Evaluation of the CGIAR Research Program on MAIZE

Volume 1 – Evaluation Report

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ACRONYMS

AATF	African Agricultural Technology Foundation
ACIAR	Australian Centre for International Agricultural Research
ARI	Agricultural Research Institute
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BMGF	Bill and Melinda Gates Foundation
BoT	Board of Trustees
CAP	Conservation Agriculture Program (CIMMYT)
CD	Capacity Development
CGBO	CGIAR Genomics Back Office, led by Cornell University
CGI	Competitive Grants Initiative
CO	Consortium Office (CO)
CoA	Clusters of Activities (CGIAR)
CRP	CGIAR Research Program
CIDA	Canadian International Development Agency
CIMMYT	International Maize and Wheat Improvement Center (Mexico/Global)
CML	CIMMYT maize lines
CSISA	Cereal Systems Inititiative for South Asia
CTD	Control Trial Data
DH	Doubled Haploid
DTMA	Drought Tolerant Maize for Africa
EC	European Commission
EIAC	Evaluation and Impact Assessment Committee (CGIAR)
EPMR	External Program and Management Review (CGIAR)
ESA	Eastern and Southern Africa
FACASI	Farm Mechanisation and Conservation Agriculture for Sustainable Intensification
FAO	*Food and Agriculture Organization* of the United Nations
FC	Fund Council
FP	Flagship Project (CGIAR)
FUT	Federal University of Technology - Nigeria
FWCI	Field-weighted Citation Impact
GCP	Generation Challenge Program
G&M	Governance and Management
GMO	genetically modified organism
GMP	Global Maize Program (CIMMYT)
GRP	Genetic Resources Program (CIMMYT)
GS	Genomic Selection
HR	Human Respources
HTMA	Heat Stress Tolerant Maize for Asia
ICIPE	*International Centre of Insect Physiology and Ecology*
ICT	Informations and Communications Technology
IDO	Intermediate Development Outcome
IEA	Independent Evaluation Arrangement (CGIAR, Rome)
IFAD	International Fund for Agricultural Development
IITA	International Institute of Tropical Agriculture

IMAS	Improved Maize for African Soils
IMIC - Asia	International Maize Improvement Consortium for Asia
INIFAP	Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (Mexico)
IP	Intellectual property
IPG	international public good
IRRI	International Rice Research Institute
IRS	Internationally Recruited Staff
ISMA	Integrated Striga Management in Africa Project
ISPC	Independent Science and Partnership Council (CGIAR)
KALRO	Kenya Agricultural & Livestock Research Organisation
KIT	Royal Tropical Institute
KPI	Key Performance Indicator
M-StAC	MAIZE Stakeholder Advisory Committee
MAB	Marker-Assisted Breeding
MAIZE	CGIAR Research Program on Maize
MC	Management Committee (MAIZE)
M&E	Monitoring and evaluation
MLN	Maize Lethal Necrosis
NARS	National agricultural research systems
NGO	Non-governmental organization (general)
PIA	Program Implementation Agreement
PMU	Program Management Unit (MAIZE at CIMMYT)
PPA	Program Participant Agreement
QofS	Quality of Science
QPM	Quality Protein Maize
QTL	Quantitative trait loci
R4D	Research and Development
RMS	Research management system
RS	Research Strategy
SAGARPA	Secretariat of Agriculture, Livestock, Rural Development, Fisheries and Food (Mexico)
SARD-SC	Support to Agricultural Research for Development of Strategic Crops in Africa
SDC	Swiss Agency for Development and Cooperation
SFSA	Syngenta Foundation For Sustainable Agriculture
SI	Strategic Initiative
SIMLESA	Sustainable Intensification of Maize-Legume Systems for Food Security in Eastern and Southern Africa
SIMLEZA	Sustainable Intensification of Maize-Legume Systems for the Eastern Province of Zambia
SMTA	Standard material transfer agreement
SRF	Strategy and Results Framework (CGIAR)
SLO	System-Level Outcome (CGIAR)
SSA	Sub-Saharan Africa
StAC	Stakeholder Advisory Committee (MAIZE)
ToR	Terms of Reference
USAID	United States Agency for International Development
USD	US dollar

WEMA	Water Efficient Maize for Africa
W1	Window 1 funding type (CGIAR)
W2	Window 2 funding type (CGIAR)
W3	Window 3 funding type (CGIAR)

Executive Summary

Background and context

Maize is one of the most important crops for poor producers and consumers in the developing world, providing at least 30 percent of the calories for nearly 5 billion people in 94 developing countries. It is estimated that over the next 35 years the demand for maize in the developing world will double.

The CGIAR Research program (CRP) on maize (MAIZE) represents a collaborative effort between the two CGIAR Centers engaged in maize research, CIMMYT and IITA, together with about 350 public and private sector partners worldwide. The aim of MAIZE is to implement a new strategy for international maize research, designed to ensure that publicly-funded international agricultural research contributes to stabilization of maize prices and doubles productivity of maize-based farming systems, making them more resilient and sustainable. This will significantly increase farmer income and livelihood opportunities, without the requirement for more land, and will take account of changes in climate and increasing costs of fertilizer, water and labour.

MAIZE is led by CIMMYT and it brings together the research activities of CIMMYT and IITA. MAIZE outputs contribute to all the CGIAR System Level Outcomes. MAIZE was initially approved for a three-year period and operations began in mid-2011. Following a 6-month extension until the end of 2014, to synchronize the funding cycle for all CRPs, MAIZE was approved an extension phase for 2015–2016.

During the course of the evaluation the structure of MAIZE changed and the original nine Strategic Initiatives became five Flagship Projects (FP). In the 2015–2016 Extension Proposal MAIZE presented a streamlined structure in line with instructions from the Consortium Office (CO) and further developed its impact pathways and Theories of Change (ToC). The current structure comprises five FPs that contribute to three Research Strategies: Sustainable intensification of maize-based cropping systems, Stress resilient and nutritious maize, and Inclusive and profitable maize futures.

Purpose, scope and objectives of the evaluation

The primary purpose of the evaluation of MAIZE was to enhance the contribution the CRP is likely to make towards reaching the CGIAR goals, reducing poverty and improving food security for people whose livelihoods depend on maize and maize-based farming systems. The audiences for the evaluation are the CGIAR Fund Council and the Consortium, CIMMYT and IITA Boards of Trustees (BoT) and the centers' management, the MAIZE management committee, stakeholder committees, funding agencies and staff of MAIZE and its partner organizations.

The evaluation includes both summative and formative aspects. The summative part encompassing an assessment of research outcomes, primarily from pre-CRP research and outputs from current research and the period leading to MAIZE. The formative aspects focus on current research and evolution of MAIZE over the past four years from the perspective of program design and governance and management arrangements. Furthermore, the Evaluation looked at the extent to which current research is influenced by feedback from impacts derived from pre-CRP research. The evaluation also

addressed three cross-cutting issues as part of programmatic performance: gender, capacity development and partnerships.

The Evaluation Team developed evaluation questions at two levels: overarching questions and questions in connection with the key evaluation criteria of relevance, quality of science, efficiency, effectiveness, impact and sustainability. Programmatic and organizational aspects of MAIZE were considered as distinct entities for defining the criteria-specific evaluation questions.

The evaluation addressed five overarching questions related to CGIAR reform principles and MAIZE in the new CGIAR structure:

1. Is MAIZE evolving in such a way as to demonstrate added value of maize research and maize-based systems in comparison with research done by CIMMYT and IITA previously?
2. Is MAIZE priority-setting effective in terms of program coherence and focus of research on intended objectives, given the relatively small proportion of unrestricted (W1/2) funding and the historic mandates of CIMMYT and IITA?
3. Is MAIZE able to aid design and shaping of future partnerships to develop a sustainable research project portfolio?
4. Is MAIZE managing well the very high and increasing level of restricted funding in terms of program quality and effectiveness (including attracting and retaining high quality staff), sustainability and administrative load?
5. Are the impact pathways in the MAIZE structure sufficiently defined regarding target beneficiary groups, and are they clearly formulated and used in program monitoring and management?

Questions for the evaluation of governance and management focused on legitimacy, accountability, transparency, conflicts of interest and efficiency, and aspects of program management, including effectiveness, financial management, resource mobilization, monitoring and reporting, collaboration, risk management, and management of intellectual property (IP). Moreover, the evaluation explored the effects of CGIAR reform on the efficiency and likely success of program implementation.

Approach and methodology

The Team based its findings, conclusions and recommendations on data collection and analysis from several sources:

- review of program documents
- review of previous evaluations and assessments
- sampling of 28 MAIZE projects
- more than 100 interviews with MAIZE, CIMMYT and IITA, staff, partners, donors and stakeholders
- field visits to Mexico, Kenya, Ethiopia, Ghana and Nepal
- attendance of CIMMYT BoT and MAIZE stakeholders meetings in Beijing
- a survey among MAIZE research staff

- bibliometric analysis of MAIZE publications
- in-depth analysis of 22 publications
- H-index analyses of 28 researchers
- impact narrative prepared by MAIZE

A Discovery to Deployment framework was used to classify project components and make recommendations for upstream and downstream activities, incorporating those for FPs. The evaluation took place when MAIZE had been operational for three years and consequently many research results and impacts were attributed, at least in part, to pre-CRP research done at CIMMYT and IITA.

Main findings and conclusions

Overall, the Evaluation Team concludes that MAIZE is progressing well and it represents a promising program that is already delivering results. The program is on track in reaching most of its near-term milestones and targets and is working well towards achieving its goals, particularly those concerning productivity improvement. MAIZE adds value compared with the previous center-based approach to crop research, and warrants continuation beyond the 2015-2016 extension phase. CIMMYT and IITA work well together and can now move towards further integration, resulting in a single maize program, headed by a CRP Director.

For the most part MAIZE is a coherent program with a strong comparative advantage in the global setting, largely care of the unique genetic resources held in trust by the two centers, the long established partnerships of CIMMYT and IITA and their presence in and agreements with countries hosting research in the developing regions targeted. However, MAIZE should continue to assess its role and priorities in the light of changes in the private sector and NARS involvement and interest. The quality of MAIZE science is good, even excellent in some areas, but greater efforts are needed in mentoring newly recruited staff. The program's effectiveness can be further improved through development of protocols for research operations and delivery, and by establishing a more pro-active research and monitoring capacity for projecting emerging issues in maize diseases and environmental characterization. Links with other CRPs need to be strengthened, particularly regarding agronomy.

MAIZE comprises a broad range of partnerships that are mostly appropriate and strong, and NARS are appreciative of the collaborations. Efforts in capacity development have been productive.

Adoption of improved maize varieties as a result of past CIMMYT and IITA breeding and partnerships is widespread. Impact assessment is conducted to document delivery and dissemination of MAIZE products, although some strategic impact assessment issues still need to be addressed.

Governance and management arrangements of MAIZE have generally been appropriate, and the Team considers the on-going improvements, including further integration between CIMMYT and IITA, to be positive. Good progress has also been made in implementing a gender strategy, but some issues still require attention at the program and management level.

Overall, MAIZE is a strong program that is addressing appropriate research issues for meeting the challenges to increasing maize productivity and maize systems' sustainability, and it continues to contribute substantially to the goals of the CGIAR.

Relevance

MAIZE is largely a coherent program, which because of the unique genetic resources at its disposal, its excellent research facilities, its considerable breeding capacity and its partnerships and global mandate, has a strong comparative advantage that is consistent with its goals, SLOs and the SRF of the CGIAR. MAIZE has a clear comparative advantage in supplying improved germplasm at different stages of advancement for the needs of smallholder farmers both in stress-prone and in market-oriented environments. MAIZE also leads in long-term field experimentation, evaluating conservation agriculture, and in organizing regional breeding networks, and it has unique experience in agroecological zones that are of high priority for the CGIAR. Furthermore, MAIZE benefits from and contributes to the global reputation and strong credibility of the CGIAR among policy makers and the scientific community. The ability of MAIZE to mobilize efforts for strategic research, technology design and mechanisms for delivery of outputs further adds to the strength and comparative advantage of MAIZE.

The rationale for the five FPs and the Research Strategies on Sustainable intensification and Stress resilient and nutritious maize is realistic and practical. Coherence could be further strengthened by improving the impact pathways for FPs, particularly concerning their inter-linkages and the assumptions that relate to the doubling of productivity in the target regions. Incorporating social science with other research activities in a cross-cutting manner, rather than packaging it with post-harvest research in FP5 (in the research strategy of Inclusive and profitable maize futures), would improve the CRP's strategic orientation and ensure continuing relevance. There is specific need to integrate socio-economic research with germplasm improvement and agronomy.

MAIZE has received a relatively low level of W1/2 funding and a high share of bilateral funding. In operational plans and realization of projects and partners, MAIZE has targeted W1/W2 funds internally and via competitive partner grants, and the Team considers that this has helped increase program coherence. Some of the bilateral funding includes a strong delivery component for which the CGIAR centers may not have a comparative advantage.

The Team considers that priority-setting has generally been effective, and MAIZE has been able to focus its research on program objectives. However, MAIZE may need to review its priorities in FP4 and FP5, regarding evolution of its comparative advantage in view of developments in the private sector and NARS. While not leading certain activities, MAIZE has a clear catalytic role to play in engaging private, public and civil society organizations to develop (in case of hybrids) and deliver improved maize germplasm. The private sector is important in supplying seed of improved maize varieties, and in developing market-ready parental lines and hybrids but mostly not for the geographic areas and for the groups that MAIZE targets. However, the situation is changing rapidly, particularly in irrigated areas of Asia, and mid-altitude higher-yielding areas of southern and eastern Africa. MAIZE needs to keep abreast of such developments.

In some geographic areas, MAIZE should reconsider its role in deploying finished hybrid products. The strategic leadership of MAIZE is strongest in maize breeding and agronomy in developing international public goods and responding to the needs of users, particularly for the MAIZE target areas, farming systems and smallholder farmers. As mentioned before, social science responds to a cross-cutting need and could strengthen priority setting and coherence in each of the RSs.

Regarding the CIMMYT- and IITA-led aspects of MAIZE, scientific leadership in both centers has mapped out realistic and relevant research strategies, but these will change over time and must be kept up-to-date. These processes should lead to closure, redesign or shifting of allocations as research matures or priorities change. This is a key aspect of coherence and program design that should drive MAIZE priority setting and ensure resources match with priorities.

MAIZE impact pathways are generally well-defined, but more attention should be given to outputs that contribute to more than a single IDO and where there are strong inter-linkages among FPs. The specific requirements of poor consumers and the market outlook of the different uses of maize merit greater attention than they currently receive. Impact pathway development could be strengthened by carrying out sensitivity analysis and visioning exercises that address the underlying assumptions. Thus the TOCs that underpin the impact pathways need to be used in a dynamic way for research planning and monitoring. This will improve the capacity of MAIZE to respond to challenges in productivity and sustainability of maize systems, including disease outbreaks and swings in markets.

A key aspect of coherence of MAIZE is the potential for enhanced synergy between CIMMYT and IITA scientists and each center's programs. An agreement is under development between CIMMYT and IITA for closer collaboration. The Team supports this effort because it is important to develop a better coordinated and more relevant global research program. The Team considers that the integration of the maize programs of CIMMYT and IITA into a single program with dedicated leadership will increase the efficiency and effectiveness of MAIZE at all levels. On the basis of its findings on coherence, program design and comparative advantage, the Team concludes that MAIZE is highly relevant to the CGIAR.

Quality of science

The quality of MAIZE science ranges from good to excellent. Since the beginning MAIZE has maintained a strong publications record and visibility is respected journals. Research design and approaches are innovative and methodologically mostly up-to-date. Internal processes to assure high science quality appear to be robust. MAIZE has been able to recruit and maintain a cadre of high quality scientists and to develop strong partnerships with advanced research institutes (ARI). These partnerships are designed to ensure that latest scientific thinking is reflected in research projects, research methodology and methods of analysis. Research has been productive in various aspects of generating genetic data and discovery resources, and also in pyramiding genes that control important tolerance traits. MAIZE has also been able to make good progress in research on physiology and in developing tolerance to abiotic and biotic stresses. Modern molecular techniques have also been successfully employed in making maize breeding processes more efficient.

Outputs, staff and processes associated with RS2 are of exceptionally high quality compared with public sector breeding efforts for maize. Facilities are also good. However, while the MAIZE publication

record is commendable, there exist challenges to ensure that the best science is deployed in breeding programs in MAIZE and among partners. There is scope for MAIZE to enhance the quality and efficiency of its breeding processes, for example for leveraging germplasm globally and among projects, by learning from the best practices in the private sector. Furthermore, for example, common protocols and protocol documentation are essential for maintaining science quality in all research strategies.

MAIZE needs to continue to invest in its capabilities in data and information management in all research areas in order to accelerate research feedback, and to comply with CGIAR policies on open-data access. In phenotyping, platforms will need to implement better environmental monitoring and data management. MAIZE should also improve the links of its agronomy research with other CRPs such as that for the humid tropics, to strengthen methodological approaches to research on sustainable intensification.

Effectiveness

MAIZE has made solid efforts to define measurable targets and milestones, which are to be reached to ensure progress toward outcomes and goals. MAIZE reports annually on progress achieved, and overall 80–90% of milestones have been reached. Indicators are still being designed for progress towards and results at IDO level, but since the start of the CRP progress been made and research plans have been refined in the light of experience. Due to funding issues, and occasional overambitious goals, some projects were not initiated as planned. Nevertheless, the Team found evidence, through an assessment of seed production, that MAIZE is on target to reach its goals for productivity improvement.

MAIZE has many large projects that are successfully implemented and have generated useful research results according to the planned schedule. The largest projects related to stress tolerance in maize have a strong focus on deployment of technologies and adoption, increasing their likely effectiveness in out-scaling MAIZE results. For many projects, however, assumptions underlying the TOCs need to be reviewed and adjustments made for enhancing the likely effectiveness. This will require increased and better directed social science input.

Effectiveness was also gauged in terms of the balance among i) people, organization and infrastructure, ii) processes and protocols and iii) the project portfolio. The overall finding was that processes and protocols were not yet adequately adjusted to accommodate the growth in staff numbers and the size of the project portfolio. MAIZE effectiveness can thus be further improved through adoption of common processes and exchange mechanisms between CIMMYT and IITA. These have not yet been fully implemented. The Team considers that MAIZE has to define more clearly processes, protocols and working methods and to document them. This will be key for articulating common understanding across projects, and for standardizing data generation, management and open access practices. Implementation and application of these procedures will require provision of internal training. This is particularly important with regard to the relatively large numbers of newly recruited scientists (numbers have nearly doubled at CIMMYT and IITA in three years), who often require mentoring in order for them to be fully effective in their posts. Such training and standardization of practices would also benefit field staff in remote areas who otherwise may not be

sufficiently linked with HQ operations. It is also important that project implementation be better integrated to the longer-term program objectives for enhancing overall effectiveness.

Capacity development, gender and partnerships

MAIZE has partnerships with many strategically appropriate organizations in the public and private sector, including NARS, seed sector entities, universities and ARIs. These partnerships are mostly effective, ensure state-of-the-art science and research approaches, and facilitate downstream delivery of MAIZE products. The partnerships are complementary, generally well managed and are much appreciated by the stakeholders themselves. The MAIZE research approaches largely reflect good quality thinking and a good understanding of the specific roles of the individual partners.

Major investments have been made by MAIZE in capacity development. Innovation platforms and field days have attracted thousands of farmers and hundreds of national program collaborators have been trained. Over 100 advanced degree scientists have been able to pursue their doctoral research through MAIZE each year. In their feedback to the Team, national programs considered the training efforts to be very useful. Numerous other training courses are promoted through MAIZE.

MAIZE has made efforts to incorporate gender considerations into research design. Progress has been made in generating gender-disaggregated data and in initiating research projects that address gender issues in maize. More work is needed on analyzing the implications of gender for technology adoption and ensuring feedback from analysis to research, conducting strategic gender research for better research prioritization, and developing quality standards for gender analysis. One area that requires attention is recruitment and retention of female scientists who are currently under-represented in MAIZE.

Impact and sustainability

It is too early to assess impact of MAIZE after only three years of operation. The adoption and impact studies undertaken to date provide substantial evidence, however, that adoption of improved varieties resulting from pre-CRP breeding activities has been widespread across the developing world, particularly in many African countries. Much of this achievement in adoption can be attributed to CIMMYT and IITA efforts, but evidence of impact on the higher system level goals has been patchy and generally based on ex ante extrapolations from adoption evidence — sometimes based on limited samples and relying on numerous assumptions. While several adoption and impact studies are available, it seems that results from these studies are not adequately fed back into research design and technology requirement assessments. Furthermore, most adoption studies have focused on the effects of varietal improvement, and evidence is still limited on the effects of sustainable intensification agronomy. MAIZE should invest more resources in ex post impact assessment, and impact pathways should be strengthened through adoption studies. Addressing these shortcomings will require more extensive interdisciplinary efforts because understanding farmer practices and varietal adoption is more complex than merely tracking genetic improvements. Adoption and impact studies should take better account of gender differences as a component of systematic gender mainstreaming.

Governance and management

Governance and management of MAIZE has been satisfactory to date, with the CIMMYT BoT having assumed its responsibilities and delivered acceptable governance and accountability in line with what was promised. The CRP is well managed, with clear reporting lines and transparent decision-making. CIMMYT and IITA provide excellent overall research leadership and have worked well together. MAIZE has been well served by a program manager who has had responsibility over necessary coordination functions. Management of MAIZE is dynamic and the evidence from senior-level meeting minutes and actions is that management is geared towards learning from experiences so that potential weaknesses are recognized and addressed appropriately. The rapid and efficient response to the outbreak of the MLN virus, involving effective resource mobilization, illustrates the responsiveness of MAIZE management.

MAIZE is now moving further towards more complete integration of individual center maize programs and to strengthening research leadership and governance. This integration would be enhanced by the appointment of a MAIZE director with increased authority over program and management matters, reporting directly to the CIMMYT BoT (and the Program Committee of IITA). This would improve mutual accountability, allow more efficient use of resources, introduce common research management systems, stimulate development of more effective monitoring and evaluation procedures, enhance collaboration with other CRPs and provide greater emphasis on common methods and research protocols.

MAIZE has relatively high transaction costs, particularly regarding the heavy reporting duties. Scientists spend a considerable amount of their time attending planning, consultation and evaluation meetings, including for this evaluation. Donor and CGIAR reporting requirements are substantial. The Team considers it important that the time dedicated by scientists to reporting can be reduced through standardizing processes to enable research to be given more attention than is currently possible. Beyond internal MAIZE adjustments, this requires also improved clarity in the CGIAR central requirements.

Added value of MAIZE

After only three years progress in MAIZE is substantial and it is delivering results. Although CIMMYT accounts for 84% of the budget for the largest share of MAIZE projects and IITA for only 16% of the budget, the organization of maize research through a CRP provides added value in comparison with the research done through the individual centers prior to establishing the CRP. The CRP enables maize research to be conducted with a much broader range of partners and the CRP planning framework has been used to develop a largely rationale research structure with target-oriented research activities within strategies and FPs. This program design caters for conducting high priority strategic research and delivery of improved technologies and adapted germplasm. MAIZE has also facilitated mobilization of funding, particularly through bilateral projects. Given the scale of effort, impact potential through CRP is judged by the Team to be on a much bigger scale than would have been possible through individual center work. Collaboration between CIMMYT and IITA has worked well and MAIZE provides an excellent framework through which to integrate their programs further for greater efficiency and effectiveness, to strengthen governance and management functions and to

capture further synergies. The Team concludes that the added value from MAIZE compared with the pre-CRP center-based approach is clear and becoming more evident as MAIZE evolves.

