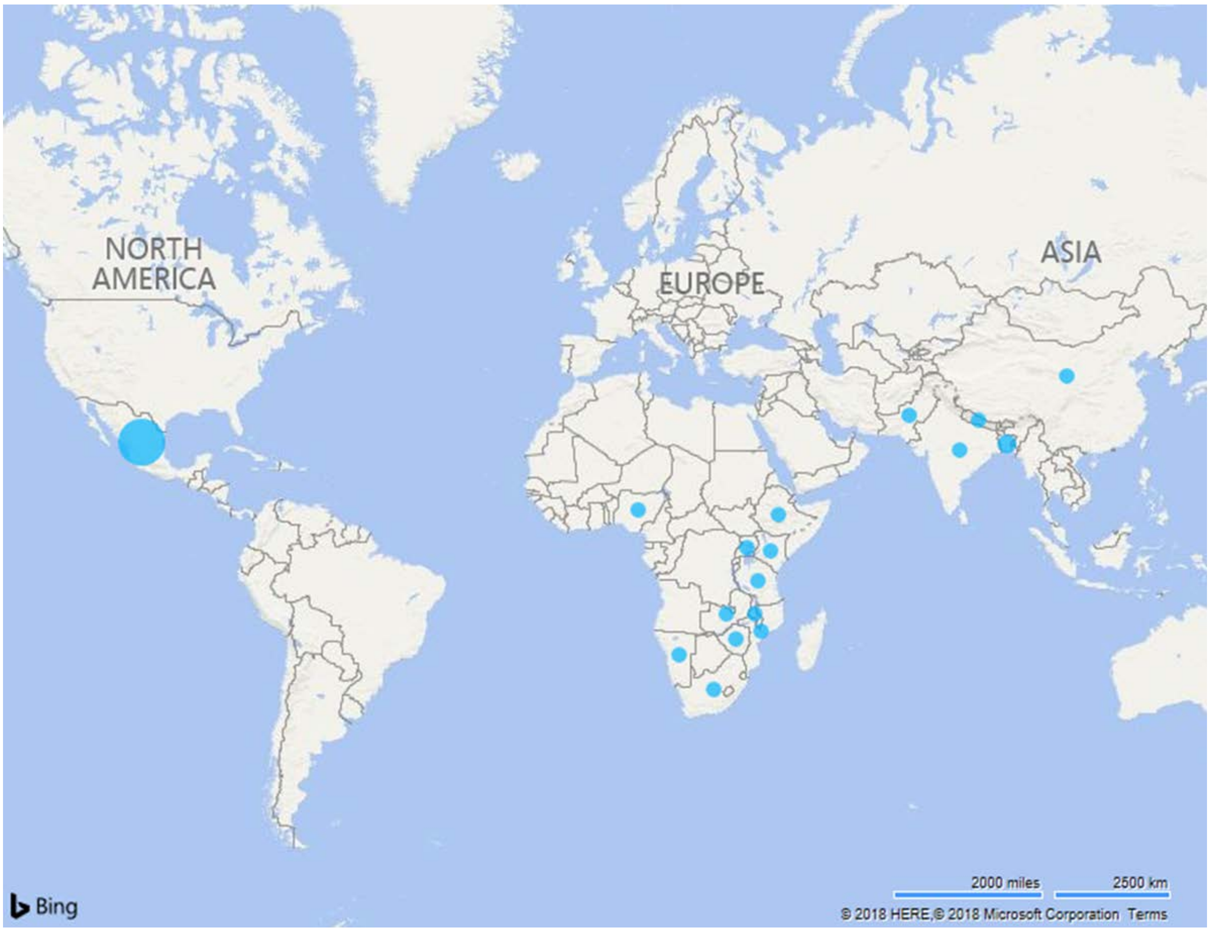


	Country	BANGLADESH	CHINA	ETHIOPIA	INDIA	KENYA	MALAWI	MEXICO	MOZAMBIQUE	NAMIBIA	NEPAL	NIGERIA	PAKISTAN	SOUTH AFRICA	TANZANIA	UGANDA	ZAMBIA	ZIMBABWE
Female %	0	17%	36%	17%	17%	20%	41%	23%	29%	33%	19%	20%	4%	36%	28%	24%	56%	58%
Male %	0	83%	65%	83%	83%	61%	59%	77%	71%	67%	81%	80%	96%	21%	72%	76%	44%	42%


Number of Males and Females per Training Category
25000
20000
15000
10000
5000
0
Values
Females
Males
Field day
Meeting
Training course
Travelling workshops
Females 8090 1311 2015 272
Males 24479 2253 7041 1101

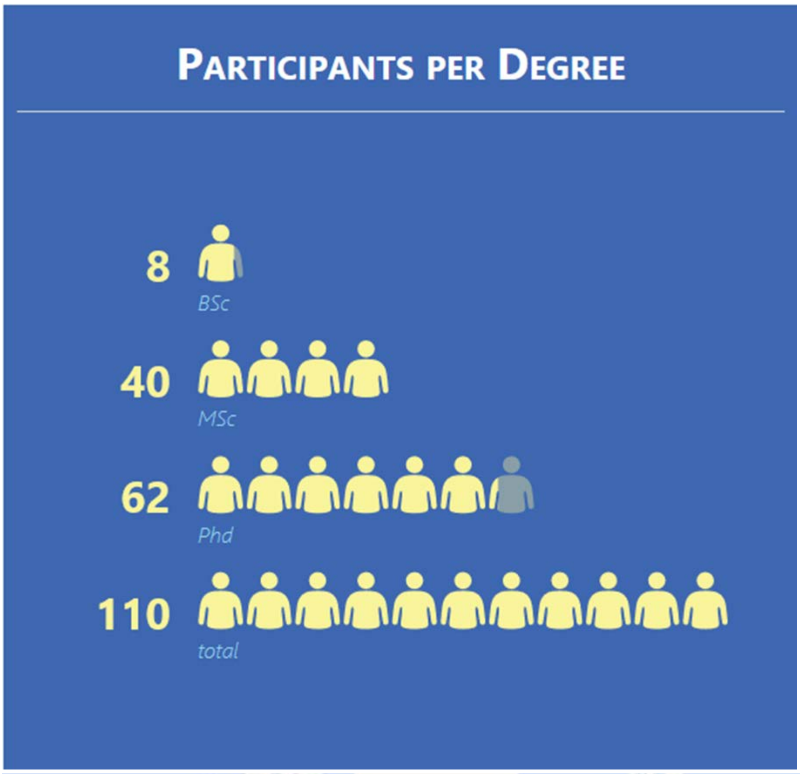

Number of Females per Training Activity
8,090
Field day
1,311
Meeting
2,015
Training course
272
Travelling workshops
11,688
Grand Total





MAIZE provided training in 17 countries: Bangladesh, China, Ethiopia, India, Kenya, Malawi, Mexico, Mozambique, Namibia, Nepal, Nigeria, Pakistan, South Africa, Tanzania, Uganda, Zambia and Zimbabwe.

Annex 3: MAIZE- funded Students



Maize Supported Scholars in 26 Countries around the globe: Australia, Bangladesh, Belgium, Brazil, Canada, China, Colombia, Ethiopia, Germany, India, Italy, Japan, Kenya, Mexico, Nepal, Netherlands, Nicaragua, Nigeria, Pakistan, Rwanda, South Sudan, Tanzania, UK, Uruguay, USA, Zimbabwe

RESEARCH PROGRAM ON Maize

CGIAR

MAIZE is an alliance of more than 300 research and development partners worldwide.