The Team concludes that MAIZE is an effective and efficient program that is oriented towards results and impact. Its success rests on strong partnerships and good quality science. The Team stresses the importance of MAIZE for the poor smallholder farmers and consumers for whom maize is their staple crop. Investments in maize research in the past have had high returns, particularly in terms of adoption of improved maize varieties. MAIZE is currently on target regarding its milestones and on the basis of its observations of MAIZE field operations, partnerships and science quality, the Evaluation Team considers it highly plausible that MAIZE and its partners will reach the medium-term goal, which is to increase maize productivity in the two MAIZE target groups by 7% in 2020 and 33% in 2030. Such increases in productivity would provide sufficient maize grain to meet the annual food demand of an additional 135 million poor consumers in 2020 and of 600 million in 2030. The Team is confident that MAIZE will be able to address future challenges in maize in the developing countries and will contribute substantially to the goals of the CGIAR for poverty alleviation, food security and sustainable management of natural resources.

Recommendations

The Evaluation Team makes a total of 11 recommendations presented below by the main evaluation criteria.

Relevance

Recommendation 1: Given the evolution of the private sector, MAIZE will need to continue to assess its target smallholder groups, ecologies, geographies and commercial seed markets. This assessment should aim at:

- Accurately defining the germplasm products and associated technologies needed – regarding delivery of improved lines, parental lines, hybrids (finished products) and technical issues of maturity, disease and stress tolerance, and grain quality attributes and its unique support of managed stress networks.
- Establishing "rules" to customize and change MAIZE roles and involvement, e.g. default focus should be delivery of regionally-adapted improved lines and expert science/capability development in markers, traits and phenotyping.

Recommendation 2: MAIZE should review its priorities in FPs 4 and 5 where it has less comparative advantage and where smallholders already have a certain access to appropriate technology. This needs to be considered in the light of the large proportion of W3 funding. In particular, MAIZE needs to consider reducing efforts in final product (hybrid) delivery where the private sector is strong. MAIZE should also consider reducing investments in the non-germplasm components of FP5 areas of aflatoxin and postharvest storage research where other agencies have greater comparative advantage.

Recommendation 3: **MAIZE** should establish pro-active research and monitoring capability to provide foresight on emerging issues in diseases and to support environmental characterization.

Quality of Science

Recommendation 4: MAIZE should Improve deployment of new phenotyping technologies into breeding and extend science into trait dissection, plant-based phenotyping and modelling for adaptive traits through engagement with other CRPs and groups of excellence. A study to benchmark research activities in MAIZE with best-practice in private sector should be conducted to identify opportunities for improvement.

Recommendation 5: MAIZE should continue to support the deployment of a broad array of germplasm options and genetic resources and broaden the funding base for discovery and development of high-value trait lines. More focused product design, network trial results and seed market assessments should be used to decide when to withdraw to a "regional role". A study should be commissioned on collaboration models, such as fee-based hybrid consortia, to explore options for funding support toward the development of parental lines.

Effectiveness

Recommendation 6: MAIZE should institute **management** measures to ensure efficiency and effectiveness in management of staff and research activities over the long term. These measures should include:

- processes for engaging and motivating staff in delivery oriented research through mentoring, training, and cross disciplinary and cross-institutional lateral learning;
- protocols for data collection and management;
- streamlined processes for linking exploratory science and research outputs through multiple stages to intermediate products and final products delivered by MAIZE;
- integration of project implementation to program objectives over medium- and long-term through innovation platforms and long-term field trials.

Recommendation 7: MAIZE should improve its links in agronomy research with other CRPs such as Humid Tropics. This would serve development of sustainable intensification indicators and metrics.

Gender, Capacity development and partnerships

Recommendation 8: MAIZE should take action to improve its gender orientation. It should maintain investments in gender/social inclusion and sharpen its focus on gender analysis at project level. MAIZE should take measures to enhance the employment of women scientists at all levels by improving recruitment, and by developing an enabling environment to attract and retain women scientists.

Impact and sustainability

Recommendation 9: MAIZE should develop a strategy for impact assessment that sets clear priorities for focusing such assessments, provides an analytical framework and elaborates on the use of impact pathways in planning and documenting scaling up of results and impact.

Recommendation 10: MAIZE should **enhance** the conduct and use of impact assessment. The steps to be taken include:

- Adequate resources are allocated in major project proposals to enable ex-post impact assessment at the end of project support and strengthen feedback to MAIZE for portfolio development.
- Proactive planning is done to ensure that results from adoption and impact studies feedback to specification of desired technology characteristics in project design.
- More systematic studies are conducted on the impact of gender on technology adoption and its implication for technology design.

Way forward

Recommendation 11: CIMMYT and IITA should agree on the establishment of a single global maize program in the CGIAR that integrates efforts of the two centers. This MAIZE program should be led by a director.

1. Introduction

1.1 Purpose and audience

The primary purpose of this evaluation of the MAIZE CRP is to enhance the contribution that MAIZE is likely to make towards reaching the CGIAR goals on poverty reduction, improving food security, nutrition, and health and enhancing sustainable management of natural resources. The evaluation provides essential evaluative information to MAIZE management, funding agencies and partners on issues including MAIZE extension, expansion and adjustments of content.

In November 2013, the Fund Council of the CGIAR agreed that all current CRPs should undergo an evaluation before decisions are made on the second cycle of CRP funding. The MAIZE evaluation has been completed in time to provide information to MAIZE management and staff at CIMMYT and IITA to help prepare a MAIZE proposal for the second phase. The first round of CRP evaluations, including that for MAIZE, will also contribute to the first system-wide evaluation on the CGIAR reform.

The audience for the evaluation includes the staff and management of MAIZE, core partners, governing bodies, the Consortium and the Fund Council. The evaluation should also be of interest to the broader partnership involved in MAIZE, including partners involved in research for development (R4D) and delivery of products. The evaluation was carried out according to the Terms of Reference[1] and as outlined in the evaluation Inception Report.[2] The Evaluation Team member biodata are provided in Annex A.

1.2 The evolving CGIAR context

In the course of the CGIAR reform, initiated in 2008, the CGIAR adopted a Strategy and Results Framework (SRF) in 2011. In parallel, the Fund Council approved 15 CRPs, most of which started their operations in 2011-12. In the first three years of the CRP operation, and under the instruction of the Consortium Office (CO), the CRPs have been developing their impact pathways and theories of change (ToC) that link CRP activities and outputs to Intermediate Development Outcomes (IDOs) that are, in turn, linked to the CGIAR's high level goals, the System Level Outcomes (SLOs). The CRPs have begun defining quantitative targets and measurable indicators for progress and for the IDOs. All CRPs have been extended until the end of 2016. A new CRP cycle begins in 2017.

A new SRF has been developed and is at its final stage of approval. The new SRF defines a revised set of SLOs[3] and a results framework that incorporates a new level of sub-IDOs that feed into the IDOs (also a revised set) and link to SLOs. The new SRF will be a guiding document for development of CRPs for the second cycle. The instructions concerning the CRP portfolio, development and approval processes are due at the same time as the SRF is endorsed.

The CRPs are the main organizational mechanism for planning and conducting research in the CGIAR and are built on three core principles: demonstrate a strategic approach to achieving impact on one or more of the SLOs; integrate research across CGIAR core competencies and centers; and engage with stakeholders and develop effective partnerships throughout the R4D process.

[1] http://www.iea.cgiar.org/sites/default/files/WHEAT%20ToR%20FINAL%20Jan%202014.pdf
[2] http://www.iea.cgiar.org/sites/default/files/WHEAT-Inception_Report-Final-OCT-2014.pdf
[3] The three SLOs in the new SRF are: Reduced poverty, improved food and nutrition security for health and improved natural resource systems and ecosystems services. CGIAR Strategy and Results Framework for 2016-2025. February 2015. Draft for final consultation.

The CGIAR reform involves shifting to central annual reporting to the consortium, and applies to all sources of funding (see Box 1 on CGIAR funding). This reporting has not yet replaced the requirements of center reporting to bilateral donors, who often have specific requirements.

Box 1: Major Sources of Funding in the CGIAR System

To maximize coordination and harmonization of funding, donors to CGIAR are strongly encouraged to channel their resources through the CGIAR Fund. Donors to the Fund may designate their contributions to one or more of three funding "windows":

- Contributions to **Window 1** (W1) are the least restricted, leaving to the Fund Council how these funds are allocated to CGIAR Research Programs, used to pay system costs or otherwise applied to achieving the CGIAR mission.
- Contributions to **Window 2** (W2) are designated by Fund donors to specific CGIAR Research Programs.
- Contributions to **Window 3** (W3) are allocated by Fund donors to specific CGIAR Centers.

Participating Centers also mobilize financial resources for specific activities directly from donors as **bilateral funding** and negotiate agreements with their respective donors for the use of these resources.

Source: CGIAR website: http://www.cgiar.org/who-we-are/cgiar-fund/

1.3 Evaluation questions

The Evaluation Team posed evaluation questions at two levels, overarching questions and questions regarding the key evaluation criteria of relevance, quality of science, efficiency, effectiveness, impact and sustainability. Programmatic and organizational aspects of MAIZE were considered as distinct entities for defining the criteria-specific evaluation questions.

The overarching questions were:

- Is MAIZE evolving in such a way as to demonstrate added value of maize research and maize-based systems in comparison with research done by CIMMYT and IITA previously?
- Is MAIZE priority-setting effective in terms of program coherence and focus of research on intended objectives, given the relatively small proportion of unrestricted (W1/2) funding and the historic mandates of CIMMYT and IITA?
- Is MAIZE able to aid design and shaping of future partnerships to develop a sustainable research project portfolio?
- Is MAIZE managing well the very high and increasing level of restricted funding in terms of program quality and effectiveness (including attracting and retaining high quality staff), sustainability and administrative load?
- Are the impact pathways in the MAIZE structure sufficiently defined regarding target beneficiary groups, and are they clearly formulated and used in program monitoring and management?

Regarding the key evaluation criteria, the current MAIZE research was assessed for relevance, quality of science and likely effectiveness though an additional set of questions:

- Relevance: coherence and consistency of MAIZE objectives and CGIAR goals; the rationale for the five Flagship Projects (FPs); the extent to which MAIZE focuses on priority areas; the comparative advantage of MAIZE in delivering international public goods (IPGs) relative to other research and the work of its partners; and program design in terms of targeting appropriate Intermediate Development Outcomes (IDOs) along plausible impact pathways.

- Quality of science: quality of program design and research approaches; internal processes and conditions for assuring science quality, including high quality research staff; and quality of outputs.

- Likely effectiveness: MAIZE progress towards outputs and outcomes along the pathway towards IDOs; using the monitoring system for tracking, learning and adjusting the program; the extent to which constraint analyses are being done to adjust the program and enhance the likelihood of impact, addressing the enabling factors for scaling up; and the logic and validity of theories of change.

The evaluation also covered past impact of research that continues in MAIZE, and the extent to which current research is influenced by feedback from impacts derived from previous research:

- Impact and sustainability: the extent to which outcomes and impacts have been achieved and documented, including their magnitude and distribution of benefits; efforts to document outcome and impact results within the portfolio; and the likelihood of sustaining derived benefits.

The evaluation covered three crosscutting issues addressed as part of programmatic performance: gender, capacity development and partnerships:

- Gender: the extent of incorporating gender analysis results into program design in terms of relevance and effects on women; incorporating gender issues in impact pathways in terms of differential roles and division of benefits between men and women; and progress in implementing the CRP gender strategy, including monitoring.

- Capacity development: the extent to which capacity development is needs based, targets men and women and is implemented in research; the extent to which capacity issues have been considered in impact pathways; and integrating capacity development into research and delivery activities.

- Partnerships: the extent to which partnerships are relevant to achieving program objectives, and maximizing efficiency and mutual benefits.

Questions for the evaluation of governance and management (G&M) addressed legitimacy, accountability, transparency, conflicts of interest and efficiency, and aspects of program management, including effectiveness, financial management, resource mobilization, monitoring and reporting, collaboration, risk management, and management of IP. The evaluation also explored the effects of CGIAR reform on the efficiency and likely success of program implementation, and lessons from changes made to CRP G&M.

The evaluation covered program planning, all research and research related activities of MAIZE, irrespective of funding sources. It also addressed the component of funding presented as "supplementary" in the budgets for 2013–2014. It also covered all W1/2 funded activities in the MAIZE research portfolio. The evaluation assessed the purpose of competitive funding in W1/2 and its contribution to results and engagement of partners. W3 and bilaterally funded projects were covered by sampling.

1.4 Evaluation methodology

The evaluation methodology is described in detail in the inception report, and only the key methodological components are presented here. The evaluation used a combination of qualitative and quantitative methods, which are briefly explained below.

Review of program documents. The main program documents included the original MAIZE proposal from 2011, the extension proposal for 2015–2016, and the annual Program of Work and Budget reports. The team also reviewed material related to the process of approval of MAIZE, including the ISPC commentaries and Fund Council decisions. Specific documents were reviewed for the evaluation of G&M of MAIZE, including the cross-CRP review commissioned by the IEA. The team used several documents related to the CGIAR reform, including the Strategy and Results Framework (SRF; 2011) and the draft revised SRF, working documents related to IDO development, and material related to the second CRP call. The documents reviewed are listed in Annex D.

Sampling of projects. 28 MAIZE projects, including those funded bilaterally and through W1/2 and W3, were reviewed according to a comprehensive assessment guide. The assessment focused on relevance, quality of science, likely effectiveness and crosscutting issues. Projects with a budget under USD 50,000 were excluded from the sample. The projects were selected at random in each FP (listed in Annex F, template provided in Annex H). A standard project assessment template was used to ensure consistency among all team members.

Field visits. The countries visited were chosen on the basis of the extent of activities and partnerships. The field visits were used for collecting additional information on projects sampled, conducting interviews with staff and partners, documenting perceptions at the higher scales of program operation and specifically for looking at partnerships. A team member also attended the MAIZE Stakeholder Advisory Committee (M-StAC) meeting and meeting of the CIMMYT BoT.

Interviews. Semi-structured interviews were conducted during field visits and virtually. A total of 107 persons were interviewed on a confidential basis. The questions addressed activities at the program level and at the sample project level when the interviewees were knowledgeable about the project work. The interviews were used mainly to assess relevance, quality of science, likely effectiveness and the crosscutting issues. Interviews on G&M were conducted separately. Depending on the interviewee, different aspects of program performance were emphasized during the interview. A list of interviewees is given in Annex B.

Researcher survey. The survey was targeted at CIMMYT and IITA researchers who contributed time to MAIZE (total of 294). Some non-CGIAR partners were also included. The response rate was 36% for CIMMYT and 48% for IITA. Only 5% of partner researcher responded. The questions addressed relevance, science management, management for results, research facilities, partnerships, gender and capacity development, and perceptions of the value added by MAIZE. Open-ended questions were also included. A large number of CIMMYT researchers work in WHEAT and MAIZE and were asked to respond to one of the surveys and in open sections highlight differences regarding the other

CRP. The survey was conducted in such a way that confidentiality was assured to respondents. The results of the survey can be found in Annex E.

Bibliometrics. Quantitative and descriptive analyses were conducted for MAIZE scientific journal publications. The parameters included volume, frequency of articles by journal, citation analysis for 2012 and 2013 and publishing affiliations with IITA and CIMMYT. These results were used to assess the volume and impact of scientific publications and the appropriateness of journals considering the designated MAIZE audiences.

Research publications analysis. For analysis of research output quality (a dimension of the quality of science assessment), a qualitative assessment was made of a random sample of research articles (Annex D) covering the complete range of disciplines. The parameters included methodological rigor, research narrative, innovativeness, quality of venue, co-authorship, and fit with MAIZE objectives. Scores were assigned to gauge overall quality (template provided in Annex G).

H-index analysis. H-index analysis included researchers with a team leader or supervisory role – 28 researchers in total (21 from CIMMYT and 7 from IITA). In the analysis the team looked at variance, taking into consideration that a large number of MAIZE researchers focus on plant breeding and publications are a secondary output.

Impact narrative. MAIZE was asked to prepare a narrative on outcomes and impacts, covering the period since the most recent EPMRs for the participating centers. Evidence was requested to support the claims made. The team member responsible for impact reviewed the narrative and evidence for credibility, magnitude of reported impacts and extent of impact studies across specific research areas. This item of analysis contributed directly to answering questions on impact and sustainability.

1.5 Analysis framework

For analyzing some of the evidence for information resulting from the methods and tools explained above, the Evaluation Team used a conceptual tool described below to analyze MAIZE activities.

A Discovery to Deployment (see Figure 1-1) framework (R4D stage plan) was used to classify project components and make recommendations for upstream and downstream activities, incorporating FP activities. The framework is presented as linear, but the process involves feed-back loops. The stages that are particularly related to plant breeding are:

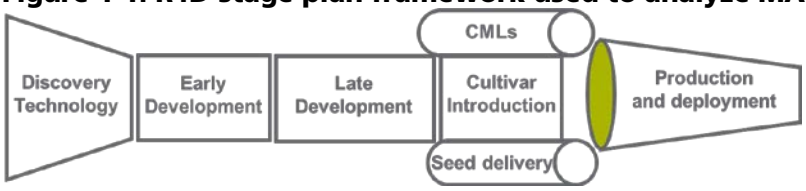
a. Discovery and technology - mostly FP2
b. Early development – FP2, 3
c. Late development – FP3
d. Cultivar/technology introduction, seed systems – FP3, 4
e. Production and deployment – FP1, 3, 4, 5

Several basic technologies underlie the R4D stages that support the breeding process, including phenotyping, environment characterization, nursery and DH technologies, genetic understanding of traits, data analysis and information management.

Production and deployment could be further expanded to consider issues concerning farming system initiatives (FP1), e.g. to consider deployment as a function of seed supply, technology availability and appropriateness, farmer resources and capability, market constraints for supply of inputs and delivery of harvested products. FP5 comprises activities that both prioritize and review performance

of MAIZE and can also be considered to be a design and review process to improve the function of the framework.

Figure 1-1: R4D stage plan framework used to analyze MAIZE activities



Source: Evaluation team.

To function efficiently, the R4D plan needs to include "handover" measures/milestones and definitions of responsibilities for delivery via gateways between consecutive stages. The results of this analysis are reported in Chapter 4 on the quality of science.

1.6 Timeline and organization

The organization and timeline of the review of MAIZE is given in Annex C. The evaluation inception meeting was held at CIMMYT headquarters in Mexico in May 2014. Field visits were made to Ghana, Ethiopia, Kenya and Nepal during September-October. The team shared its preliminary findings with MAIZE Management Committee (M-MC) and the Reference Group set up for the evaluation. A report writing workshop was organized at the IEA office in January, 2015.

1.7 Deviation from inception report

The evaluation did not involve in-depth case studies as planned in the inception report. Instead, the sample project analysis was done in a more comprehensive manner and it involved interviews and field observations in addition to project document review.

The Team intended to conduct qualitative assessment of a total of 40 randomly sample journal articles for assessing quality of science. Due to time pressure only 22 articles were reviewed in the formal format. However, team members also reviewed a number of publications in a more informal way related to the sampled project review, and to specific research areas, and these contributed also to the science quality assessment.

1.8 Limitations to the evaluation

This evaluation took place when MAIZE had been operational for only three years and consequently many research results and impacts were attributable, at least in part, to previous research done at CIMMYT and IITA. Furthermore, during its first years MAIZE had been adjusting according to instructions from the CGIAR Consortium Office and Fund Council relating to reporting, development of targets for outcomes and impact pathways, development of gender strategy, and submission of funding extensions.

During the evaluation MAIZE changed its structure from nine strategic initiatives into five FPs and the portfolio was in transition. The CIMMYT project management system was not fully implemented and had limited functionality for program management, which had implications for data gathering at the portfolio level.

The evaluation benefited considerably from a survey of MAIZE researchers and partners. Response rate was adequate for CIMMYT and IITA staff, but low (only 5 %) for partner researchers. Their views may, therefore, not be adequately represented in issues that were covered by the survey.

The Evaluation Team was unable to visit the maize research programs and IITA headquarters in Nigeria and instead visited maize research activities in Ghana, where it also met with the IITA Management Committee. The MAIZE stakeholder committee meetings, planned to take place in Ghana and Ethiopia, were cancelled and stakeholders were only met in Beijing. This lack of opportunity to meet more formally with stakeholders in Africa may have reduced our capacity for in depth assessment of these partnerships. The Team regrettably was not able to meet with the IITA DG.

Due to the fact that the number of projects was large (approximately 200) and varied greatly in scale and duration, stratified random sampling done within FPs resulted in the selection of a few projects that were not highly representative of the FP.

The evaluation took place at a time when the CGIAR was going through adjustments in its reform, including development of new SRF, responding to a Mid-Term Review and preparing for the second call for CRP funding.

1.9 Structure of the report

The outline of this report for presenting the findings follows the TOR for the evaluation. Chapter 2 gives an overview of MAIZE. Chapter 3 discusses the relevance of MAIZE and its comparative advantages. Chapter 4 analyses the quality of science, including human resources, processes and outputs. Chapter 5 analyses program effectiveness. Chapter 6 addresses issues related to the crosscutting activities of gender, partnerships and capacity development. Chapter 7 reviews the evidence for adoption, impact assessment and sustainability of outcome. Chapter 8 reviews G&M. Finally, Chapter 9 provides a summary of the Team's assessment of the overarching evaluation questions, and main overall conclusions, and presents a vision for the way forward.

2. MAIZE Background

2.1 Maize in the agricultural economy

Maize is one of the most important crops for the poor in developing countries, being produced on nearly 100 million hectares in 125 developing countries. Together with rice and wheat, maize provides at least 30% of the calories of more than 4.5 billion people in 94 developing countries, including 900 million poor consumers for whom maize is the preferred staple and 120–140 million poor farm families. Maize is also increasingly important as animal feed. It is estimated that by 2025 maize will have become the crop with highest production in the developing world. At current levels of productivity it is estimated that harvests will fall short of demand. There is therefore a need to stabilize food prices, accelerate yield growth, increase incomes from more productive, sustainable and resilient maize-based systems, and provide greater opportunities to women and young adults in maize-based agricultural livelihoods and economies. Given the importance of maize, the CGIAR initiated work on maize research at its inception nearly 50 years ago. CIMMYT has had the global mandate for maize research, and IITA a regional mandate for the tropical areas in SSA, particularly in West, Central and southern Africa.

2.2 MAIZE program

2.2.1. Objectives, structure and activities

MAIZE is led by CIMMYT. It brings together the previously separate mandates of CIMMYT and IITA on maize research. MAIZE was approved in 2011 for a 3-year period and operations started in mid-2011. Following a 6-month extension until the end of 2014 to synchronize the funding cycle for all CRPs, MAIZE and other CRPs were approved for an extension phase of 2015–2016. MAIZE builds on the long-term maize-related research at CIMMYT and IITA, and as a CRP was designed for at least ten years duration. It encompasses maize related breeding, resource management and social science research at CIMMYT and IITA.

The MAIZE strategy as outlined in the original proposal4 aims to: “double productivity and significantly increase the incomes and livelihood opportunities from more productive, resilient and sustainable maize-based farming systems on essentially the same land area while contending with climate change and increasing costs of fertilizer, water, and labor.”

MAIZE defines two main target groups in the developing regions:

- Smallholders who live in stress-prone environments and who have poor market access (about 275 million people).
- Market-oriented smallholders in more favorable production areas and with great potential to supply markets but who lack access to appropriate technology (about 367 million people).

Beyond these two target groups, there will be spillover benefits to other farmers in developing countries. The third group of beneficiaries includes poor maize consumers and governments in low and middle-income countries affected by maize price fluctuations.

[4] MAIZE – Global Alliance to improve the food security and the livelihoods of resource-poor in the developing world. Original proposal to the Consortium, 1 June, 2011.

During the first three years of operations MAIZE was structured around a set of nine Strategic Initiatives (SI)[5] covering activities in breeding, maize systems, and socio-economics[6]. In the 2015–2016 extension proposal[7] MAIZE presents a streamlined structure in line with the instructions from the CO requirements and has further developed its impact pathways and Theories of Change (ToC). The current structure consists of five FPs that contribute to three Research Strategies:

- RS1: Sustainable intensification of maize-based cropping systems
- RS2: Stress resilient and nutritious maize
- RS3: Inclusive and profitable maize futures

The third strategy initially related to post-harvest management only, but was expanded with social science research.

Table 2-1: Current MAIZE structure and IDOs

FLAGSHIP	IDO	Former SI
Research Strategy 1: Sustainable intensification of maize-based farming systems		
Flagship 1 – Sustainable intensification and income opportunities for the poor	IDO1: Productivity IDO2: Food security IDO4: Income IDO5: Gender IDO6&7: Capacity to innovate and adapt IDO9: Environment IDO11: Climate	SI 2 and SI 3
Research Strategy 2: Stress resilient and nutritious maize		
Flagship 2 – Novel tools, technologies and traits for improving genetic gains and breeding efficiency	IDO1: Productivity IDO2: Food security IDO3: Nutrition IDO4: Income	SI 4, SI 8, SI 9
Flagship 3 – Stress resilient and nutritious maize	IDO5: Gender IDO9: Environment	SI 4, SI 7
Flagship 4- Aligning with strengthening maize seed systems for effective product delivery	IDO11: Climate	SI 5
Research Strategy 3: Inclusive and profitable maize futures		
Flagship 5 – Inclusive and profitable maize futures	IDO2: Food security IDO4: Income	SI 6 and SI 1

Source: Evaluation Team, based on POWB 2014 and Extension Proposal 2015-2016.

In the extension proposal MAIZE describes the impact pathways for the FPs that target one or more IDOs. MAIZE is still in the process of defining measurable targets for the IDOs. The current program structure is shown in Table 2-1 where the alignment of FPs within RSs to the IDOs is shown and the linkage to the former SIs is indicated.

[5] SI 1 Socioeconomics and policies for maize futures, SI 2 Sustainable intensification and income opportunities for the poor, SI 3 Smallholder precision agriculture, SI 4 Stress tolerant maize for the poorest, SI 5 Towards doubling maize productivity, SI 6 Integrated postharvest management, SI 7 Nutritious maize, SI 8 Seeds of discovery, SI 9 New tools and methods for NARS and SMEs

[6] Initially a crosscutting SI on capacity building was presented, but this was not approved since capacity building is treated as a cross-cutting issue in the CGIAR

[7] MAIZE CRP: Extension Proposal 2015–2016

2.2.2. MAIZE funding

The full funding scenario presented in the MAIZE proposal (2011) was USD 238M over three years. The proposal also included two more conservative scenarios for likely available funding that were about 70% of the full funding. MAIZE was approved with a total budget of USD 170.2M. The Fund Council considered the difference as an "expanded funding component". The approved budget was the basis for the Programme Implementation Agreement (PIA) between the Consortium and CIMMYT. Of the approved budget about 26% was to be funded through W1/2. Table 2-2 shows the actual W1/2 funding over the first three years.

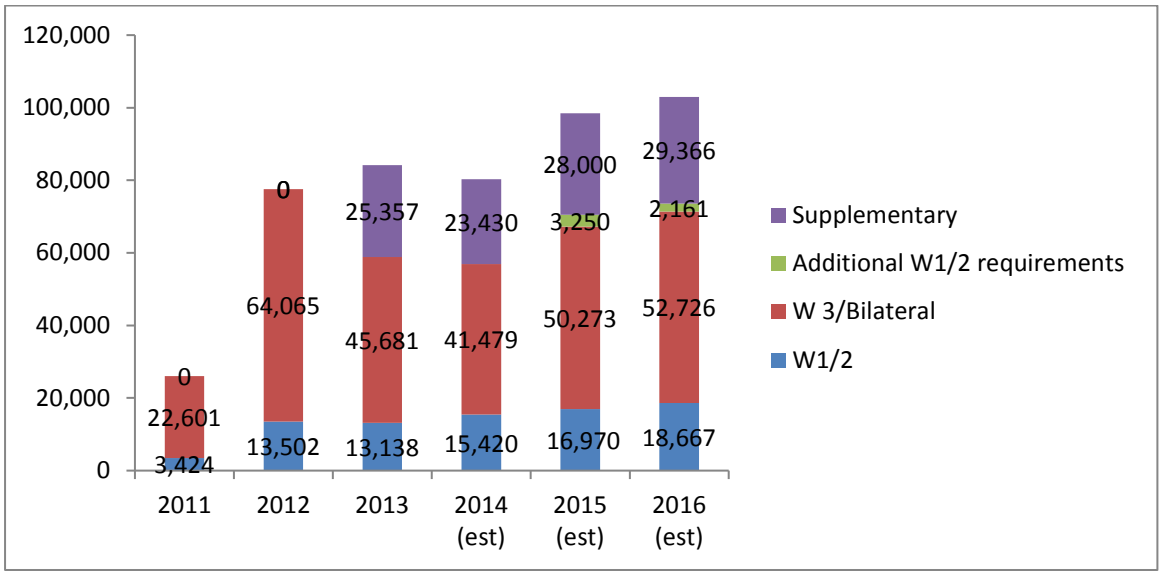
In the 2013 Annual Report MAIZE presented an additional budget for "supplementary" funding that exceeded the budget defined in the PIA. MAIZE considers the "supplementary" funding for activities that are reported separately from the "CRP strategic funding" and support out-scaling and acceleration of results along the impact pathways.

Table 2-2: Actual W1/2 expenses for MAIZE in USD '000 (July 2011 – June 2014).

Item	Expenses 2011	Expenses 2012	Expenses 2013	Budget 2014 6 month	Total Phase I	Percentage 2012 – 2014
CRP Management	493	1,713	1,872	1,124	5,202	14%
CIMMYT	2,225	8,546	6,655	3,832	21,259	56%
IITA	682	1,578	1,520	860	4,640	12%
Partners	24	1,664	3,091	1,894	6,674	18%
Total	3,424	13,502	13,138	7,710	37,774	86%

Source: MAIZE management.

Figure 2-1: MAIZE expenditures (2012, 2013) and budget predictions (2014-2016) in USD '000.



Source: Financial Reports 2012 and 2013, POWB 2014, Extension Proposal 2015-2016.

Figure 2-1 shows MAIZE expenditures for 2012 to 2013, budget estimates for 20148 and for the extension period 2015–2016.

Following CO guidelines, the level of W1/2 funding was initially established on the basis of unrestricted core funding for center research in 2010 and was estimated to grow by 5% annually. W1 complements W2 within these limits, which has restricted incentives for mobilizing this core-type funding in either window. In its first 30 months of operation (mid 2011–2013) MAIZE received the smallest amount of W1/2 funding (19% of total MAIZE expenditures) compared with the other CRPs.

The W1/2 funds are assigned to specific CRP research activities, partners and CRP management. Management costs related to the management unit, ICT and systems, in addition to communications and knowledge management, accounted for USD 1.2 million in 2013. An important use of W1/2 funding is the competitive partner grants that are awarded to institutions on a global basis, including in MAIZE target countries. In addition to 50 ongoing competitive and commissioned grants, MAIZE approved and financed 15 new grants in 2014, which last 1-3 years and range from around USD 20,000 to USD 100,000 per annum.

The CRP Management is covered by W1/2 funding and expenditures (USD 1.8 million in 2012 and 2 million in 2013) include the salaries for staff of the CRP management unit, governance and management meeting costs, travel costs and contributions to ICT systems.

[8] Program of Work and Budget, 2014

2.2.3. Maize Project portfolio

The evaluation used 2013 as a basis for its financial information analysis. In 2013, CIMMYT reported 107 bilateral/W3 funded projects and IITA reported nine bilateral/W3 funded projects.

The current database of projects includes a total of 220 different bilateral and W3 funded projects and W1/2 activities (related W1/2 activities spread over several years were consolidated for the purpose of establishing the project portfolio).9 It includes 22 IITA projects currently mapped to MAIZE. Since the database only refers to total (often multi-year) budgets and since the grant durations vary, comparisons are misleading.

The five FPs shown in Table 2-1 in the current structure of MAIZE have large differences in funding structure and project profile.

- FP1, on sustainable intensification, aims to empower 20 million smallholder farmers (MAIZE Proposal 2011, p.32) and includes large bilateral projects such as CSISA, SIMLESA, MasAgro (including Take it to the Farmer), FACASI and additional post-harvest work.

- FP2, on novel tools, technologies and traits for improving genetic gains and breeding efficiency, includes several activities related to discovery research and breeding platforms and networks (some ongoing work from the Generation Challenge Program).

- FP3 is the largest FP and includes large bilateral projects such as Drought Tolerant Maize for Africa (DTMA), Maize Lethal Necrosis (MLN), Water Efficient Maize for Africa (WEMA), Improved Maize for African Soils (IMAS), and MasAgro Maize.

- FP4 on seed systems and delivery includes a large number of competitive partner grants and several W1/2 funded activities related to capacity building.

- FP5 addresses socio-economic analysis, impact assessments and strategic targeting and evaluation in addition to gender activities and is mostly funded through W1/2. It also includes post-harvest work that is mostly bilaterally funded.

The largest budget was allocated to SSA (around 72% of the total), and covers country-level projects and several regional initiatives. IITA covers West and Central Africa and CIMMYT mostly Eastern and Southern Africa (ESA). Most of the budget in Mexico is allocated to the SAGARPA funded MasAgro project (shared with WHEAT), which accounts for most MAIZE activities in Latin America. In Asia MAIZE has far fewer projects; examples are HTMA, ACIAR-Climate Resilient Systems in Nepal and the CSISA program in Bangladesh, India and Nepal, as well as a hill maize research project in Nepal. About 10% of total funds have global focus.

Some projects also contribute to other CRPs and are not fully accounted for in the project portfolio. For example, outside of MAIZE IITA reports 50% of the large project “Achieving sustainable Striga control for poor farmers in Africa” and 25% of the SARD-SC project. Shares of the CIMMYT projects CSISA and MasAgro “Take it to the farmer” are also reported under WHEAT.

2.2.4. Donors

The largest donors to MAIZE (based on MAIZE Financial Reports) are shown in Table 2-3. BMGF, through various projects, and SAGARPA through MasAgro, are the most important bilateral donors to

[9] Ten of the IITA activities that were initially included have been re-mapped.

MAIZE. The CGIAR Fund contribution via W1/2 is less than either of the two contributions. It has to be noted though that some of the expenditure in 2013 had been reported as supplementary and therefore is not reflected in the 2013 information below.

Table 2-3: Largest donors to MAIZE (funding in USD '000).

DONOR	2012	2013	Comments (main activities)
AATF	1,969	-	Pass through funds from WEMA (in 2013, CIMMYT received funds directly from BMGF for WEMA)
ACIAR	12,416	2,444	SIMLESA and FACASI
AFDB	1,087	1,840	SARD-SC project, which is led by IITA
BMGF	17,543	14,873	CSISA DTMA – Phase III, IMAS, WEMA-Phase II, Achieving sustainable Striga control for poor farmers in Africa, DH maize: A doubled haploid facility for strengthening maize breeding programs in Africa
CIDA	1,645	-	Nutritious maize for Ethiopia
Harvest Plus	1,381	-	Only in 2012, since 2013 it is part of CRP on A4NH
IFAD	2,791	1,548	EC/IFAD CGIAR Programme
SAGARPA	22,678	12,589	MasAGro
SDC	3,876	2,549	Effective Grain Storage for better livelihoods of African Farmers-Phase II, NSIMA - Phase III, HMRP - Phase IV
SFSA	1,487	1,757	Developing maize resistant to stem borer and storage insect pests for ESA - IRMA III Conventional, Affordable, Accessible, Asian (Triple A) drought tolerant maize
USAID	4,224	2,955	CSISA components which are in MAIZE, co-funder of several projects that BMGF funds, also substantial funds to IITA

Source: MAIZE Annual Reports 2012 and 2013.

3. Relevance

3.1. Coherence and program design

This section reviews the strategic coherence of MAIZE and the consistency of program design with MAIZE objectives and the goals of the CGIAR. It also assesses the rationale for the three RSs and the five FPs, and the use of core funding (W1/W2) in key areas of the program. Evaluation of the issues addressed in this chapter was undertaken by the Evaluation Team through a desk review of the MAIZE proposals 2012–2014, the MAIZE extension proposal 2015–2016, and ISPC Commentaries. Sample projects were also evaluated and stakeholder interviews held.

3.1.1 Research strategies

The MAIZE strategy and activities were initially (in 2012) grouped around a set of nine SIs (see section 2.3 on MAIZE structure), which in the 2015-2016 extension proposal have been reorganized into five FPs (see Table 1). This largely represents a consolidation of the nine SIs. The systems oriented SIs (2 and 3) are in FP1 on sustainable intensification. The commodity-specific SIs (4, 5, 7 and 8) were consolidated in FPs 2-4 that focus on yield, stress resilience, nutritional quality, seed systems and delivery. SI1 on socio-economics and 6 on post-harvest management were combined in FP5. The FPs are organized into 21 Clusters of Activities (CoA), each FP being composed of 3-5 CoAs. Compared with the original CRP proposal, there is currently more emphasis on gender and MLN resistance research.

In its 2015–2016 extension proposal MAIZE defined three research strategies that were defined through a theory of change and impact pathway analysis: RS1, Sustainable intensification of maize-based cropping systems, RS2, Stress resilient and nutritious maize and RS3, Inclusive and profitable maize futures. The three strategies encompass the five FPs (as shown in Table 1). The 2015–2016 CRP extension proposal shows the alignment of RSs and FPs with measurable outputs, IDOs and performance indicators. 10 All three RSs contribute to IDOs for food security, income and gender. RS1 and RS2 also contribute to IDOs on productivity, environment and climate change. RS1 contributes to an IDO on capacity to innovate and adapt, and RS2 contributes to an IDO on nutrition. The IDOs are further aligned with the SLOs for productivity, food security, nutrition and health.

RS1 on maize cropping systems and RS2 on maize commodity specific work each require a separate strategy. On the basis of analysis planned of the activities and impact pathways, these strategies are judged to be well-aligned and they combine appropriate FPs and CoAs in the research portfolio. RS3 on maize futures is however a less than optimal mixture of social science analysis (priority setting, impact assessment, gender analysis) and harnessing marketing opportunities (value chain analysis and post-harvest research). Until 2014, FP5 addressed post-harvest management, and social science analysis was a global, cross-cutting dimension. The Evaluation Team could not establish the rationale for this change. Social science needs to support the other FPs and strengthen their coherence (as in WHEAT), and the combination with post-harvest issues appears superficial. There is a need to strengthen integration of socio-economics with RS1 and RS2. It is suggested that RS3 be looked at again in the next proposal call.

[10] MAIZE CRP: Extension Proposal 2015-2016. Table 1

3.1.2 Consistency with reform principles

The CRPs were built on three core principles: impact on the CGIAR's SLOs, integration across CGIAR core competencies, and appropriate partnerships at the different stages of R4D.

The Evaluation Team considered the extent to which MAIZE is consistent with the first two organizing principles; partnerships are discussed in Chapter 6.

Impact on system level outcomes. Section 2.1 highlighted the importance of maize for food security of poor farmers and poor consumers. Over the next 35 years the demand for maize in the developing world is estimated to double. The goals of MAIZE to stabilize maize prices and double the productivity of maize-based farming systems are consistent particularly with the food-security related SLO of the CGIAR. Furthermore, the IDOs formulated in the 2015–2016 extension proposal are aligned with the SLOs for reduced poverty, improved food and nutrition security, and improved natural resource systems and ecosystem services. These alignments are argued using the TOC and impact pathways. Considering that the SLOs are aspirational the Team considers that MAIZE research is coherent with these goals.

Integrate CGIAR core competences. Initially MAIZE was, to a large extent, based on presenting the existing maize research programs of CIMMYT and IITA in the same CRP, expanded with new bilateral projects and a much broader range of partnerships. Based on interviews and activity analysis, the Evaluation Team considers that over the last three years the collaboration between CIMMYT and IITA has strengthened, which has contributed to coordinated projects on drought tolerant maize, Striga resistance, integrated Striga management and development of Quality Protein Maize (QPM). The two centers also have established joint efforts to breed for resistance to maize streak virus. Both CIMMYT and IITA still manage their own maize programs however. In the Team's views integration of the two centers' maize programs into a single program, headed by a CRP director, as is being discussed by the two BoTs (see Chapter 8), will strengthen the authority of the MAIZE leader and enable greater relevance and synergies in all areas including socio-economics and gender.

3.1.3 Targeting and impact pathways

Impact pathways specify the routes by which CRP actions lead to measurable outputs, IDOs, strategic goals and ultimately system-level impacts regarding the CGIAR SLOs. In MAIZE these pathways are dynamic and are revised each year in the light of experience and as the role of partners becomes clearer. Each RS has its own impact pathway, and key performance indicators (KPI) are specified for each FP.

The target beneficiaries of MAIZE are resource-poor farmers and consumers in low and middle-income countries for whom maize is a preferred crop or food, with a focus on the disadvantaged. MAIZE targets two types of farmers and their service providers:

- Target group 1: smallholders in stress-prone environments with poor market access
- Target group 2: market-oriented, technology-constrained smallholders in more benign environments

A third group includes farmers in developing countries who may benefit from spillover effects of research targeting the two target groups described.

The impact domains of each target group are quantified in terms of maize area, number of people living in the area, number of poor in total in those areas and number of maize-dependent poor, level

of stunting among children and characteristics of farming systems. The impact domains are not well specified in terms of technologies and products. The impact domains for technologies need to be included in the research plans. Once breeding products are defined for a given target, this information needs to feed back for directing the focus of the breeding effort. The five FPs are interlinked and contribute to the same IDOs. Impact pathways are provided in a narrative for each RS and FP, and include an overview of the links between goals, research outputs and immediate and intermediate outcomes. The partnerships needed at every step and the assumptions made at every stage for each RS are defined, although performance indicators are described but not quantified. The impact pathways are not clear as to how MAIZE will achieve the goal to double maize productivity in target zones. There is a need for a more systematic analysis of alternative scenarios. More robust ToC is needed that includes both assumptions underpinning the impact pathway related to the productivity goal, and risk scenarios in the case the assumptions do not hold. The impact pathway towards stabilized maize prices is long and indicators should be defined along the pathway.

The Evaluation Team noted that the three research strategies have outcomes and indicators at the farm and farmers level. As also discussed by ISPC in its commentary, there is a need to give more strategic consideration in the FPs to indicators for “poor consumers” as a distinct group from other targeted groups and beneficiaries of maize research.

To contribute to the stabilization of maize prices is one of the goals of MAIZE. However, prices are determined not only by availability of improved technology, but also other factors influence price. MAIZE should therefore give greater attention in the impact pathway analysis to the dynamics of maize demand and supply considering the various uses of maize. The interviews also revealed that, particularly in Asia, attention was needed on the future role of maize in the agricultural systems and the economy. More emphasis could be given to dynamics in research supply, particularly regarding the role of the private sector in selected target areas (e.g. irrigated areas of Asia). Some of these issues could be addressed through *ex ante* analysis.

As indicated earlier, the five FPs are interlinked but impact pathways do not show details of the linkages. FP1 has a pathway to support adoption of outputs from FP3 and FP4, and to catalyze innovation around sustainable intensification. FP2 delivers almost exclusively to FP3, which is where germplasm products originate for FPs 1, 4 and 5. These interrelationships are integral to the design of MAIZE and ensure output delivery. The Team noted that it was not clear how an FP could contribute directly to IDOs when its impact pathway involves delivery through another FP. The social science component of FP5 should clearly have its impact pathway through other FPs, but mixing socioeconomics and policy with post-harvest issues has reduced the coherence of the FP and alignment with other impact pathways. The Team considered that there was a need for greater integration of socio-economic research with agronomy and breeding. While the Team saw several good publications that reported on interdisciplinary matters, it also noted that this kind of integration was uneven across geographical regions.

Coherence and impact pathways were also assessed through the review of 32 MAIZE projects, of which 27 were considered very well aligned. Only five were judged as being poorly or moderately linked with MAIZE objectives. With respect to providing information on impact pathways, 25 projects provided the required information, while seven did not specify their impact pathways.

Overall, the Team considers that there is adequate rationale and internal coherence for the FPs 1-4, which have CoAs directly relating to the FP goals. Impact pathways could be strengthened in situations of interlinkages and in project formulation. The Evaluation Team was not convinced about FP5, with its mix of social science, market and post-harvest activities. RS3 appeared to be the only

area where coherence of activities was not always evident. Consideration should be given to social science research becoming a cross-cutting theme.

3.1.4 Use of W1/2 funding

In the first two and a half years of operation 19% of MAIZE funding was from W1/W2, which is one of the lowest shares of this core-type funding among the CRPs. In 2014, from a total W1/W2 budget of USD 15,420 million, the largest share, 23%, was allocated to FP2, followed by 21% to FP5, 18% to FP 3 and 15% to FP1. FP4 received 9% of W1/2 funding. About 14% was allocated to MAIZE management. Although relatively little W1/2 funding has been allocated to FP1/RS1 this strategy has been successful in attracting bilateral funds. In RS2 (FPs 2-4), W1/W2 funds are used to make a programmatically more coherent agenda, with a focus on enabling tools (e.g. double haploids, informatics/databases, new phenotyping methods) and delivery of these to partners. In RS3, W1/W2 funds have been used across the different activities for foresight and targeting, impact assessment, gender analysis and targeting, post-harvest research and market opportunities.

Asked about the use of W1/2 funding in the researcher survey, the respondents considered that filling gaps in research funding was the most important purpose of W1/2 funding. Increasing integration between different areas of research was also considered a purpose of W1/2 funding, and, to a lesser extent, providing opportunities for long-term high risk research and increasing gender relevant research. Only half of the respondent considered that W1/2 funding was used to providing relevance through *ex ante* studies.

Overall, the Evaluation Team considers that W1/W2 funding has been used to add coherence to the research portfolio largely funded through bilateral funds.

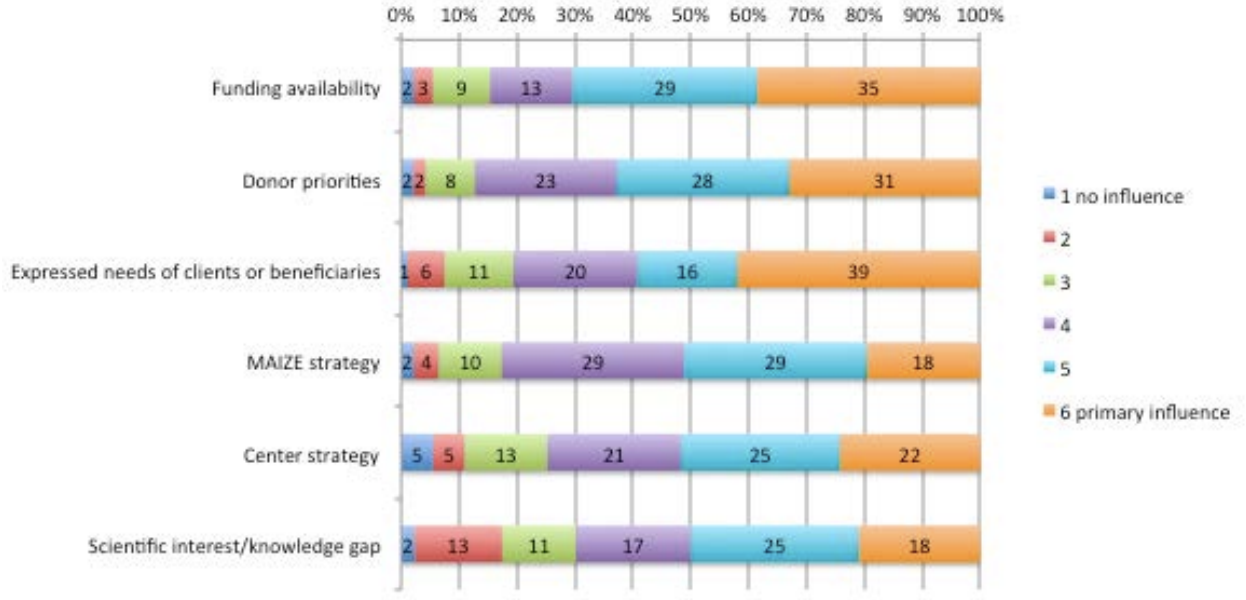
3.1.5 Priority setting

MAIZE does not have an overall formal priority-setting framework. “Priority-setting and review is implemented through SI-specific *ex ante* analysis, expert panels, workshops, web platforms and other means”.[11]

The researcher survey results on factors influencing research focus are shown in Figure 3-1.

[11] MAIZE proposal, June 2011, page 63

Figure 3-1: MAIZE researcher survey: perception of influence on choice of research topics[12]



Source: MAIZE researcher survey.

Large majority of respondents considered that funding availability was the single most important factor influencing research focus (perceived as high or primary influence by 64% of respondents), followed by donor priorities (59%), and expressed needs of beneficiaries (55%). These influences may result in a perceived imbalance of projects, with more efforts dedicated to either early discovery or later stages of development and deployment, i.e. where donors search for immediate impact in farmers' fields or for "high-tech, big data". MAIZE has some risk of becoming strategically driven by funding agencies, especially in bilateral projects. Furthermore, staff interviews indicated that field sites were sometimes chosen on the basis of funding availability rather than by priority setting considerations. However, the Team did not consider that this substantially hampered the overall relevance of FP research. While the survey respondents felt that the emphasis in high risk and strategic research (combined) was at the right level, several felt that there should be more attention to scaling-out of research results. The Evaluation Team also noted that a relatively high share of survey respondents (26%) found that "scientific interest/knowledge gap" was of little or no influence in the choice of research topics.

The Evaluation Team identified two areas that MAIZE should reconsider in its next round of priority setting. Firstly, aflatoxin research has been very successful, with well-documented results. As the ISPC noted in its comments on the extension proposal, there is no new strategy and target for tackling issues in the proposed research on aflatoxin. The proposals seem to imply a continuation of ongoing research and a strengthening of delivery activities. MAIZE should consider the extent to which ARIs and NARS could assume further responsibility for this type of research. Secondly, the Evaluation Team in its review of sample projects considered that research on improved grain storage was very much focused on adaptive research and delivery activities, which could also be undertaken by NARS. The Team could not see an advantage for MAIZE to be involved in these types of activities, even though bilateral funding is available. The Team also questions whether work to promote the use of

[12] Survey Question 14: What is your perception of the factors influencing the choice of research topics in the MAIZE Flagship you mostly contribute to?

metal containers[13] should be continued. This is also an issue of the CGIAR's comparative advantage . Outputs are strongly development oriented and research focuses on the adaptive side. While such post-harvest research may lead to quick results, there is no obvious strategic research component. It appears that some of this work could be undertaken by NARS or large NGOs.

The Evaluation Team acknowledges MAIZE's rapid and efficient response to the outbreak of MLN in eastern Africa. The availability at short notice of W1/W2 funding was crucially important to mount a rapid and efficient response while waiting for additional funds to be mobilized from the donor community.

The Evaluation Team considers that in the future MAIZE should make efforts to develop a more pro-active, early warning capacity so that preventive measures can be taken and timely new research approaches initiated. This should be part of the foresight expected from MAIZE as a world leader in research.

3.2. Comparative advantage

The Evaluation Team considered the comparative advantage of MAIZE by interviewing stakeholders, and through sample project analysis and CRP reports.

CIMMYT and IITA hold unique genetic resources in trust and these are used in breeding programs to develop improved germplasm and varieties. MAIZE has an excellent research infrastructure, and legal arrangements with national governments that facilitate germplasm exchange and good working conditions for scientists. MAIZE also takes the lead in organizing regional breeding networks, and has unique experience in priority agroecological zones that it targets. Furthermore, MAIZE benefits from the global reputation and strong credibility of the CGIAR among policy makers and the scientific community. CIMMYT and IITA also offer attractive working conditions and benefit packages for their scientists. As a result, MAIZE is able to recruit and maintain high quality scientists and develop strong partnerships with NARS, ARIs, and development agencies. The ability of MAIZE to mobilize efforts for the full research spectrum, ranging from strategic research, technology design and research output to delivery mechanisms, further adds strength to the CRP concept.

The Evaluation Team therefore concludes that MAIZE has a strong comparative advantage, in terms of CGIAR mandate for delivering IPGs, relative to other efforts and initiatives.

However, the concept of comparative advantage is dynamic. The private sector has become an important player in seed supply of improved maize varieties, and in developing market-ready parental lines and hybrids. However, because of the lack of profitability in producing for smallholder, resource-poor farmers, and given the complexity in the breeding operations required, the private sector has not been very active in maize breeding in the geographic areas and for the groups that MAIZE targets. However, the situation is changing rapidly, particularly in irrigated areas of Asia, and some mid-altitude areas of southern Africa.

Two examples where MAIZE has a clear comparative advantage at a smaller geographic scale are in highland QPM germplasm for Ethiopia, and in Nepal. These unique ecologies (and the QPM characteristic in the first case) are likely to generate little market interest for multi-national seed companies. As both projects began well before MAIZE was established, the Team suggests that

[13] e.g. Demonstration and promotion of metal silo grain storage technology to small-scale farmers in central Ethiopia

extensions be clearly justified with reference to the IDOs of the RS2 FPs, and for QPM to consider how to include industrial partners (e.g. baby-food companies) to build an improved market.

With regard to activities related to germplasm improvement; MAIZE is involved in supplying different types of germplasm, including genebank accessions, germplasm with specific traits, advanced parental lines (i.e. verified in test-cross, but not "optimized"), market-ready parental lines and hybrids. While MAIZE focuses mostly in delivering the first four types of germplasm, and to some extent hybrids, the role of the private sector is increasingly important, particularly in hybrid production. MAIZE will need to reflect on its role in final product delivery, especially for hybrids, in regions where the private sector and national seed companies are strong, such as parts of mid-altitude Africa, and irrigated areas in Asia; i.e. consider releasing potential parental lines with broad combining ability or proven test-cross performance, but without the substantial extra effort to create market-ready lines.

There is increasing commercial presence in India (for maize for poultry feed) and in some African mid-altitude environments. For example, at least one multinational company sells hybrid maize in India[14] adapted for high-temperature spring planting. While HTMA might justify development of high-temperature inbred lines, it may have to specify its role in delivery of hybrids. In mid-altitude Africa, the sites are better suited to introduction of temperate germplasm, albeit of various grain colors and disease resistance profiles. For example, in Ethiopia between 2005 and 2011 one company's seed sales increased steadily from 1500 to 3000 t per year[15]. In 2010, the major (state) producer (Ethiopian Seed Enterprises) produced 7300 t of seed, but sold 4400 t. While drought and disease differ according to site, the relatively low genotype by environment interaction for geographical adaptation between eastern and southern environments in Africa (according to reviews of DTMA[16]) indicate that there are good opportunities for seed companies to deliver broadly-adapted hybrids. In the medium to longer-term (3 to 10 years), MAIZE needs to monitor and address the rapidly evolving capabilities of NARS, small and medium enterprises, and multi-national breeding companies. As these parties strengthen or enter countries to support the seed systems and variety delivery, MAIZE could consider a greater emphasis to deliver unique parental lines (i.e. proven to test-cross level) and to support the commercial agencies to assemble these into varieties, perhaps for a commercial return to MAIZE as happens for hybrid rice[17].

MAIZE has a clear role in catalyzing engagement of private, public and civil society organizations to develop and deliver improved germplasm and genetic resources. In Africa MAIZE brings together efforts of 90 seed companies. The Team encourages MAIZE to continue in its current process of re-designing RS2 along the lines of a modern breeding model – discovery, line development, product development, and special projects (see Chapters 4 and 5). This includes a greater focus on developing (to the point of test-cross validation) unique lines, both phenotypically and genetically well-characterized, with less focus on "market-ready" hybrids, and developing and implementing clear roadmaps to validate new phenotyping methods.

[14] http://www.pioneer.com/web/site/india/Corn/

[15] T Kumsa (2012) p. 250 Proceedings of the 3rd National Maize Workshop of Ethiopia (in 2011, sponsored by EARI and CIMMYT) http://repository.cimmyt.org/xmlui/bitstream/handle/10883/1329/96072.pdf

[16] Edmeades and Westphall DTMA Review of phases 1 and 2, 15 April 2011, page 5

[17] IRRI Guidelines for Public-Private Sector Partnership in the Hybrid Rice Development Consortium http://hrdc.irri.org/images/HRDC_Guidelines/2013%20hrdc%20guidelines.pdf

MAIZE also has a comparative advantage in RS3 and FP5 as most activities produce IPG. Because of its of datasets, expertise and presence in the field, MAIZE has a clear advantage in conducting social science research with other organizations. Further links with PIM are under consideration.

Some research areas in RS3 have already been identified above where the Team suggests shifting priorities. While there is a role for the RS2 in developing post-harvest traits (insect and aflatoxin resistance) in maize lines, and in documenting aflatoxin issues, MAIZE could look to partners for applied aflatoxin research and solutions. For example, ICIPE has quickly become a strong partner MAIZE for MLN work and there may be other agencies that have comparative advantage and can deliver in a similar way for the aflatoxin research. As the maize breeding sector evolves, MAIZE necessarily shifts its attention to areas less attractive to the private breeding sector or strong NARS.

3.3. Conclusions and recommendations

On the basis of the above analysis, the Evaluation Team concludes that the MAIZE runs a coherent program, with a strong comparative advantage overall over other agencies. Coherence could be further strengthened by making social sciences a cross-cutting theme rather than be embedded in a separate RS, and by strengthening aspects of impact pathways.

A key aspect of coherence through MAIZE is the potential for enhanced synergy between CIMMYT and IITA scientists and center programs. There is an agreement under development between CIMMYT and IITA for closer collaboration and the Team supports this effort as being important to develop a more coordinated and relevant global research program. Scientists and technical staff are engaged in center-based projects as well as implementing the MAIZE process of change and integration. Partners with the CGIAR centers, in the main, still relate more to center-based projects that were initially developed by CIMMYT and IITA independently. There is a framework in place, and it is expected that partners will become more aware of and participate in MAIZE where appropriate. For example, MAIZE is increasing the frequency of meetings of breeders (including via video) to facilitate more exchange of germplasm and protocols.

There was evidence that priority setting needs attention. The integration of socio-economics with germplasm improvement efforts, and with systems agronomy, was strong in some geographic areas but absent in others. The scientific leadership within CIMMYT and IITA-led aspects of MAIZE is making considerable efforts to map out research strategies, but the Team did not find many examples of any research programs had been closed down or redesigned as a result of the review process. Pertinent examples were the reduced emphasis on low P and acidic soils, and of QPM research. Greater emphasis is given to abiotic stress tolerance, and MLN was rapidly given greater focus. This is an important aspect of coherence and program design, to set priorities for MAIZE and ensure resources follow those priorities.

Recommendation 1: Given the evolution of the private sector, MAIZE will need to continue to assess its target smallholder groups, ecologies, geographies and commercial seed markets. This assessment should aim at:

- Accurately defining the germplasm products and associated technologies needed – regarding delivery of improved lines, parental lines, hybrids (finished products) and technical issues of maturity, disease and stress tolerance, and grain quality attributes and its unique support of managed stress networks.

- Establishing "rules" to customize and change MAIZE roles and involvement, e.g. default focus should be delivery of regionally-adapted improved lines and expert science/capability development in markers, traits and phenotyping.

Recommendation 2: MAIZE should review its priorities in FPs 4 and 5 where it has less comparative advantage and where smallholders already have a certain access to appropriate technology. This needs to be considered in the light of the large proportion of W3 funding. In particular, MAIZE needs to consider reducing efforts in final product (hybrid) delivery where the private sector is strong. MAIZE should also consider reducing investments in the non-germplasm components of FP5 areas of aflatoxin and postharvest storage research where other agencies have greater comparative advantage.

Recommendation 3: MAIZE should establish pro-active research and monitoring capability to provide foresight on emerging issues in diseases and to support environmental characterization.

4. Quality of science

4.1 Introduction

This Chapter reports the Evaluation Team's assessment of Quality of Science (QofS) as related to scientific staff, processes, outputs and infrastructure. The framework for assessing QofS is presented in the evaluation Inception Report.[18] The methods used were described in Chapter 1. Results of bibliometric analyses and document analysis related to prior studies on publication quality were included. The discussion is mostly arranged by the three research strategies.

4.2 CRP-wide assessment of staff and publications output

4.2.1 Research staff in MAIZE

MAIZE draws on about 110 to 120 internationally recruited staff (IRS) equivalents from CIMMYT and IITA[19]. The survey indicated that 40% (48) of respondents had worked at their center only since 2012, and only 28% (34) were employed pre 2008. At 30 May 2014, CIMMYT had 138 IRS in Global Maize Program (GMP; 47 full time staff), Conservation Agriculture Program (CAP; part-time 37), Socio-Economics Program (part-time 30) and Genetic Resources Program (GRP; 24). Of these, 68 had been employed since 30 May 2012, i.e. > 50% of staff had less than two years' experience at CIMMYT. Almost half (30) of the new appointees were at grade R1 (post-doc) or R2 (associate scientist).

An H-index study of 35 team leaders/supervisors (28 CIMMYT, 7 IITA) showed that the majority had indices between 10 and 20 (16 staff) or 5 and 9 (13 staff). Three researchers had an H-index greater than 20 and the top 10 staff had indices of 15 or greater, which represents a reasonable impact level. The highest values were for senior, long-standing staff, although two of the top five were recent appointments into RS1. It needs to be noted however, that H-indices are discipline-specific and poorly suited for comparisons across fields of research. A much broader analysis would be needed to place the staff in the context of peers from other agencies.

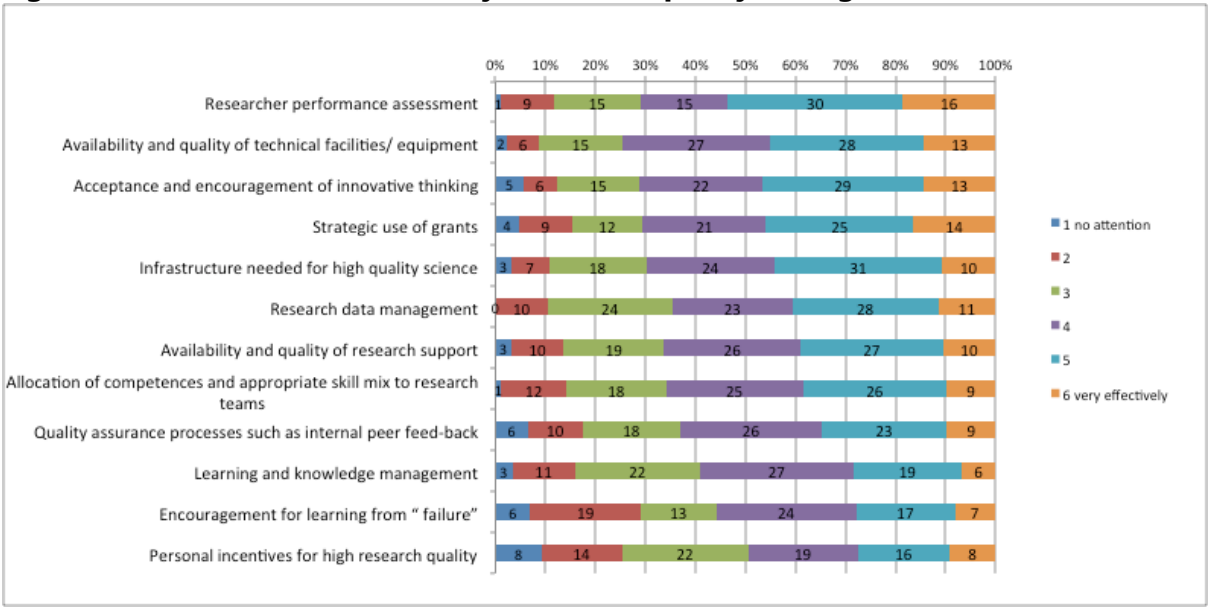
4.2.2 Research staff perceptions of QofS

Aspects of research quality management were explored in the researcher survey. With the exception of Researcher performance assessment, fewer than half of the respondents perceived that the various aspects were effectively or very effectively managed. More than half considered that personal incentives for high quality were not effectively managed. The results are shown in Figure 4-1 in the order of satisfaction.

[18] http://www.iea.cgiar.org/sites/default/files/MAIZE%20IR%20OCT%202014%20FINAL_0.pdf

[19] At 30 May 2014, CIMMYT had 213 IRS, and assuming CRP Staff comprise 100% of GMP, 50% of CAP, Socio-Economic Program and GRP and 20% of support programs, then about 100 CIMMYT IRS are allocated to MAIZE. IITA reported 36 IRS as "working with MAIZE projects", but, the ratio of 2013 expenses of CIMMYT and IITA (exc. collaborator expenses) is 0.16. Hence, IITA likely has about 16 IRS equivalents allocated to MAIZE, giving 116 in total. Using the same 2013 expenses and an average cost of USD 70 000/person (CIMMYT approximation), the total international + national staff allocation to MAIZE is about 545 for CIMMYT, and 87 for IITA. Payments to other CGIAR centers indicate about another 40 staff, and perhaps >100 equivalents with other partners.

Figure 4-1: MAIZE researcher survey - Research quality management20



Source: MAIZE researcher survey.

4.2.3 Publication quality

A recent study commissioned by the Consortium assessed research output by CGIAR Centers in 2003–2012[21]. In this period, CIMMYT (1124) and IITA (>1000) were 1st and 3rd, respectively in number of publications in agricultural and biological sciences, with CIMMYT (at 1.8) in the top group for FWCI (Field-weighted Citation Impact) and IITA (0.8) a little below the world average (1). For social sciences, CIMMYT had the highest FWCI (2.36) of all centers, with IITA at 0.9. CIMMYT and IITA were average in number of environmental sciences papers, with FWCI values similar to those for agricultural and biological sciences. The study established that 41% of CIMMYT's social science publications were in the top 10% of highly cited articles, this figure being 22% for CIMMYT's agricultural and biological science publications.

A bibliometric analysis done for this evaluation considered MAIZE publications (by CIMMYT and IITA) during 2012–2014. A total of 262 publications were included, among them 238 journal articles (including those in press at the end of 2014). Table 4-2 shows the most frequently used journals and their impact factors.

[20] Survey question 19. In your view, how effectively are the measures listed below managed in your Center/CRP for assuring and enhancing high quality of research? Please score using a scale of 6 where 1=no attention at all and 6=very effectively.

[21] Elsevier. 2014. CGIAR Research Output and Collaboration Study 2014. Consortium Board, Montpellier.

Table 4-2: MAIZE publication journals

Journal	No. of articles published in 2012–14	JCR Impact Factor 2013
Field Crops Research	26	2.474
Crop Science	23	1.513
Theoretical and Applied Genetics	12	3.658
Euphytica	9	1.643
Molecular Breeding	8	3.251
Heredity	6	4.110
Maydica	6	0.368
Revista Fitotecnia Mexicana	5	0.264
Agriculture, Ecosystems and Environment	5	2.859
Journal of Integrative Plant Biology	5	3.75
PLoS ONE	5	3.73
Plant Breeding	4	1.175
IITA R4D review	4	-
Agronomy Journal	4	1.518
Biological Control	3	1.917
International Journal of Agricultural Sustainability	3	1.493
Journal of Crop Improvement	3	-
Methods in Molecular Biology	3	1.290
Soil and Tillage Research	3	2.367

Source: Bibliometic Analysis.

In 2012–2014, 23% of the journal articles were published in three leading crops journals (Field Crops Research, Crop Science and Theoretical and Applied Genetics). As much as 19% of the articles were published in journals that do not have an impact factor and may not have undergone sufficient peer review. MAIZE published in a range of journals, the majority being highly accessible and relevant to maize researchers. Table 4-3 shows citation results for journal articles published in 2012–2013; almost 30% (47 articles) have been already cited more than ten times.[22]

Table 4-3: Citation rate of MAIZE 2012 / 2013 publications.

	No. of articles by year (%)	
Number of citations (GS)	2012	2013
0	4 (5.3)	17 (19.5)
1 to 10	40 (52.6)	55 (63.2)
11 to 20	12 (15.8)	8 (9.2)
21 to 30	13 (17.1)	6 (6.9)
31 to 40	7 (9.2)	1 (1.1)

Source: Bibliometric Analysis

[22] Google Scholar analysis, Jan 2015

Of the journal articles analyzed, about 30% were in the broad area of agronomy (RS1), roughly 60% in breeding (RS2) and 10% in socio-economics (RS3). About 70 % were CIMMYT publications and the remaining from IITA. Figure 4-2 presents a visual analysis of the titles for the three main categories of journal articles.

Figure 4-2: Wordcloud of journal article titles for MAIZE publications (2012–2014) for the publication categories Agronomy, Breeding and Socio-Economics.23

Source: Evaluation team

4.3 Quality in Research Strategy 1

Our focus regarding RS1 was on CIMMYT-led research because IITA agronomic research is largely allocated to other CRPs such as Humid Tropics. The leadership of RS1 is strategically based in key locations in Mexico, Africa and South Asia.

4.3.1 RS1 Research staff

Due to rapid growth in the CIMMYT CAP, 92% of staff have been less than five years in the center and 21 staff (60%) less than two years. A major and sustained effort is needed to mentor younger staff (eight are post-docs or associate scientists), especially in African locations where agronomic infrastructure is generally weak outside of the research stations at Ibadan (Nigeria) and Harare (Zimbabwe). Based on interviews, field visits and the survey of MAIZE staff, the leadership is proactive and invests time and resources in areas such as prioritization, synthesis of findings, and developing new research initiatives, all of which will help address challenges associated with remote stations and large numbers of new hires.

To address challenges mentioned by less experienced staff and new hires, developing protocols and training, mentoring and retaining staff should be top priorities. Agronomic research is a rapidly evolving field, where in-depth documentation of open-access datasets is a time intensive but essential requirement for high quality science. Few remote staff are listed in recent publications, and, when asked, they were often not aware of new CGIAR policies for open-access data[24]. According to the survey, more than 50% of staff were in three or more projects in MAIZE, and each respondent at CIMMYT had an average of six people reporting directly to them, at IITA even 16. Junior and new staff

[23] The smallest font in each is for words that appeared three times.

[24] Inception meeting May 2014, CGIAR Open Access Policy, CGIAR Core Metadata Guidelines–Draft, CIMMYT Research Data and Information Management Policy

are often engaged in donor-driven projects, sometimes with major reporting demands and a focus on developing large numbers of demonstration plots and maintaining good relations on site.

New hires were more evident in Africa and Asia (compared with Mexico), and there was evidence of the need and interest for further training in participatory experimental design, in protocols to develop datasets, in simulation and in writing extension guides and papers to synthesize new knowledge. An online survey, conducted in November, 2014, of 37 farming systems staff in SIMLESA and Nepal indicated that 84% were very or extremely interested in online statistical training and support[25]. MAIZE is uneven in simulation modeling; too few top scientists to provide the support, although SIMLESA contributes via PhD supervision in Australia and training workshops in Africa. Partners, national scientists and MAIZE staff identified capability needs in all these areas. These needs in RS1 have resulted from rapid growth in staff (see conceptual "triangle" in Chapter 5) and require that processes are strengthened to sustain quality science and future impact. Connections with top institutions help develop capacity among young staff and partner organization staff, as indicated by the scope of bilateral investment in RS1. More is needed however.

4.3.2 Processes in RS1

Long-term strategic field experimentation at CIMMYT headquarters serves RS1. This infrastructure is of global significance, with similar trials as in Mexico initiated in Zimbabwe and Nigeria. Use of the data generated for systems analysis and making datasets publically available is on-going, and initial steps have systematized electronic field "manuals" for data collection. There is adequate allocation to support these processes, at least in Mexico (strong publication record in high impact journals). Interviews revealed that there are plans in place to enhance system characterization through expanded use of geospatial tools and participatory action research. The long-term goal includes implementing "big data" systems analysis techniques, pioneered in the MasAgro project, e.g. for advanced trade-off analyses to compare value of residues for conserving soil resources versus use as livestock feed. At present, at other sites, data management in farming systems is an issue that could result in data quality problems and pose a risk to science quality, especially for remote staff.

Other strengths of RS1 are in the characterization and assessment of trade-offs in farming systems, including identification of optimization options, and support for sustainable intensification trajectories. The recent journal articles and on-going research are outstanding in this area, well supported by surveys, modeling, field experimentation and statistical analysis.

Interdisciplinary approaches to systems research are important to science quality, particularly the collaboration of socio-economists and agronomists in agricultural systems research, but examples were few[26] compared to those for germplasm. MAIZE has invested in hiring socio-economists, but more attention should be given to adoption of improved agronomic practices also as these practices relate to the germplasm (RS2).

Partnership with experts from ARIs and developed country universities has helped generate successful examples of interdisciplinary agricultural systems research, including crop and soil simulation modeling in Africa. This approach could be deepened through participatory modeling research, agent-based modeling and related emerging tools in systems research that are not yet much in evidence in MAIZE.

[25] Dr Miranda Mortlock, The University of Queensland, SIMLESA project online course http://yieldingresults.org
[26] Based on authorship of publications, field visits and reviews of research projects.

Capacity building via protocol development, accompanied by manuals with detailed instructions in methodology, represents a major process to support and ensure science quality. The agronomic systems research included a substantial amount of field experimentation, monitoring and sample processing as well as data management and analysis, but field staff had few common defined protocols. The need for protocol documentation is urgent to maintain science quality.

4.3.3 RS1 Outputs

RS1 is a leader among international research efforts in developing accessible datasets. These data are a valuable IPG, and website access to supporting data is increasingly a requirement for high impact publications. This ensures that datasets are available for synthetic research and for transparent reproducible knowledge generation. MAIZE needs to continue to lead in this area, and to invest in training and infrastructure at strategic sites in Africa and South Asia. The Team notes that the MasAgro project has taken data generation with farmers and a wide range of civil society partners to a new level through novel ways of monitoring, combined with support for on-farm experimentation in Mexico. This has not yet been underway in Africa at the time of the evaluation, but the newly funded project Taking Maize Agronomy to Scale in Africa (TAMASA, funded by BMGF) is addressing this. There was no opportunity to visit CSISA sites (apart from Nepal) during the review, so we cannot comment on implementation in Asia.

Partnerships between NARS programs and MAIZE research have generally been very strong. However, partnerships that include systems CRPs such as Humid Tropics could be improved; the IITA led Humid Tropics CRP is developing sustainable intensification indicators and metrics – activities that could help support MAIZE agricultural systems research done at CIMMYT. These types of processes could help bolster IPG output (datasets, decision tools and publications). Indicators for sustainable intensification and good agronomic data management could be better supported to move agronomy-type research to the next level to underpin meta-analysis and rigorous recommendations. Working with international institutions and other initiatives on agronomic protocols for on-farm experimentation in ESA and Asia will be essential as MAIZE moves forward.

According to Team reviews of sampled papers, and the bibliometric analysis, MAIZE research publications in RS1 were rated as being of very high quality. They appear in the journals of record for agronomic research and include emerging research areas. One issue is that there is less evidence of publication from partners and junior scientists. Some research projects deal with very applied research, and the fact that there is limited training in agronomic research of partners in Africa may contribute to their relatively limited contribution in publications. Therefore, support for research outputs associated with these projects will require particular attention and investment if quality publications are to be produced.

4.4 Quality in Research Strategy 2

In order to implement and monitor breeding programs properly, a fully documented R4D stage plan (Figure 1, Chapter 1) and policies/processes to manage the staging and effectiveness of breeding are needed. Issues related to the stage plan and its operation are addressed in Chapter 5 on “Effectiveness”. All of the activities in R4D also need policies, processes, protocols and working instructions to ensure consistent breeding procedures, for handover of intermediate products between stages, and for training and deployment of new staff. These are important quality-related issues in breeding and are considered here.

For each country and ecology/maturity type, seed roadmaps have been developed to determine the potential farmer demand for seed, the net annual market for that seed and support delivery of

product at the farm level. The major MAIZE breeding projects (DTMA, WEMA, IMAS in SSA, MasAgro-IMIC in Latin America, IMIC-Asia in South Asia) are designed to develop products for these seed roadmaps in one or more countries. MAIZE is typically involved at the regional-evaluation stage and although final delivery of products to the seed sales systems may occur within projects, this varies according to project, geography and the strength of the local seed delivery system.

4.4.1 RS2 Research staff

In RS2, the research staff comprise field breeders, molecular breeders, seed systems specialists who are supported by discipline-oriented scientists in physiology, plant pathology and entomology, and by researchers in bioinformatics/statistics/genetics. At the start of this evaluation (May 2014) about 60 staff at CIMMYT could be counted as contributing to MAIZE RS2, consisting of 47 scientific staff in the GMP and 24 in the Genetic Resources Program. IITA reported 36 people working in maize, but did not specify their involvement in a particular RS. Although less so than in the other RS, there have been many new hires during the last two years at CIMMYT (no data for IITA), with 35 new staff in GMP and GRP together. The knowledge, capabilities and qualifications of the breeders are generally excellent, as evidenced by interviews and the substantial outputs discussed below.

4.4.2 Processes in RS2

Over the last 20 years CIMMYT, and subsequently MAIZE, breeding programs shifted toward the delivery of hybrid products (with open-pollinated varieties and synthetics still produced where needed) and the use of managed environment screening to accelerate selection for adaptation to drought, low N, high temperature and biotic stresses. Currently these successful phenotypic breeding systems are being complemented by accelerated germplasm development (doubled haploids; DH) and molecular breeding[27]. Modern plant breeding can be accelerated by three molecular technologies: genetic modification (GMO: genetically modified organism), marker-assisted breeding (MAB) and recently, genomic selection (GS). Over the last 15 to 20 years, all of these technologies have been adopted by all multinational companies that breed maize, with MAB used in many smaller national companies and public programs. A major challenge is how best to deploy these “modern” methods in MAIZE and its partners’ programs. MAIZE is investing in these areas and the 2015–2016 plan shows a continuous effort, especially to develop the new skills and tools for transfer to partners.

The following sections address issues associated with the breeding stages (Figure 1, Chapter 1) and the supporting processes and technologies to deliver outputs.

Discovery:

Discovery applies to many areas of breeding, but can be summarized as the:

1. identification of useful transgenes
2. identification/methods for useful genes or traits (native traits)
3. characterization of genetic relationships among germplasm to inform decision making

Major projects and their discovery activities include:

- MasAgro – SeeDs of Discovery component to build a Molecular Atlas from 30,000 germplasm bank accessions; novel allele discovery; bridging germplasm
- WEMA – transgenics for drought tolerance and insect resistance (two Bt genes for stem borer); novel parental material from Monsanto

[27] DTMA reviews (espec. Edmeades and Westphal 2011), details capabilities in breeding

- DTMA – drought tolerance trait phenotyping, and use of MAB and piloting GS
- IMAS – low N trait phenotyping, converted lines for N efficiency genes from Pioneer Hi-Bred, using Genome-Wide Association Studies leads (50 markers) for N traits into DH pipeline, validating and/or using MAB to introgress multiple traits (resistance to Maize Streak Virus, Maize Leaf Necrosis, Grey Leaf Spot)
- Harvest Plus – breeding for QPM and utilisation of molecular selection for CRTRB1 allele to increase provitamin A (from CRP4 HarvestPlus)
- IITA – *Striga* tolerance research
- HTMA project – novel phenotyping and genetic evaluations for heat tolerance

Transgenes

Transgene solutions in maize (mainly USA, Latin America and parts of Asia) have been deployed for traits with relatively simple genetics (GMO herbicide tolerance and insect tolerance each affect only one biochemical reaction). The GMO "contained testing facilities" at five sites of African Agricultural Technology Foundation/WEMA, including Kenya, Tanzania and South Africa, allow safe evaluation of GMOs and provide data to support 2014 submissions for commercial release of GMO hybrids in Kenya and South Africa[28]. In the WEMA project, MAIZE has made the first major test of transgenes for drought tolerance in non-temperate germplasm, with requests for release currently in process.

MAIZE, appropriately, does not directly discover transgenes. Activities in SeeDs and in physiology projects have included studies of both gene associations with adaptation in diverse germplasm and assessments of gene expression and metabolite expression in drought/non-drought hybrid comparisons. These activities can provide leads on mechanisms that might be manipulated with transgenes, but development and registration is extremely expensive and complex. MAIZE is commended for developing co-investment models in WEMA and IMAS to access royalty-free licensing arrangements to deploy commercial transgenes in MAIZE germplasm.

MAIZE does not research herbicide-tolerance transgenes, although weed management remains a major challenge in cropping systems, especially when labor is scarce. MAIZE managers described three years of discussions with multinational companies to try to introduce this technology on a royalty-free basis, but without success. While there may be commercial barriers to this technology, IP for GMOs is also of concern. The WEMA provides valuable experience in this type of IP, but it is essential that the CGIAR/CRP IP policies provide protection to support the use of GMOs, for both project needs and to reassure stakeholders of due diligence.

Native genes and traits

Few large effect QTL exist in maize for adaptive and stress-tolerance traits, either biotic or abiotic. However, several major markers for diseases are being routinely used for screening germplasms with more in development. Adaptation to stresses such as salinity and drought, and even for most diseases and pests, appears to require many small effect genes. Despite this genetic complexity, conventional genetic advance has been delivered by the centers and MAIZE via high quality phenotyping for biotic, and especially for abiotic stress, with success illustrated by numerous publications from CIMMYT, IITA and MAIZE.

[28] Kenya field visit presentation by S. Oikeh of WEMA/AATF "Development and Deployment of Water-Efficient, Insect-Resistant and Imazapyr-resistant Maize in PPP" (AATF 8. SOIKEH_CIMMYT-Maize CRP Review_DT-IR Maize_01 Oct 2014-Final)

Genetic data and relationships among germplasm

The MasAgro SeeDs of Discovery project is a major activity in FP2. Through SeeDs and other smaller projects, MAIZE has made substantial progress in characterizing the diversity of maize (>30,000 accessions and high density profiling of 28 samples) and of the breeding germplasm (high density for 2,200 genotypes from six GS populations). A molecular atlas of these accessions represents a valuable reference to engage all maize researchers.

In MAIZE, the new molecular technologies of MAB and GS have, or are being shown to be promising here by providing genetic association markers, although there are no great successes yet in using candidate genes or functional markers for abiotic stress adaptation in maize. GA markers are expected to be able to accelerate breeding via GS.

By 2012, SeeDs had formed approximately 4,500 test-cross populations with breeding parents. About 800 accessions, selected according to aridity indices and passport information, were screened for drought tolerance, with 150 of these (and then 50) progressing to test-cross evaluation for drought tolerance. These generate discovery resources for breeders – new markers for genes (or for alleles of known genes) and "starting" populations of diverse germplasm for those genes or traits. In terms of germplasm, the scale of SeeDs research is unprecedented, providing an immense amount of genetic information. Landraces phenotyped by SeeD are now used by farmers in Southern Mexico as sources of TarSpot resistance.

With SeeDs, the James Hutton Institute developed an online database housing the genetic, phenotypic and germplasm information – a resource for public research and collaboration. Use of this in MAIZE germplasm will be on-going and take time to be realized.

Early/Late stage product development

Germplasm leverage

CIMMYT maize germplasm pools were formed from genebank accessions and improved germplasm over 50 years ago to target various ecologies that included tropical, sub-tropical/mid-altitude and highland groups, with sub-divisions around maturity, grain type and color and other aspects of adaptation (disease tolerances etc.). A shift from population improvement to line-hybrid breeding systems enabled subsequent deliveries in the form of inbreds (i.e. CIMMYT Maize Lines; CMLs) and hybrids from the early 1990s. IITA has a strong record in development of *Striga* tolerant maize in West Africa and is well incorporated into projects (e.g. DTMA) with more testing of *Striga* tolerance in East Africa. Compared with the old international testing, the regional "IMIC" collaborations of MAIZE are more effective, engaging both NARS and SMEs in testing and supporting capacity building.

There is an increasing use of advanced lines (i.e., CMLs) across programs for both hybrid make ups and breeding starts. The CMLs database and descriptors are well documented with increased international movement and testing. The ESA projects also access external germplasm (off plant variety protection) from private companies by introgressing elite genes into MAIZE germplasm.

As documented in the 2013 annual report, the SeeD project provides many types of populations, including "bridging" lines (ca. 75% elite MAIZE germplasm and 25% accession). These are valuable resources for evaluation of novel alleles (e.g. 4,000 testcross progeny populations, 150 1st backcross populations with drought tolerance accessions and CMLs) and for utilization of GS methods to combine useful alleles.

There needs to be frequent and efficient exchange of lines to maximize genetic gain as measured by the "time to recycle" new lines as parents. At present there is no formal, structured process to leverage germplasm globally and among projects, including early stages. Interviews indicated that there are some advancement processes where breeders meet and exchange information and germplasm, but these tend to be within rather than among projects. The currently planned re-organisation of breeding roles will address this.

Pyramiding traits

The breeding programs have made and documented good genetic progress in performances for specific traits (i.e., drought tolerance, low N tolerance, etc.)[29] Several discussions during the evaluation mentioned the need to aggregate major traits and this is a target in IMAS. More special projects are probably needed, ideally assisted by introgression using molecular breeding if possible (see below), and especially for MLN resistance.

Heterotic pool management

The breeding programs apply appropriate methods for advanced line characterization, estimates of combining ability and tester identification for general assignment to A and B pools. There is increasing use of combining ability both SCA and GCA for MAIZE lines to initiate breeding starts. However, in interviews, breeders (in Africa) acknowledged that some lines do not behave as expected and that the heterotic pool definitions for parents and their best targeting for various ecologies are not well resolved. The progressive identification of key widely used inbreds is driving the development of genetic pool structure beyond the A and B general pools. Hence, characterizing this structure and design to enhance heterosis for the different maturities and targets would add value to and increase efficiency of MAIZE germplasm development.

Seed inventory, tracking and shipment

MAIZE has progressed well, managing the inventory digitally, and tracing and tracking shipments to monitor seed movement internationally. This is essential to operations, especially when diseases limit seed movement. A central system to trace and track all shipments in seed movements among the different regions and countries would ensure compliance, backup, accuracy and stewardship.

Acceleration of breeding – DH, MAB and GS technologies

The use of DH and MAB are key to modern commercial breeding. MAIZE has established DH facilities and capabilities in Mexico and Kenya (CIMMYT and KARI), with a partially open-access service model to provide access to MAIZE partners, NARS and small and medium enterprise companies, but not for multinationals. These DH facilities are a major advance for non-temperate maize breeding and MAIZE deserves recognition for innovation and partnering with the University of Hohenheim to deliver this capability for the first time for tropical germplasm (see Chapter 6 on Facilities).

During the field visit, the Kenya facility was shown to be ahead of its schedule toward a capability of 100,000 DH lines per year from 2016 onwards. The full service is a maximum of USD 3,000 per population (usually about 100 lines), while haploid induction only costs USD300 per population. Its major challenge will be sustainability of the model beyond the grant period and effects of constraints on seed circulation in ESA due to the MLN crisis.

[29] Kenya 1st Mar 2014 1. BM Prasanna - MAIZE in ESA (Nairobi; Oct 1, 2014).pdf

Molecular marker research at CIMMYT dates back >20 years, and in recent years the DTMA, WEMA, MasAgro and IMAS projects have begun to use MAB to transfer useful genomic regions between parental lines (see DTMA reviews as noted earlier). Publications and presentations demonstrated that there is excellent collaboration with the private sector and universities with good pilot studies. The molecular breeding team provided numerous examples of marker associations for quality (pro vitaminA) and priority disease traits, including for the urgently needed MLN resistance – an extremely valuable output of MAIZE to develop new MLN resistant hybrids. MAB is already implemented for MSV resistance (Maize Streak Virus).

In DTMA, GS approaches are being tested for drought resistance breeding with additional support from the GCP (Generation Challenge Program). The experience of commercial companies is that the use of markers in GS is of much greater value in a 'breeding-program-wide' approach. This requires much better genetic characterization of the germplasm, high quality data management and analysis and very high levels of cooperation across breeding programs. MAIZE has a global team of molecular breeders with regular on-line meetings and supervision of their delivery of markers and technologies to the field breeding teams, especially for specific trait targets. However, MAIZE will require better process integration to implement GS breeding. We note that increased genetic gain from GS (and MAB) typically requires additional, not substitution of, investment (2015–2016 activities are directed to this) and current phenotyping activities will need to continue.

Finally on this topic, major breeding companies are using computer simulation in genetics to optimize the design of molecular breeding programs (MAB and GS). CIMMYT has capabilities in this area (more so in wheat), although there appear not to be any current applications of simulation to questions of breeding system design in maize. Simulation becomes extremely valuable in the optimization of MAB and GS approaches and should be considered for these.

Cultivar Introduction/product release

There are well established protocols to release MAIZE lines independently at CIMMYT (CMLs) and IITA with clear documentation (web) on germplasm access and request. Both centers provide open non-exclusive access to unreleased material. The criteria and rules to allocate and deliver hybrid seeds to partners (i.e., private sector) varied across ESA projects[30]. Variation among countries in regulations regarding "branding" of germplasm also complicates regional licensing.

Germplasm technical profiles are defined by project for target traits such as abiotic and biotic stresses and by maturity/ecology. However, there are no germplasm technical profiles that aggregate different traits by target systems destination. This is a critical issue for MAIZE. It does not invest sufficient resources in carefully defining target domains. A more precise system and criteria to classify maturities by agro-ecologies, including reference checks, would allow better characterization of lines and hybrids and has begun in Mexico.

Production/Deployment/Seed delivery

There has been impressive seed delivery of hybrids and products by self-funded MAIZE partners. The major delivery occurs via MasAgro-IMIC, IMIC-Asia and the major ESA projects (DTMA, WEMA, IMAS, NUME), which form partnerships with NARS and SMEs and progress products toward commercial release[31]. Region specific germplasm (acid-soil tolerance in Central and Southern America; QPM in

[30] Interviews and discussions on Kenya field visit 1-3 Oct 2014

[31] CRP Annual Reports 2012, 2013, presentations at Inception and Kenya meetings

Ethiopia; drought tolerance in Africa) are well-targeted. Excellent training and capability deployment ensures quality seed production.

Other supporting technologies in breeding

Data and Information management

The Evaluation Team considers that organization of breeding data in MAIZE is very good. Regardless, substantial improvements in data sharing and analysis are required in a modern hybrid program based on the use of DH, MAB and GS.

MAIZE has a clear understanding of the value of having all raw data in phenotypic, genotypic and agronomic databases. Experiments are largely alpha designs, and would benefit from wider use of spatial designs (row/column) and analysis. All programs use fieldbooks with almost complete adoption of electronic fieldbooks. CIMMYT and IITA and projects use different fieldbooks/databases. For CIMMYT projects, there is a requirement for six month uploading of trial information to the central database.

A taskforce in Mexico is making good progress at developing the best system and policy for information management, taking advantage of the existing investments, including participation in the GCP Integrated Breeding Platform. The new versions of the GCP's Breeding Management System have rigorous design and statistical methods, but the CRP will need to support development for breeders using field data capture tools.

The MAIZE 2015–2016 Extension Proposal indicates essential investment in software tools to implement genomic selection. This requires accurate molecular pedigrees, assignment, tracking and recomputation of the value of different genomic regions for multiple traits. A newly funded initiative (CGBO – CGIAR Genomics Back Office), led by Cornell University, with the CG centers as partners, plans to implement genomic data management systems (databases, imputation systems and decision tools) for the integration of molecular breeding across all of the major CG crops. While this BMGF-funded project is needed, project and center relationships (including MAIZE and the GCP Integrated Breeding Platform) need to be carefully managed to enhance delivery of solutions. There was confusion about the coordination of multiple initiatives so MAIZE needs to maintain focus while anticipating developments in CGBO.

Basic research in physiology, abiotic stress, biotic stress

MAIZE builds its reputation for breeding for adaptation to drought tolerance on CIMMYT research that goes back to the 1970s. Breeding for low N began in the 1980s, while heat tolerance and water logging has received more specific attention in the last ten years.

The physiology programs in Mexico, India and Zimbabwe continue to provide excellent service to the breeders in ensuring that screening for drought, low N and high temperature is as well as water logging (India only) done according to best practices. Strong partnerships with National Research Programs, and increasingly with the private sector, have enabled rapid effective reaction to MLN in Africa.

Good screening facilities are available for all of the major biotic stresses, now including MLN and TarSpot in Mexico/Central America. IITA provides strong support for *Striga* research in West and East Africa. Breeders are well supported by protocols and skills in biotic stress evaluation. However, limited attention is given to assess new disease threats and dangers because the researchers involved in disease resistance, for example, seemed to be working directly in screening *per se* with little time

to anticipate monitor or anticipate incursions. In addition to African and Latin American sites, a small, but strong, disease resistance breeding activity is maintained in sub-tropical China and works with a molecular breeder to provide germplasm and markers for major disease resistances.

While the Team was not able to visit the physiology sites, interviews were carried out (see Chapter 6 for platforms and facilities). In Mexico (Obregon) and India (Hyderabad), sites are well-used for screening under high temperature, with extremely high temperatures (> 45C) under irrigation in the dry summer period. Mexican sites (Agua Fria and Tlaltizapan) are still used for low N and drought screening, respectively, although most of the emphasis on this screening is now in Africa. Large-scale screening sites are available in multiple locations for both drought (currently DTMA and WEMA supported) and low N (IMAS). Physiological research efforts focus on (1) improving the heritability and genetic basis for current physiological traits, (2) identifying new traits and (3) developing high-throughput screens for traits, including use of aerial surveys. The latter two activities are undertaken via research projects that involve ARIs and/or local partners[32].

In field research, MAIZE tends to develop new phenotyping capabilities in projects and to involve partners to facilitate it. Publications include new research being done on new phenotyping methods using remote sensing (thermal, Normalized Difference Vegetation Index from aerial, and digital cameras and GreenSeeker on ground). However, despite on-going physiological research into related traits, the actual phenotyping and selection protocols used by breeders have not changed substantially in 20 years, i.e. there is an opportunity to improve genetic gain by developing and deploying more efficient selection protocols. An exception may be new (unpublished) protocols (leaf firing and tassel blast) in heat trials. According to the HTMA 2014 report, the physiology focuses on leaf tolerance of heat, but elsewhere research in sorghum shows good opportunities to screen for pollen/grain-set traits under extreme heat.

The Evaluation Team noted that MAIZE has no dedicated facilities for plant-based physiology and modeling research. This is a deficiency in terms of opportunities to undertake high-throughput screening for specific traits. As noted in a recent CGIAR study commissioned by the ISPC[33], phenotyping has a new role in the genomics era. That study comments at length on the out-sourcing of genotyping and needs for capability in bioinformatics. It also indicates a strong need for improvements in “trait dissection” and phenotypic prediction and the opportunity for the CGIAR to establish high-quality hubs for such research. While the Evaluation Team does not advocate the use of expensive “conveyor-belt” systems for maize evaluation, a strong case can be made to undertake “plant-based” pot research for targeted traits like heat and drought stress. For example, ICRISAT has developed a proven platform to evaluate and select for genotypic variation in water use efficiency and response to vapour pressure deficit. IRRI has similar facilities, but such facilities are not notably part of the CIMMYT infrastructure or staffing. There is some work on pot-based drought and waterlogging assessment by CIMMYT at ICRISAT, but the Team was not briefed on this. Difficulties in screening for pollen viability under high temperature could also be addressed by pot vs. plot experiments. A recent paper from a commercial company[34] summarizes successful breeding outcomes using multiple “plant-level” and “crop-level” phenotyping technologies and crop modeling to select for drought resistance in maize. Given the co-location of MAIZE staff in Hyderabad, there should be a strong case for synergy with the Dryland Cereals CRP on this topic.

[32] For example, the aerial phenotyping research is in collaboration with the University of Barcelona with the Zimbabwe NARS facilitating the aerial activities that are contracted to the University of Cordoba.
[33] Strategic Study of Biotechnology Research in the CGIAR 2014
[34] Cooper et al. 2014 http://www.publish.csiro.au/paper/CP14007.htm

Another role in support of research is environment characterization and prediction of adaptation profiles to plan breeding activities, and in some cases directly support breeding. Crop modeling is a key tool and CIMMYT has previously made effective use of simple model analyses of weather, soil and system constraints to define mega-environment targets. This contributed to design of projects like DTMA, although the work may now reside more in other CRPs like CCAFS. No crop simulation modeling currently appears to be used in breeding or physiology[35], although we note a CGI project with the University of Florida. The only "modeling" presented was disappointingly naive and involved attempts by socio-economists (in a CCAFS project) to use crop models to predict adaptation zones and potential yield value of new hybrids. While we saw good quality validation trials in Ethiopia, which were descriptive and insufficient to allow the models to be accurately parameterized for drought traits, the modeling work (potential adaptation of a new hybrid) was based on non-validated parameterization (changing root growth parameters etc., with no experimental evidence). Substantial improvement is needed here if value is to be realized in either the conduct or assessment of breeding program efforts.

RS2 has many quality processes and protocols for discovery, breeding, product delivery and supporting technologies for the breeding programs. The next stages of molecular breeding may require reconsideration of staff needs and roles, as well as new investments (as indicated in the 2015–2016 plans) to build the required tools and databases to implement these stages. Field breeders will need direct support to use these tools.

To facilitate this research strategy, MAIZE has:

- Newly renovated state of the art R4D facilities at CIMMYT HQ
- Mechanization and use of modern equipment and techniques.
- DH facilities in Mexico and Africa (Kenya)
- Mid-altitude screening for MLN in Kenya
- SAGA (Genetic Analysis Service for Agriculture) in Mexico
- Unique networks of field phenotyping platforms for abiotic and biotic stress screening
- Confined field facilities at five sites for evaluation of GMO products (WEMA) and under low N at three sites (IMAS)
- Open access policy for most of the sites and infrastructure

The MLN and DH platforms are appropriate in terms of scale and quality, and both African facilities were developed using bilateral funds. The DH facility was fundamentally dependent on the support of the University of Hohenheim (see section on Partnerships) to deliver tropically adapted DH inducers. SAGA (funded by MasAgro SeeDs of Discovery as collaboration between INIFAP Mexico, CIMMYT and DArt (an Australian genotyping company)) complements screening and germplasm activities by providing a computerized genetic analysis platform in Mexico to supply services and training.

The phenotyping platforms have been well established to characterize particular phenotypes of value in breeding for abiotic stress tolerance. In Africa, the DTMA, WEMA and IMAS projects provided much of the support to establish field screening platforms. In Mexico, SeeDs of Discovery helped support existing platforms and develop new ones for drought tolerance screening (Tlatlizapan and Iguala), heat resistance (Ciudad Obregon), low N conditions (El Batan, Tlatlizapan, Agua Fria) and biotic stress tolerances (four sites testing for *Cercospora* leaf spots, *Fusarium* stem rot, *Puccinia* spp., rust, *Turcicum* leaf blight, and tar spot). To support the next era of phenotyping, the platforms will need to implement better environmental monitoring and data management. There are several untried

[35] U Florida have a CGI project involving modelling, but no details were given.

options for high-throughput phenotyping and support for valuable new phenotyping technologies will be needed. There are also challenges to optimize effective use of infrastructure, especially the basic research buildings, and to ensure that they remain up-to-date.

CIMMYT does not use "plant-based" platforms (greenhouses and controlled environments) that allow more thorough investigation of traits. These are typically accessed through partnerships. However, it is an issue that should be considered in molecular and trait-driven breeding, particularly as related to trait-dissection and discovery.

4.4.3 Outputs

The main IPG-type outputs of RS2 are germplasm [commercial hybrid combinations, parental lines, coded lines (CML), partially improved germplasm with specific genes or traits, synthetics and populations]. Other outputs include: screening methods and knowledge on abiotic and biotic stresses, gene and marker information associated with traits, studies of genetic diversity and the genome, breeding technologies/protocols, data management and analysis technologies, seed systems research and for all areas: reports, publications and training. Smaller projects may only produce one output, but these feed into other projects, e.g. a new phenotyping or gene-trait marker feeds into new base germplasm and future hybrids.

Novel genes, traits

The outputs of these are largely discussed in the previous section under "processes". MAIZE projects, especially MasAgro SeeDs of Discovery, have been prolific in output of gene information on bank accessions and released lines, as well as specific-purpose populations undergoing phenotyping for multiple traits. At least one new gene (for resistance to tar spot) has been discovered and is being transferred into breeder-friendly germplasm. The project has filtered a large number of accessions into crosses with elite materials that are still undergoing testing. Broad-based populations are undergoing genomic selection to create novel combinations of stress-tolerance genes, and will yield more information on traits *per se*.

Regarding physiological adaptation, MAIZE is testing high throughput phenotyping using ground and aerial methods, but these are not yet adopted in breeding. There is little plant-level or modeling physiology research for adaptation, and little evidence of outputs here, which are likely needed for the next innovation in stress adaptation. Good quality markers are developed for some specific disease tolerance genes. Methodologies around GS breeding are being developed, but there needs to be good coordination among numerous activities in this area (in-house, Integrated Breeding Platform, CGBO).

Germplasm

The latest MAIZE annual report (2013) comments on delivery of germplasm to various countries. High quality lines and hybrids are being made available for all of the MAIZE target ecologies and these are delivered to the point where needed according to the "seed roadmaps", whether it be for breeders seed or beyond. During the evaluation many examples were presented to show the historical benefits of the improved germplasm and of the new materials from several projects. Major issues relate more to the role of MAIZE in seed delivery and in inconsistencies among projects in how licensing works, including exclusivity. Conventional hybrids are being widely adopted in target countries and are delivering yield benefits, especially where the appropriate agronomy can be provided (see Chapter 7).

The main product releases from MAIZE occur in Africa. Prior to MAIZE in 2011, 90 varieties had been released by CIMMYT and IITA, increasing to 160 (mostly hybrids) by 2013, but these obviously were developed prior to MAIZE. An application by WEMA has been made for testing/release of +Bt GMO hybrids in Kenya and these could become a valuable product where stem borer exists. In field trials of 34 hybrids over 3–5 years at five sites, WEMA transgenic hybrids had yield advantages of 8 to 14% compared with their non-transgenic versions. Hence the expectations from GMOs for drought tolerance are not as high as for insect tolerance and there is likely still great value in selecting for drought tolerance using molecular breeding and managed environment phenotyping.

MAIZE works with partners on several other novel types of germplasm. For example, with the Livestock and Fish CRP it is developing dual-purpose maize to support grain production for poultry and stover for beef, stover being valuable in India. The Integrated Striga Management Project (ISMA) was not reviewed by the Team, but is an important research topic as *Striga* affects large numbers of farmers in Nigeria and Kenya. *Striga*-resistant hybrids from IITA's previous research are being tested in ESA, along with Imazapyr-resistant hybrids that were developed with BASF[36]. The Imazapyr-resistant hybrids can tolerate the Imazapyr herbicide seed coating treatment that kills *Striga* when it tries to infect the young plant. During the Kenya field visit we met a representative of a medium-sized seed company (NASECO, Uganda, >1500t seed sales) that has developed "picture" packaging and small training and demonstrations to successfully sell Imazapyr-resistant hybrid technology to smallholders and is actively working with MAIZE to deliver new Imazapyr-resistant hybrids with better stress tolerance. One issue to be considered is whether these Imazapyr-resistant hybrids can also tolerate within-season spraying of Imazapyr and if this would represent progress toward a low-till management system. A third example of specialized maize is the continued successful uptake of QPM, especially in Ethiopia. Maize production in Ethiopia has been increasing by 5% per year with a substantial development in the more moderate climates of the mid-altitude and highlands. Multinational seed companies have been attracted to these climates, which may impact on the role of MAIZE.

4.5 Quality in Research Strategy 3

4.5.1 Research staff

As in other research strategies, leadership and scientists are strategically located at in the field and at headquarters. The lead social scientist of CIMMYT was located in East Africa but has recently moved to headquarters. The lead social scientist of IITA is located in Tanzania, while the senior MAIZE agricultural economists are located at headquarters in Ibadan. In recent years there has been rapid growth in RS3 projects, with resulting substantial increase in number of scientists involved: 16 of the 30 socio-economists in CIMMYT have been there for more than two years. As for RS1, this implies a particular challenge to management to ensure that these capable, but sometimes young and relatively inexperienced, scientists are properly mentored and supported. Overall, RS3 staff maintain a culture of quality and relevance as evidenced by our interviews and field visits. Leading social scientists at CIMMYT, which accounts for 90% of MAIZE projects, have H-indices of 5 to 11, which is good given that this SCOPUS ranking includes relatively few social science journals. While most of staff have a background in social sciences (agricultural economists, sociologists, anthropologists and gender experts), the post-harvest and aflatoxin research, some of which is allocated to RS3, is conducted by other disciplines.

[36] Kenya Field Visit presentation by S. Oikeh of WEMA/AATF "Development and Deployment of Water-Efficient, Insect-Resistant and Imazapyr-resistant Maize in PPP" (AATF 8. SOIKEH_CIMMYT-Maize CRP Review_DT-IR Maize_01 Oct 2014-Final)

4.5.2 Process

A major strength of RS3 is its broad implementation of on-farm studies across the major maize growing regions, particularly of sub-Saharan Africa and East Asia. In-depth adoption and impact studies are conducted in 12 African countries with large datasets that provide the basis for cross analysis, validation of technology, specification of desired technology characteristics, priority setting and feedback to breeders, physiologists and agronomists (see also Chapters 5 and 7). Several high standard manuals and protocols have been developed for on-farm data collection and analysis, impact assessment and gender research. For improved grain storage, work has been conducted in six countries (Kenya, Malawi, Mexico, Zambia, Zimbabwe and Ethiopia). Aflatoxin bio-control research is conducted in eight countries (Nigeria, Burkina Faso, Kenya, Senegal, Zambia, Mozambique, Tanzania and Ghana).

Overall, RS3 has effective partnerships with national programs, universities and ARIs. All partners met during our field visits or interviewed praised the quality of interactions and partnerships with MAIZE. Much of the collaborative research is multidisciplinary. In general, capacity for social science research is weak in national programs in Africa, and both IITA and CIMMYT scientists play an important role in strengthening the capacity through their collaboration.

4.5.3 Outputs

Outputs of RS3 comprise mainly technical reports and publications and are generally of high quality, and correspond largely with those of the annual workplans. Many of journal articles by MAIZE social scientists in 2012–2014 were published in multidisciplinary journals. The ability of socio-economists to publish multidisciplinary research results is a major strength. The Evaluation Team concludes that these publications were of high quality. Overall the Evaluation Team considers output of RS3 to be very good. A majority of social science research outputs are studies on adoption and impact assessment (see Chapter 7). MAIZE social scientists also publish on foresight and targeting through *ex ante* analysis and these outputs are particularly innovative. Methodologically, several of the publications are front-runners in the literature. Social scientists partner with high level universities and research institutes in their fields of research and analysis, allowing this aspect of MAIZE to progress fast.

Most of the information on post-harvest and storage research was found in donor project reports. While the outputs were adequate, little evidence of research outputs appears in recognized journals. The Evaluation Team did not have sufficient information to make a judgment on the scientific rigor and quality of work on grain storage, which appeared to be more development oriented and adaptive in nature, with few if any research goals. This issue has also been addressed in Chapter 3 in the discussions on program coherence and comparative advantage. It is also pertinent to the discussions in Chapter 6.

4.6 Conclusions and recommendations

Overall, the Evaluation Team concludes that the quality of MAIZE science is good, with several areas that are excellent. Research design and approaches are innovative and sometimes state-of-the-art. Processes and partnerships are designed to ensure that latest scientific thinking is reflected in methodology and analysis. Outputs, people and processes of RS2 are of exceptionally high quality compared with any public breeding effort for maize. Internal processes to assure science quality appear to be robust. The publication record is excellent, with ten CRP scientists having H-factors greater than 15, which is good in this area of science. However, there are some challenges to ensure

that the best science is deployed in breeding programs within MAIZE and with partners. Attention needs to be given for better protocol documentation (see also Chapter 5 and Recommendation 6).

Recommendation 4: MAIZE should Improve deployment of new phenotyping technologies into breeding and extend science into trait dissection, plant-based phenotyping and modelling for adaptive traits through engagement with other CRPs and groups of excellence. A study to benchmark research activities in MAIZE with best-practice in private sector should be conducted to identify opportunities for improvement.

Recommendation 5: MAIZE should continue to support the deployment of a broad array of germplasm options and genetic resources and broaden the funding base for discovery and development of high-value trait lines. More focused product design, network trial results and seed market assessments should be used to decide when to withdraw to a "regional role". A study should be commissioned on collaboration models, such as fee-based hybrid consortia, to explore options for funding support toward the development of parental lines.

5. Effectiveness

5.1 Overview

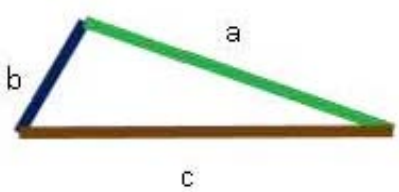
In order to estimate MAIZE effectiveness, the Evaluation Team addresses the three main structural components of MAIZE: (a) People, organization and infrastructure, (b) Processes and protocols, and (c) Project portfolio. These components are illustrated below in Figure 5-1 as the three sides of a triangle, and they have been referred to also in Chapter 4 on QofS. There is a need to establish the right dimensions for each side of the triangle in a balanced way to ensure sustainable growth and development of MAIZE. The framework also allows for an assessment of how MAIZE, through its research strategies, is making progress in producing outputs and reaching outcomes.

Figure 5-1: Balancing people, processes and project portfolio for effectiveness

Source: Constructed by Evaluation Team

The People and infrastructure side of the effectiveness triangle is part of the permanent MAIZE structure and encompasses, among other things, the MAIZE organization, functions and roles, functional and project structure, capacity development and infrastructure. The Processes and Protocols side is also part of the permanent MAIZE R4D structure and accounts for program policies, processes, protocols, working instructions, and quality management. For sustainable intensification (RS1), these would include recommendations on good practices for evaluating agronomy, biophysical, and environmental performance at agro-ecologically representative sites, including data management. In breeding (RS2), these protocols serve particularly to support measurement of Genotype x Environment x Management interactions. The Project portfolio side is the transient MAIZE R4D structure and accounts for portfolio size, synergies and design, project management, and program prioritization and resource allocation. Management that considers and adjusts the three sides of the triangle so that the permanent structures support the transient structure optimally ensures a sustainable, efficient and effective program. Figure 5-2 illustrates the current situation with MAIZE with processes and protocols not yet sufficiently adjusted to accommodate the growth in staff and the size of the project portfolio.

Figure 5-2: Current MAIZE regarding balance of people (a), processes (b) and portfolio (c).



Source: Evaluation team

During recent years MAIZE has rapidly increased its project portfolio (side c) and people and infrastructure (side a). This rapid growth has not been accompanied by development of processes and protocols (side b), which is becoming a potentially limiting component. There is, therefore, an imbalance among the three components, which ultimately affects effectiveness, impact and sustainability. All three sides of the triangle should be sufficiently strong. The imbalance was also detected in the researcher survey. Almost 40% of respondents reported that they worked in three or more MAIZE projects, which can be challenging for maintaining focus and project coherence. In Chapter 8, Figure 8-1 refers to the issue of strain in processes related to quality management, indicating lower researcher satisfaction with the measures: "Learning and knowledge management" and "Encouragement for learning from failure". When asked about the value that MAIZE had added to research implementation, disagreement was expressed for statements saying that MAIZE had "good potential to streamline administrative procedures" and "addresses capacity development more strategically", indicating these issues need to be addressed. Effectiveness of the program requires processes and protocols to be available in and across projects to guarantee quality of output. Given the rapid increase in numbers of staff and projects, more emphasis should be given to methods and manuals to ensure consistency.

5.2 Progress toward outputs

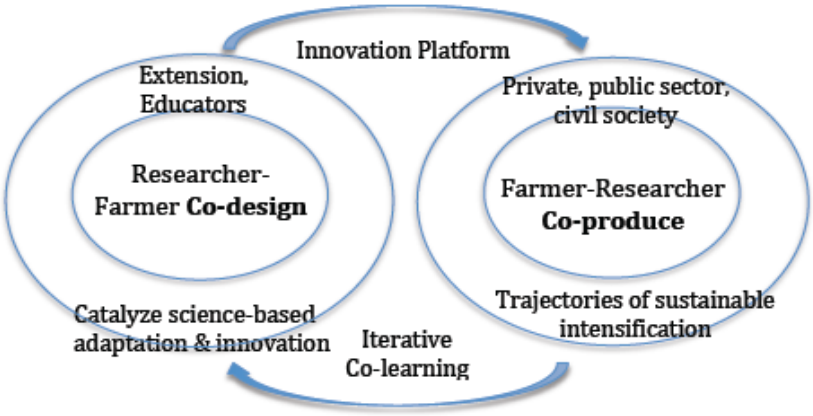
5.2.1 Research strategy 1 – Sustainable intensification

The sustainable intensification approach in MAIZE has resulted in progress in developing a science-based approach that is likely to enhance effectiveness in systems productivity and use of natural resources. Agronomy is undergoing a revolution in terms of information processing, data management and synthesis to support a systems understanding, as well as catalyze innovation at scale. MAIZE is making good progress in the application of remote sensing approaches linked to catalyzing innovation and monitoring the process, and more site-specific applications of spectral approaches and other data layers for large-scale phenotyping and assessment of heterogeneity linked to systems modeling. MAIZE is also innovative in terms of multidisciplinary research incorporating agronomy, plant physiology, plant breeding and social science. In 2013, 88% of annual milestones have been reached, with good reasons given for why not all targets were realized.[37]

Building on these strengths, a more clearly articulated research and development system for sustainable intensification is needed for MAIZE and its partners. There has been a considerable amount of work done on how to move from a pipeline model of research-extension-farmer transfer of technology to a modern, iterative co-design and co-production of knowledge model that is appropriate for the complexity of agronomic technology development. Figure 5-3 emphasizes iterative co-learning to catalyze innovation in sustainable intensification technologies so that they are adapted to local circumstances and become adopted. There is a need for MAIZE to revisit its sustainable intensification research and development strategy accordingly. Many variations of this model are under discussion in sustainable intensification science, and the Team suggests that MAIZE develop one for RS1 and train program scientists and partners to implement it. This would enhance the process of learning and adaptation of innovation, and boost effectiveness. To bring sustainable intensification science to the next level, articulation of a model is necessary to implement research activities in line with IDOs and be able to produce effectively outputs that support R4D goals.

[37] MAIZE 2013 Annual Report

Figure 5-3: Iterative co-learning and innovation platforms



Source: Personal communication with Prof. Emilio Moran.

Researchers face infrastructural, educational and resource constraints in sustainable intensification research in Africa and South Asia. MAIZE is at the cutting edge of the development of novel approaches to support quality research in this environment, working at scale with a range of partners. An iterative process is required, where "deep dive" participatory action research sites provide opportunities to understand drivers of adoption and biophysical processes, and where findings are then fed into priority setting for large-scale dissemination and education efforts and to inform new project design. Linkage of participatory research to innovation platforms is producing outputs at many sites (for example in Rwanda), although there is need to enhance investment in systems approaches, modeling and statistical synthesis in order to evaluate performance at various scales. Senior MAIZE agronomists are aware of the lack of capacity in these areas and are taking steps to address this through training, mentoring and hiring. It will continue to be a challenge to attract the necessary funding to invest in demonstrations, innovation platforms and related R4D activities, which do not necessarily achieve impact unless additional investments are made to strengthen protocols and methodologies that support science quality and learning throughout the R4D process. However, we note in the extension proposal that FP1 is seeking investments in Farming Systems Analytical Frameworks, with the main objectives being to target and monitor adoption-appropriate technologies and then to scale out.

The progress in addressing effectiveness in MAIZE is illustrated through shifting away from a promotion approach to conservation agriculture that was historically, in some cases, promoted with little regard to local biophysical and socio-economic environments or farmer priorities. In the absence of iterative and system-wide learning protocols being in place, and with continuous pressure from donors, large numbers of demonstrations were conducted and data were not always collected systematically or quality checked. This is a challenge for all large-scale R4D agronomy projects, but MAIZE has made investments and efforts in the direction of more evidence-based science, data management improvements and systems analysis. This has led to valuable publications on dual use crops for livestock-integrated systems, improved datasets, and gains in knowledge around the diversity of farmer perceptions, priorities and adaptations of technologies. Crucial steps towards achieving the ambitious targets of FP1 are underway, although continued investment in collaboration of agronomists and socio-economists will be required in order to target poorer households and understand better the dynamic market for maize as food, feed and fuel. Furthermore, breeders and systems researchers work according to different timelines and recommendation domains, but there is increasing collaboration and a joint strategy is currently elaborated.

There are strains on the process and future outputs could be in jeopardy as there is an urgent need to redress the imbalance imposed by major bilateral funded projects and the necessity to hire large numbers of sometimes inexperienced staff. This requires a focus on systematic assessment of best practices for many on-farm research approaches, to feed into protocol development and large-scale training in protocols, as well as in systems analytical tools and data management.

5.2.2 Research strategy 2 – Stress-resilient and nutritious maize

As mentioned above, the growth of this portfolio has increased during recent years with a broader and stronger donor base supporting bilateral projects. Progress towards delivery of outputs is good, and in 2013 ranged between 85% and 90%. The 2015-2016 Extension Proposal outlines CoAs, which influence the deliverables from FPs 2, 3 and 4. These CoAs range from gene discovery and informatics through to capacity building for small companies. Currently MAIZE does not have a complete and fully documented R4D stage plan (from discovery to deployment) that can be used across projects as a reference for how the CoAs fit together. The roles and functions with corresponding accountabilities within MAIZE are also not fully aligned between CIMMYT and IITA. Figure 1 in Chapter 1 presents such a stage plan.

The breeding programs are generally able to use high-quality, well-proven, managed-environment phenotyping platforms for screening for abiotic and biotic stresses, followed by regional cooperative testing. There are some informal measures for R4D and processes such as CML releases. However, there is no fully documented R4D stage plan that can be applied and used across projects as a reference. Apart from the need for precise documentation of stages and protocols, the operational needs to improve efficiency of the breeding programs are largely minor to bring them closer to commercial best-practices by deploying enabling technologies, e.g. electronic collection tools, best-practice statistical designs, use of historical pedigree data in decision making, earlier exchange of germplasm information across breeding projects. The development and implementation of an R4D stage plan with gateways, roles and accountabilities would assist MAIZE to be consistent across projects in guiding progress toward outputs and to also measure progress towards milestones and outcomes.

The open access delivery of MAIZE germplasm (CMLs and IITA inbreds) through a standard material transfer agreement (SMTA) has facilitated the deployment of MAIZE germplasm globally and increased likelihood of impact. However, some conditions in the SMTA on IP rights and benefit sharing may limit the use of germplasm breeding by large seed companies. Some bilateral projects, such as WEMA, have enabled introgression of private sector germplasm into MAIZE pools, enriching the genetic basis for developing stress tolerant varieties. Recently MAIZE has developed a new portfolio associated with seed systems and hybrid releases. The Evaluation Team considers that these systems help to scale-up the adoption and impact of improved varieties. In conjunction with the AATF, the WEMA project is also vital in establishing facilities for confined testing of GMOs and initiating government policy decisions by making commercial applications for GMO release. These activities are extremely important in a future where GMO maize (insect or herbicide tolerant) could greatly influence labor requirements and promote evolution of more flexible cropping systems.

Commonly, resources (germplasm, facilities, equipment, knowledge) from one project are used in parallel projects and/or in subsequent projects. There are good examples of continuity of projects supporting stronger networks and deliverables in RS2 (e.g., DTMA, IMAS, IRMA, WEMA). However, by design, the projects are typically managed as silos, without sufficient and timely cross leverage. In addition, different donors impose different project management requirements and conditions, limiting the synergies across projects. MAIZE infrastructure enhances an integrated approach across bilateral projects. There have been efforts to adjust the program and search for complementarities

and synergies between CIMMYT and IITA, and the Evaluation Team encourages MAIZE to drive and design processes for integration of projects.

In general, the large projects appear to be well managed with responsibilities assigned, milestones defined and timetables defined. The reports for projects are generally well documented, as evidenced by the Evaluation Team's project review, although the level of detail on results obtained varied. There is good progress towards producing research outputs in projects targeting Africa and Asia, where MAIZE (i.e., CIMMYT and IITA) has an established reputation and solid networks (e.g., DTMA, WEMA, IRMA). The number of projects has increased rapidly, presenting challenges to optimize management and delivery. There is also a series of small projects, which are orphans regarding project management. The continuous interactions of MAIZE research leaders with stakeholders and donors are crucial to ensure that project renewals are focused on joint priorities (donor & CRP) so that funding is continuous to support effectiveness towards objectives. Program design for enhancing likelihood of impact and standard reporting for all projects accepted by donors would free time to key scientists who are currently overloaded with administrative tasks.[38]

People and their organization are essential components for a program's effectiveness. MAIZE attracts international talent and supports high quality science and critical staff establishment. Staff are the principal asset that require good management. The rapid increase in the number of scientific staff has presented management with challenges. There are still differences in organization and personnel management between CIMMYT and IITA. The Evaluation Team encourages MAIZE to develop and enhance opportunities for skills development and training of MAIZE scientists. Bringing in new skills to conduct modern breeding and research, with a solid training curriculum, is crucial to MAIZE's success. This would also include mentoring of young scientists.

The staff performance management system at CIMMYT aims to provide institution-wide equitable treatment for all IRS, recognition of outstanding performance, and alignment of staff success with project and institutional success. According to the documentation shared by CIMMYT with the Evaluation Team, the KPIs, workplans and other information routinely uploaded to the online Research Management System (RMS) provides information for annual performance assessment of CIMMYT IRS involved in CRP-related research. Multi-source feedback is obtained on competencies such as teamwork, partnership, and responsiveness, as well as on skills such as work planning, achievement of KPIs, and budget management. This feedback is obtained annually from supervisors, project leaders, program managers and program directors. Based on KPIs accumulated by individual researchers over several years, the CIMMYT Management Committee decides on merit increases and promotions (researcher perceptions on incentives for science quality are discussed in Chapter 4). A joint capability and education program (i.e. $Research^{Capability} = R^{C}$) in MAIZE would enhance further the scientists' power to deliver results. The issues discussed above apply to researchers beyond RS2, but are particularly important in the sequence of research and breeding activities in this strategy.

The Evaluation Team encourages MAIZE to address its R4D policies, processes, protocols and working instructions (side "b" of the triangle). There are some processes established and documented for CML releases, international testing, information management, RMS, personnel performance management, etc. Nevertheless, there are gaps at all levels in quality management. The documentation of policies, processes and working instructions is neither sufficiently evident nor clearly structured when it is evident. This affects negatively on the effectiveness of MAIZE.

As seen in the R4D stage plan, the central breeding effort comprises four activities. Commercial breeding programs use line breeders and product development breeders, who then hand over

[38] See Annex E for survey responses on questions 26 and 27

products to seed systems specialists who manage germplasm distribution for targeted markets. A fourth activity is sometimes termed "special projects" or "conversion projects" where a breeder targets a specific challenge by exploiting diverse source germplasm and/or develops methods to introgress specific traits into existing parental lines (aided by "discovery" in both native traits and GMO traits). The MAIZE breeding programs are clearly involved in all of these activities, but the lack of clear handovers between stages and the project-driven structure mean that there are inefficiencies in the timeliness of exchange of knowledge and germplasm that potentially slow genetic gain.

On the positive side, interviews conducted at the inception meeting assured the Evaluation Team that MAIZE is in the process of restructuring staffing to have line, product and special project breeders, rather than having single breeders manage the entire process. Special project breeding is becoming more important and is driven by the use of molecular tools to identify markers for useful genes and creation of novel parents to integrate into populations. Interviews indicated that the molecular breeding team meets regularly (almost weekly) to set priorities and ensure that they can inform field breeders of progress in introgression across all of the projects. While the special project (molecular) breeder roles are well defined and managed, the staffing of field breeding may be better supported if the R4D stage plan specifically articulates products as being lines and hybrids, so that breeders are properly recognized for delivery in both areas. Currently, evidence from interviews suggests that there is some perception that there is a higher level of prestige associated with delivery of hybrids. Defining processes, protocols and working instructions for the main activities in MAIZE would articulate common understanding across projects, support internal training for implementation and enhance evaluation for improvement of activities.

5.2.3 Research strategy 3 – Inclusive and profitable maize futures

This research strategy is new and combines earlier strategic initiatives of different orientation (as discussed in Chapter 3). Overall, on the basis of annual reports, it seems that since the inception of MAIZE 90% of planned activities have been realized and milestones reached. Outputs have been clearly linked to outcomes and broader development goals. Annual reporting is highly satisfactory. It was however not clear whether and how results from on-farm and adoption studies were used feeding back into program design and prioritization (identification of new technology needs) for improving efficiency and likely effectiveness. For example, gender studies (Kenya, Malawi) indicated a lower rate of adoption of modern varieties by female farmers, but it was unclear how these results were subsequently used to improve technologies, extension guidelines and policy design. Lack of feedback mechanisms was also noted by Royal Tropical Institute (KIT; 2013) in its evaluation of innovation platforms.

In interviews during field visits, scientists sometimes expressed frustration about the lack of a mechanism for sharing results and experiences across projects, and for ensuring that projects were building blocks towards a program.

Reasons for non-adoption of technology are not always adequately translated into specific recommendations for technology design or policy changes. While almost all adoption studies provide adequate reasons for non-adoption, it was not clear to the Evaluation Team how this information was fed back more broadly beyond the project. Only few project reports made systematic use of this information. As noted in Chapter 3, the question could be raised as to whether socio-economic studies should be crosscutting to support the relevance and impact-orientation of RS1 ad RS2. As evidenced by the Evaluation Team's field visits and interviews, and the quality of outputs, partnerships in RS3 are considered productive and effective. It is too early for the CRP to estimate actual development level results of RS3 activities (to the extent they have direct development target

domains rather than influence other RSs), but adoption rates of technology developed pre-MAIZE appear to be very promising.

Overall, it is concluded that CoAs in RS3 were on track and making progress, that monitoring and reporting on milestones is adequate, but that feedback mechanisms, an essential impact pathway for some of RS3 activities, need to be improved. FP5 and earlier social science work has played a major role in enhancing the likely effectiveness of MAIZE (*ex ante*, constraint studies etc.). Mechanisms for quality assurance seem to be in place through the RMS and M&E systems. Given that RS3 and FP5 were only conceived in 2014, it is considered as work in progress, but as noted earlier, this strategy may need to be revised by making social sciences as a cross-cutting theme. Financial constraints appear to cause delays in implementation of much needed studies on new market opportunities, consumer acceptance and value chain analysis. It also appears that the innovation platforms are, according to field interviews, very promising in countries including Rwanda, but not yet fully operational in other countries, such as Ghana. MAIZE is currently conducting a study on the reasons for success or otherwise of its innovation platforms in Africa.

5.3 Monitoring, evaluation and enabling for internal processes for enhanced effectiveness

In reviewing the effectiveness of MAIZE, the Evaluation Team also looked at its management system. The achievements and KPIs for scientists are also used in the on-line RMS by CIMMYT and MAIZE to assess progress. The RMS also includes information on research publications, training events organized by scientists, and the students, interns, and visiting scientists supervised by them. Based on documentation review and analysis, overviews provided by MAIZE staff, and discussions with researchers, supervisors, project leaders, and program directors during field visits, the Evaluation Team concludes that the system for managing MAIZE-related research projects and the research portfolio as a whole is an appropriate one, but can be improved. Projects are generally well run, but during the field visits it appeared that there was little interaction and exchange of results among projects. Some of the bilaterally funded projects are not well integrated with the rest of the MAIZE portfolio and learning from project experience is not systematically shared across projects or countries/sub-regions. A general lack of opportunities for lateral learning across projects and research areas was observed.

The researcher survey indicated that 25-30% of the staff were dissatisfied with aspects of their working conditions, including the reliability and predictability of W1-W2 and bilateral project funding, and the share of time allocated to research compared with that allocated to or required for non-research activities, such as administration, meetings, coordinating among partners, other CRPs and centers, and training and mentoring. About 25% of the survey respondents were also dissatisfied with the incentives for working across themes and disciplines in MAIZE.[39] This level of dissatisfaction could have negative implications for effectiveness.

Management and oversight of CRP progress are discussed in Chapter 8. Each partner institution uses its own monitoring system, but the lead center has the responsibility of ensuring that the MAIZE-funded research is managed, monitored and reported in accordance with the applicable agreement with CIMMYT.

Information of the CRP-related M&E system was obtained through extensive document review, overviews provided by CIMMYT and MAIZE staff during the Evaluation Team's inception visit to

[39] See Annex E for researcher survey results on question 27

Mexico in May 2014, and discussions with researchers and managers involved in MAIZE-funded research. The M&E system is being set up and therefore the extent to which it is likely to enhance the CRP's efficiency and effectiveness cannot yet be assessed. A new M&E specialist has recently been added to the MAIZE management unit (as a joint appointment with the WHEAT management unit). During the past few years, as part of the CGIAR reform, external reporting requirements and associated transaction costs have increased significantly. The new M&E specialist has reviewed the M&E system of MAIZE and identified gaps that need to be addressed, including inadequate feedback mechanisms and results orientation, and the need to strengthen performance measurement standards and learning experiences. These measures are likely to enhance the effectiveness or M&E for management purposes. The overall goal of the new M&E system will be to foster a results culture. This will include a performance measurement plan and a rolling evaluation plan, and more emphasis on M&E learning and knowledge management. Based on this information, the Evaluation Team considers that the efforts to strengthen the MAIZE M&E system are appropriate. The M&E system, when fully established, is likely to strengthen learning culture and results-oriented approaches.

The MAIZE socio-economics program, in terms of relevance, quality and effectiveness, has been discussed in previous sections. Socio-economic analysis is also needed for identifying areas of research that can be terminated. *Ex post* assessment is also an important dimension of M&E, and a specialized area of socio-economic research. MAIZE needs to assure adequate resources at the end of project assessment and for *ex post* impact assessment, both for accountability and for strengthening feedback to MAIZE for portfolio development. The expectation of CRPs to document achievement of results at development level and contribute to the IDOs means that MAIZE needs to allocate adequate resources to this.

5.4 Conclusions and recommendations

Overall MAIZE is on track in terms of progress toward outputs and outcomes. The Evaluation Team assessed milestones and outputs mainly on a project basis. In the biggest projects (DTMA, WEMA, IMAS, etc.) the issues of scaling out, and limitations and delays to progress, are being addressed. MAIZE projects have a strong focus on deployment of technology and adoption, increasing their likely effectiveness. In many projects, assumptions related to the theories of change need to be sufficiently understood and acted on for enhancing potential for impact.

MAIZE has many large projects that are successfully implemented and have generated research results on schedule. While individual projects can be very effective, MAIZE effectiveness can be improved, particularly through enhancing the CIMMYT – IITA relationship and partnership through adoption of common processes and exchange mechanisms not yet fully implemented. Program effectiveness could be improved by better defining processes and protocols, enhancing synergies across projects, and introducing common organization across CIMMYT and IITA. The integration of the currently separate maize programs of CIMMYT and IITA into a single maize program, would improve cost-efficiency and effectiveness in the organization of the research and capacity building activities.

Recommendation 6: MAIZE should institute management measures to ensure efficiency and effectiveness in management of staff and research activities over the long term. These measures should include:

- processes for engaging and motivating staff in delivery oriented research through mentoring, training, and cross disciplinary and cross-institutional lateral learning;
- protocols for data collection and management;
- streamlined processes for linking exploratory science and research outputs through multiple stages to intermediate products and final products delivered by MAIZE;
- integration of project implementation to program objectives over medium- and long-term through innovation platforms and long-term field trials.

Recommendation 7: MAIZE should improve its links in agronomy research with other CRPs such as Humid Tropics. This would serve development of sustainable intensification indicators and metrics.

6. Gender, capacity development and partnerships

6.1 Introduction

This chapter considers three crosscutting issues in MAIZE; gender, capacity development and partnerships, all of which are needed to target MAIZE activities appropriately and address constraints to making progress towards equitable outcomes. The assessment draws on document review (gender strategy, project analysis and prior assessments), interviews and the researcher survey.

6.2 Gender

The Evaluation Team investigated gender in research design and impact pathways analysis. The Team looked at MAIZE regarding gender strategy and considered the extent to which targeting IDOs and monitoring take gender into account. The MAIZE gender strategy was published in January 2013, its objective being "to strengthen the institutional capacity to address issues of gender in maize R4D, and promote equality of opportunity and outcomes between resource-poor women and men farmers in maize-based systems".

The gender budget, which is largely supported by W1/2 has been increased from 1.3 million in 2012 to almost 9 million USD in 2014 (16% of total budget). It has to be noted that the actual expenditures reported for gender have been much lower in 2012 (only around half a million USD was spent) and around 1.5 million USD less in 2013.

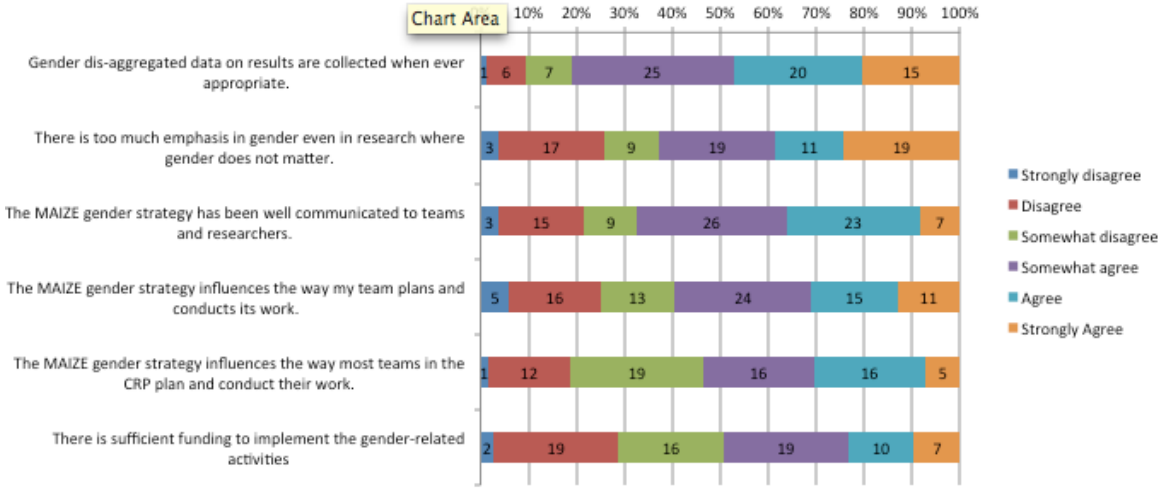
The work has included development and finalization of the gender strategy, hiring gender specialists, a comprehensive gender audit carried out by the KIT and completed in October 2014, and expansion of training in gender-awareness. The activities also include database development, policy analysis and protocol development. The gender strategy provides a comprehensive overview of activities to be undertaken. According to the audit, the understanding was uneven across MAIZE regarding what gender consideration means for research design and impact pathways. Interviews with staff also revealed that understanding varies among scientists regarding what gender-aware science is, and many projects have no guidelines to address gender in research systematically. However, the audit highlighted that the recognition of gender for equity and research effectiveness, and monitoring of the implementation of the gender strategy is improving. As pointed out in the ISPC commentary on the 2015–2016 Extension Proposal regarding gender mainstreaming performance, there are several fundamental aspects that need to be addressed, including equity (differential access to resources) and understanding how priorities vary according to gender.

The Evaluation Team found that good progress has been made in terms of gender disaggregation of data at project level, with explicit recording noted in five of the ten projects reviewed for RS1. This disaggregation of data is also evidenced in several publications that report on results of social science research. Gender-sensitive approaches were less evident in major RS2 projects, such as DTMA and WEMA, and gender was rarely mentioned in project results and outcomes. Projects in West Africa also tended to pay less attention to gender equity issues in research design than those from other regions. Gender focused varietal preference studies were conducted in Nigeria, Ghana, Benin and Mali. Guidance is needed at project level to enhance systematic approaches and data gathering where currently there are major gaps.

The Team was made aware of two compelling examples of proactive attention to gender. The FACASI mechanization project in Ethiopia[40] (commissioned using W1/2 and ACIAR funds) worked with local partners to assess the impact of mechanization on gender and to investigate women's perceptions of agricultural labor issues and opportunities for mechanization. This project means a departure from earlier work in CIMMYT and IITA where training on mechanization projects targeted male farmers, and focus was on activities for which men traditionally assume responsibility. A second study[41] examined seed purchase systems among seed dealers in Africa, analyzing the likelihood among men and women to buy seed of improved maize varieties. The study showed that while men were 1.5 to 2 times as likely to buy improved maize seed than women, men often perceived that seed was the wife's responsibility due to her knowing which seed to buy and how to access the trading center. These MAIZE-supported gender studies provide analysis and understanding of men's and women's differential roles and represent positive approaches to integrating gender into research design in a systematic manner, and enhancing relevance of research to women farmers. Such studies help demonstrate within MAIZE the value of gender analysis in research and indicate that MAIZE is making progress toward integrating gender into projects.

To some extent the researcher survey echoed the observations regarding level of interest and understanding of gender in research (Figure 6-1). The question on gender was responded to by fewer respondents than other questions. A relatively high number of respondents, 45%, agreed with the statement that "There is too much emphasis on gender even in research where gender does not matter". While about 70% of the respondents agreed that gender strategy had been well communicated among researchers, only slightly over 50% agreed that it had influenced research. Half of the respondents felt that gender activities were not adequately funded.

Figure 6-1: Researcher survey responses about gender in MAIZE42



Source: MAIZE researcher survey.

Gender is becoming an integral part of research management in program implementation and is considered in impact pathways. However, indicators for gender are set only at a general level. To move

[40] Ethiopia field visit 6th Oct 2014 by Frederic Baudron "Farm Power & Conservation Agriculture for Sustainable Intensification" (4-FACASI-Frederic Baudron.pptx Slide 20)

[41] Kenya field visit 1st Oct 2014 by Vongai Kandiwa "Unlocking the Potential Contributions of African Smallholder Farmers: Gender Social Inclusion in Maize Development and Deployment" (4. Unlocking Potential_CRP Review_Vongai Kandiwa_October 1 2014_Final)

[42] Survey question 25: Please indicate your agreement with the following statements that relate to mainstreaming of gender issues in your work and MAIZE.

forward MAIZE should strengthen its collaboration with other CRPs and ARIs. Such a relationship has been developed by MAIZE with KIT gender scientists.

There is a low representation of women among research staff that work for MAIZE. Among scientists, team leaders and senior management only 18% are women. In the CIMMYT GMP, proportion of female IRS is only 11%. This is lower than in other CIMMYT programs where the average is 26%. Greater attention to recruitment and retention of women scientists is necessary. This means ensuring more gender-inclusive working environments that attract more women to apply for posts and help retention of women scientists at every level, from entry level to leadership positions. While CIMMYT has appropriate spouse employment and gender policies, the situation in field stations is often not family conducive. The Evaluation Team did not have the mandate to undertake a detailed review of HR management at CIMMYT and IITA. The CIMMYT BoT and HR Director are taking this issue seriously, and are planning center specific strategies to address current shortfalls.

6.3 Capacity development

6.3.1 Training

MAIZE engages in many types of broadly targeted training activities, from scientists to professionals engaged in delivery to farmers. The following are examples of major activities on training:

1. farmer field days, demonstrations, e.g. in MasAgro, SIMLESA, CSISA
2. technical training, training trainers, e.g.in the MasAgro, SIMLESA, CSISA
3. planned research training courses, e.g. in farming systems and breeding/seed systems
4. advanced degree training via co-supervision of postgraduate students
5. ad-hoc, on-the-job training of visiting scientists

The large farming systems projects in RS1 (MasAgro, SIMLESA, CSISA) organize field days and technical training via partners, i.e. by training trainers. In 2013, CIMMYT recorded 1695 short-term training events in 28 countries associated with MAIZE. There were almost 64,000 participants at these training events (1351 were field days; 193 were training courses), and for the events where gender was recorded, 28% of the attendees were female.[43] These participant numbers represent a substantial increase from 2012 when CIMMYT recorded close to 31,000 participants (22% female) at 871 events associated with either MAIZE or MAIZE and WHEAT together. The MAIZE annual report of 2013[44] indicates that two activities, SIMLESA and Total LandCare in Malawi, reached over 40,000 and 18,000 farmers, respectively. Details of events and participants for these types of training were not available for IITA.

In RS1, the main training activities take place within the large collaborative research projects and account for the majority of the short-term events for training, including field days and technical training. For example, in 2013, MasAGRO and CSISA sponsored 1124 and 257 events (mostly field days) and 39 and 60 short training courses, respectively. Judging by the descriptions of sponsors and courses, about 15 courses were associated with RS2 and related to breeding and seed systems. Most courses lasted 1-4 days. In 2013, SIMLESA trained or mentored more than 3,000 scientists in the maize/legume

[43] "2013 CIMMYT Training.xlsx" provided 29 Jan 2015. Apparently does not include SIMLESA field days.
[44] MAIZE CRP ANNUAL REPORT 2013

value chains. The field days of MasAGRO, CSISA and SIMLESA were mainly undertaken with the assistance of boundary partners as part of scaling out of new or farmer-proven technologies.

IITA reported 61 MAIZE students in 2012 but no data were available for 2013. CIMMYT data for students and visiting scientists in 2013 are shown in Table 6-1. The number of postgraduate students for MAIZE in 2012 was 92. Combining data for advanced degree students at CIMMYT and IITA in 2012 and CIMMYT in 2013, 35% of the students were female. The proportion of women trainees and post-docs is higher than for full-time scientists, but representation could be improved in both cases.

Table 6-1: Student and visiting scientists associated with MAIZE in 2013

Type	Female	Male	Total
Student degree	44	75	119
Student non-degree	13	33	46
Visiting scientist	8	28	36
Total	65	136	201

Source: Evaluation team, based on information received from MAIZE management.

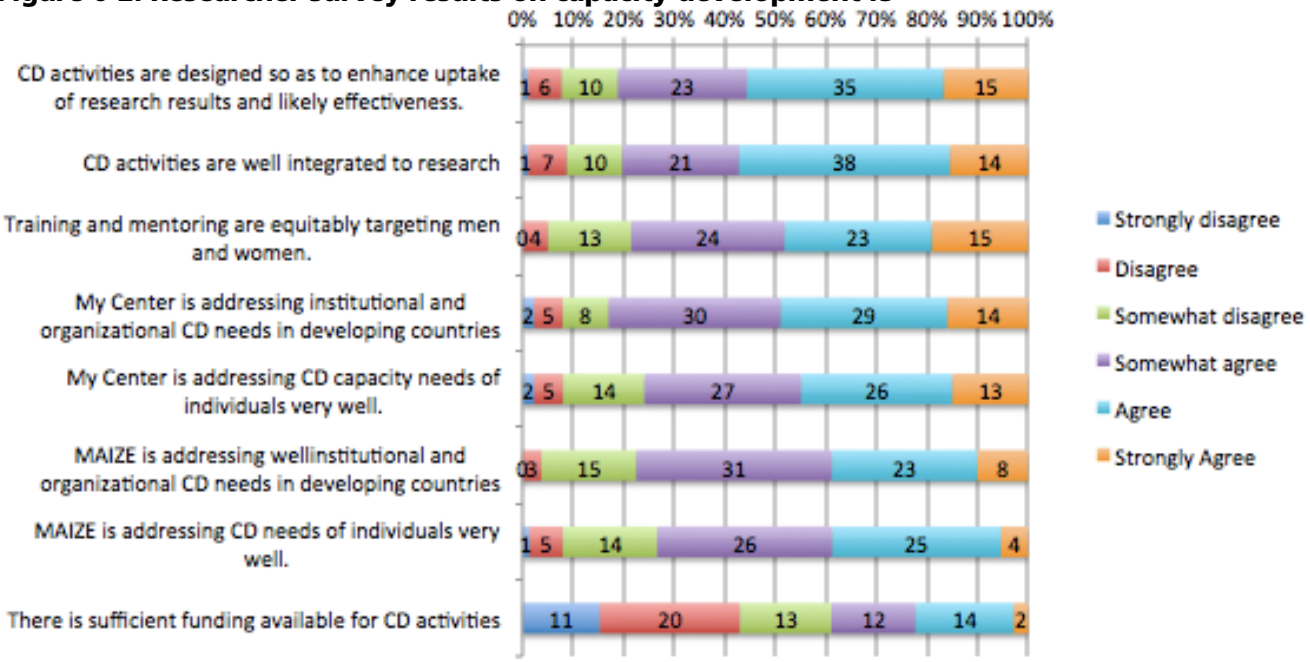
Advanced degree training is largely in-country. Of 119 advanced degree students in 2013, the majority were in-country university enrolments at the University of Zimbabwe (22), Chapingo Mexico (15), CAAS (12), Midlands State University Zimbabwe (8), the University of Nairobi (7), the University of Agricultural Sciences Bangalore (5), other Mexican universities (ca. 25), other South Asian universities (ca. 20) and other African universities (ca. 18). The 17 advanced degree students enrolled at high-ranked universities were all working on topics related to RS1 and RS3, with only one student (Agrocampus Ouest, France) studying a topic related to plant breeding.

The numbers of training courses of various types, from workshops to advanced degree training, are substantial given the size of MAIZE. Partners are essential to scaling out and scientific training. In the 33 desktop project reviews, and according to the feedback from interviewees, the majority of projects actively looked for engagement and capacity development opportunities. The large breeding projects (e.g. DTMA, WEMA, IMAS, HTMA) regularly run training workshops, although there could be better coordination among the projects in organizing them to ensure complementarity.

Overall, the Evaluation Team sensed a lot of appreciation for capacity development efforts of MAIZE, in terms of extent and quality. During the Team's field visits, all partners interviewed expressed appreciation for these efforts, which generally met their needs. MAIZE makes special efforts to include women. Capacity development is an integral part of impact pathways analysis, and of MAIZE research strategy. Continuous efforts will be required in this area to ensure long-term sustainability of MAIZE program partnerships, particularly also in the light of the need for mentoring of young staff.

In the researcher survey slightly more than 40% of respondents felt that as a measure for enhancing effectiveness, capacity development was well or very well managed. About a third of respondents felt that it was not well managed. Researcher responses to a specific question on capacity development are shown in Figure 6-2. The majority of the respondents agreed that capacity development activities were well integrated to research and designed to enhance research effectiveness. Some 60% of respondents felt that funding was not adequate for capacity development.

Figure 6-2: Researcher survey results on capacity development45



Source: MAIZE researcher survey.

6.4 Partnerships

MAIZE has strong research and boundary partners engaged throughout the MAIZE target geographies. A CO commissioned survey[46] of 249 partners/potential partners reported high satisfaction with MAIZE (84% of respondents satisfied). MAIZE performed also well in research outcomes and expertise, less well in collaboration (62%). There was scope for improvement on fair distribution of funding (48%) and making information available (49%). However, at that time it is likely that partners' comments referred to CIMMYT and IITA rather than to MAIZE.

The primary non-CGIAR research partners of MAIZE are SARGAPA (Mexico), KARI and the Syngenta Foundation. Primary partners have an institutional commitment and are signatories of MAIZE. Secondary research partners are involved in leading or participating in projects and include in-country partners, ARIs and universities. Their contributions can be in terms of research facilities, staff, provision of data, students and visitors. The contributions can be in-kind or resourced by donors via projects or directly resourced through the CGI, which is made annually according to research and delivery gaps identified. The main forms of engagement with ARIs and universities include student exchanges, bilateral projects and the relatively small CGI funds.

MAIZE boundary partners are targeted stakeholders for implementing change and upon whom development outcomes depend. They include a range of entities from government institutions, NARS, seed companies and agronomy/fertilizer/crop health companies. In Mexico and India, and increasingly in SSA, MAIZE has been developing innovation platform models to engage farmers and industry professionals directly. In RS2, the main breeding projects extend to delivery of training and direct engagement in seed production for SMEs with MAIZE, augmenting the capacity of 180 seed companies

[45] Survey Question 26. Please indicate your agreement your agreement with the following statements that related to capacity development (CD) in your work and in MAIZE

[46] CGIAR Stakeholder Perception Survey (2012)

and 226 community-based seed producers according to the 2013 MAIZE Annual Report[47]. RS3 has excellent partnerships with ARIs (such as KIT), universities (for impact assessment) and NARS (for post-harvest work) to ensure quality in areas where it does not have critical mass.

There is no consistent record of the research of boundary partners in any single project[48]. The most complete lists of partners are in the annual reports, which in 2013 indicated that CIMMYT expended USD 51 million and IITA USD 7.8 million. Of the total, USD 8.7 million was disbursed from W1/W2, W3 or bilateral funds to about 80 non-CGIAR partners who are listed as having spent >USD 25,000 each in 2013.

A subset of partnerships can be examined by studying the CGI projects (W1/W2 funds only) for which partners received about USD 3.17 million of the total USD 8.7 million disbursed in 2013. By 23 May 2014, MAIZE had allocated these funds to support 46 CGI projects (median grant of USD 69,500)[49]. Most funds were allocated to Africa in RS1 and RS2 (see Table 6-2). In 2013, RS3/FP5 received just over USD 750,000: USD 200,000 for gender research (based in CIMMYT Mexico) and three grants totaling more than USD 550,000 to KIT.

In RS2 proportionally greater CGI funds are allocated to FP3, the central part of the breeding process, which MAIZE staff described as being more difficult to fund bilaterally than the upstream (FP2) and downstream (FP4) components.

Table 6-2: Competitive Grants Initiative (CGI) funds by region/ARI and Flagship (2013; USD).

Research Strategy	1	2	2	2	3	•
Flagship	1	2	3	4	5	Total
SSA	939,493	68,200	284,850	105,130	•	1,397,673
Asia	156,500	62,475	173,500	181,727	•	574,202
LAC	100,000	•	•	•	•	100,000
ARIs	211,468	128,633	•	•	553,402	893,503
Global (Gender)	•	•	•	•	200,000	200,000
Total	1,407,461	259,308	458,350	286,857	753,402	3,165,378

The Evaluation Team found in its project review and during field visits that most partners effectively participated in projects, including during the design stage. Weaknesses were found in the extent to which projects were aligned with the Program and in delivery of results. Poor quality and execution at project level likely resulted from limited attention to mentoring and capacity development of those participating in the projects. In the case of the Integrated Breeding Platform project (managed by GCP, not MAIZE) results improved once commercial partners took on more of the software development responsibility, which illustrates the importance of engaging suitable partners early on. In contrast, the

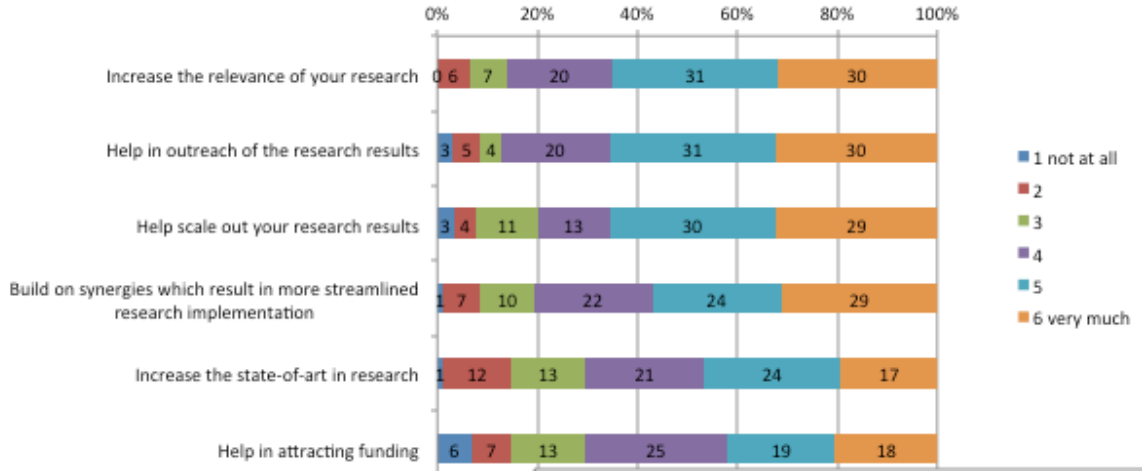
[47] MAIZE CRP Annual Report 2013
[48] Maize Extension Proposal 2014
[49] 2014 CPG Master List and Contacts with Traffic Light.xlsx

MLN project was a good example of what MAIZE can achieve with partnerships (funding, infrastructure, research) in the short term in response to a major breeding challenge.

The research survey indicated that NARS partners are perceived overall as the most important partners for MAIZE. During the Team's field visits in Kenya, Ghana, Ethiopia and Nepal extensive discussions were held with NARS partners of MAIZE. Considerable appreciation was expressed by NARS leaders and scientists, not only for the quality and efficiency of collaborative activities, but also for the sustainability and long-term nature of CIMMYT and IITA's efforts in collaboration. Their only concern was the sometimes limited amount of funding for operational activities in collaborative research. There was unanimous high appreciation for MAIZE training efforts.

Outside the options provided in the question of the researcher survey about partnerships, several respondents mentioned the importance of the private sector and seed companies. Generally partnerships were perceived as effective (see Figure 6-3), and partners' roles seen as most important in increasing the relevance of research. When asked about transaction costs, only a few respondents felt that the costs outweighed the benefits considering the current number of partnerships. When asked about the involvement of partners, about 40% of respondents indicated that partners were much or very much involved in the activities mentioned in the question (Figure 6-4). There would seem to be scope for enhancing partners' engagement, particularly in research prioritization, planning and publishing results (when applicable). Also partner feedback to research could be improved.

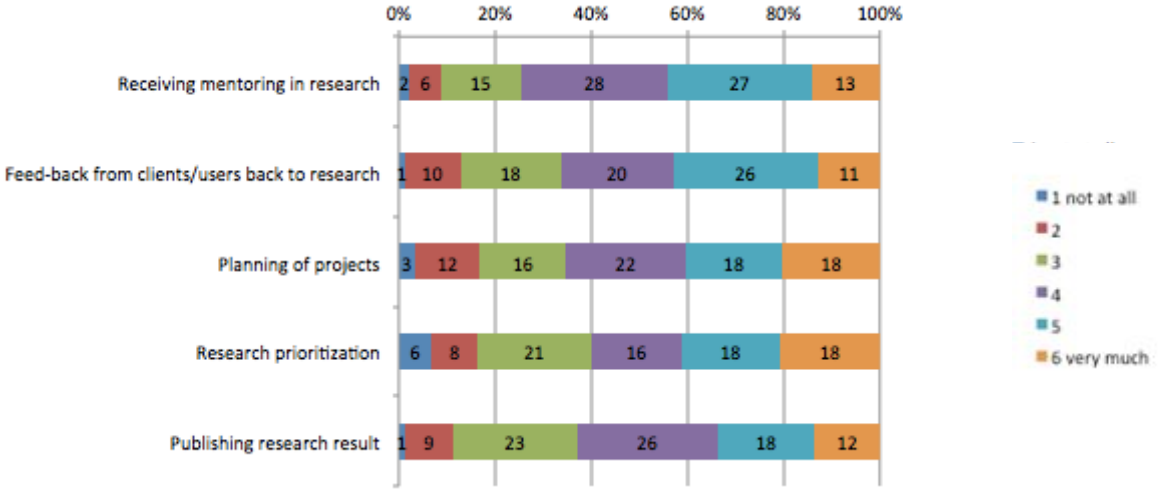
Figure6-3: Research survey results regarding the effectiveness of partnerships[50]



Source: MAIZE researcher survey

[50] Survey Question 22. In your view, to what extent do the current partnerships increase the likely effectiveness of your MAIZE-related research in areas listed below?

Figure 6-4: Research survey results regarding the involvement of partners in MAIZE[51]



Source: MAIZE researcher survey

6.4.1 Research partners

CIMMYT and IITA facilities and infrastructure are essential for MAIZE and are used particularly for farming systems research (RS1) and plant breeding (RS2). Activities associated with RS3 are based mostly in Addis Ababa (headquarters of CIMMYT Socio-Economics program), Mexico (gender-based research) and Kenya (gender and post-harvest research). There are major research sites at SARGAPA in Mexico (MasAGRO) and KARI in Kenya (multiple projects including DTMA, WEMA, IMAS). In Central America, India and Africa, MAIZE CIMMYT/IITA staff are co-located with other CGIAR Centers, NARS and universities.

In terms of advanced research, MAIZE also has bilateral project partners, including in the "SeeDs of Discovery" component of the MasAGRO project relating to RS2/FP2 (involving Cornell University; DArT, Australia; and James Hutton Institute, Scotland), and the initiatives with Wageningen University in systems research. Although based in FP2, the "SeeDs" activities deliver potential outcomes through FP3 via the development of technologies related to genotyping and databases. The DH facility (described in Chapter 4) was dependent on the support of the University of Hohenheim in order to develop the first tropically adapted DH inducer, although also W1/W2 funds are required. Purdue University is engaged in heat tolerance research via a USAID initiative. Various universities support trait research (e.g. University of Florida evaluating heat response in a small number of maize genotypes for modeling). Universities in Spain have been engaged to provide support to the development of field phenotyping technologies by ground and air. Cornell has recently been engaged to support the CGBO, which includes support for molecular breeding (see Chapter 4).

The evidence gathered during the evaluation indicates that MAIZE engages with appropriate national partners, who, because MAIZE is relatively new, are often more associated with CIMMYT and IITA and specific projects rather than MAIZE. However, the perceptions suggest that MAIZE is evolving toward a more inclusive program as new projects are developed, and role of the CGI is recognized in engaging partners for research. The 2013 CGI shows a diverse range of research institutions in the Netherlands

[51] Survey Question 24. In your view, to what extent are the partners in MAIZE involved in Program activities as listed below?

(RTI), USA (WSU, UF), Kenya (ICIPE), Mozambique (IIAM), Nigeria (FUT, IITA) and Mexico (INIFAP, UNACH), involved in researching topics for the three RSs[52]. Three institutes and four seed companies in South Asia and one seed company in eastern Africa have been engaged to test and deploy new germplasm.

CGI projects fill gaps, particularly in areas related to breeding (FP3) and socio-economic studies and gender (FP5), which were initially under-funded. This is confirmed by staff perceptions. Through partnerships MAIZE has been able to respond quickly to important issues, such as MLN. Partnerships with KARI, ICIPE and ASARECA, supported with bilateral funds, resulted in establishment of the MLN screening facility.

Fortunately, many of the partnership monies needed for scaling-out in RS1 and RS2 can be sourced from the major bilateral projects (see below).

6.4.2 Boundary partners

In Mexico (MasAGRO) and India (CSISA), the boundary partners are engaged in innovation and delivery platforms/projects associated with RS1 (>200,000 farmers engaged in Mexico according to the 2013 Annual Report), with the engagement rapidly increasing in Africa (SIMLESA, SIMLEZA, Africa Rising). In RS2, these boundary partners are mainly seed companies engaged in projects or competitive grants. The annual reports provide information on the numbers of partners engaged and farmers and breeding companies reached in these activities.

The engagement of seed companies in the delivery of outcomes is important as varieties become available for new regions. According to the 2013 MAIZE Annual report (page 3), 110 seed companies are supported in SSA by bilateral projects (DTMA, WEMA, IMAS) with about 35 additional seed companies in each of IMIC-Asia (including CGI funds) and MasAgro-IMIC. In Kenya and Ethiopia, the Team met representatives of seed company partners, many of whom receive funding from various projects to support seed delivery. Some of the partners are relatively strong[53] and keen to compete in an independent market. NASECO gave an example of delivering 100 t seed for sale 18 months after hybrid release was approved. They are also working with new Imazapyr-resistant (*Striga*) germplasm and support demonstrations to farmers and visualization of the technology to support its use. The Team also heard about the major challenge regarding country-specific regulations – the expense of compliance with six quarantine visits for new hybrid seed production was excessive, and the certifications where delays risk the release of seed in time for delivery to dealers and farmers.

In conclusion, boundary partners are well engaged in project inception and operation most of the time. This reflects not only MAIZE but also the major large projects that pre-date the CRP. Some NARS have expectations of greater engagement in MAIZE but reported some constraints to this engagement, such as limited funding.

6.5 Conclusions and recommendations

MAIZE is making good progress in incorporating gender in research design and impact pathways. Gender disaggregated datasets are increasingly available and are good, but gender now needs to become part of the mainstream research activity. Capacity development is highly appreciated by

[52] 2013_MAIZE_CGI_WINNERS.pdf
[53] Kenya Field visit 2nd Oct 2014, presentation from NASECO seeds Uganda "12. Naseco Cimmyt CRP meeting October 2014.pdf"

MAIZE partners and needs continuous funding. Partnerships in general are very effective and in line with the comparative advantages of partners at the upstream and the delivery ends.

Recommendation 8: MAIZE should take action to improve its gender orientation. It should maintain investments in gender/social inclusion and sharpen its focus on gender analysis at project level. MAIZE should take measures to enhance the employment of women scientists at all levels by improving recruitment, and by developing an enabling environment to attract and retain women scientists**.**

7. Impact and sustainability

7.1 Introduction

This chapter reviews available evidence on adoption, outcomes and impact of MAIZE. The Evaluation Team benefited from an impact narrative provided by MAIZE at the request of the IEA, which was accompanied by a list of 49 journal articles related to adoption and impact. The Team reviewed six of the publications in depth. The Team also drew on impact studies of the Standing Panel on Impact Assessment of the CGIAR (SPIA), and on information provided in the MAIZE annual report of 2013, which provides in almost every case a specific publication that documents the evidence. The Evaluation Team also reviewed outputs, impact pathways, outcomes and adoption and impact in the 32 projects it sampled.

Most of the results in this chapter refer to maize adoption and impact studies initiated by the CIMMYT and IITA maize programs well before the start of MAIZE. As MAIZE only began in 2012, time has been too short to achieve impact that can be directly attributed to it. The Team also comments on the adequacy and coverage of impact documentation over recent years, the extent to which adoption and impact are addressed in MAIZE and the extent to which *ex post* studies are geared toward and used for learning and program adjustment.

7.2 Results of studies

7.2.1 Adoption studies

Several adoption studies were referred to in the impact narrative. A major study led by IITA reported that in West and Central Africa the adoption of modern varieties had increased from 5% of planted area in 1970 to 60% in 2005.[54] Half of the resulting impacts could be attributed to IITA and CIMMYT maize research. Other studies reported adoption rates for modern maize varieties of 76% in southern Malawi, 80% in Uganda and 60% in Ethiopia. The major reasons listed for non-adoption of improved varieties were: poor seed supply, poor extension services, lack of assets or human capital, and policy restrictions.

SPIA produced a major report on the effectiveness of crop improvement research in SSA[55]. This DIVA (Diffusion and Impact of Improved Varieties in Africa) study reported that in 2010 44% of maize area in ESA was sown to modern varieties and this share was 66% in West and Central Africa. It was reported that adoption levels for modern maize varieties more than doubled between 1998 and 2010. Hybrids became particularly important in Ethiopia, Zambia and Malawi. Yield levels of DTMA maize in Ethiopia doubled between 2002 and 2012.

A recent SPIA study on improved maize varieties and poverty in rural Ethiopia found that 39% of total maize area in Ethiopia was sown to improved varieties, with a yield advantage at plot level of 48–63% over traditional varieties.[56] Adoption of improved varieties had led to a 0.8–1.3% reduction in overall rural poverty headcount ratio, and proportional declines in poverty depth and severity.

[54] Alene A.D. et al. 2009. Agricultural Economics 40:535–550.
[55] Walker, T. et al. 2014, *Measuring the Effectiveness of Crop Improvement Research in Sub Saharan Africa from the Perspectives of Varietal Output, Adoption and Change: 20 crops, 30 countries and 1150 cultivators in Farmers Fields. Report of the Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council Secretariat, Rome, Italy*
[56] Zheng, D. et al., 2015

Some studies reported the impacts of conservation agriculture and of dual purpose maize. For the latter, it was concluded that there is effective demand for varieties with improved stover quality and quantity, as long as they do not compromise grain yield and consumer qualities.[57]

Overall in SSA, according to FAO data, maize yields increased from 0.88 t/ha in 1971 to 2 t/ha in 2005, with an average growth rate of 2% a year, while the area of land sown to maize increased by 3% annually over the same period. Most of this increase can be attributed to the use of modern varieties, given that fertilizer use has not changed much.

Certain groups of farmers, particularly women, have lower rates of adoption of modern maize varieties. A study in Malawi indicated that the probability of adoption of modern maize varieties was 11–12% lower for female farmers than for male farmers.[58] In Ethiopia, farmers with smaller farms benefitted less from improved varieties than those with bigger ones.

CIMMYT employs seven staff in the GMP in India and two in China. However, the Evaluation Team did not find evidence for the adoption or impacts of varieties in those countries, probably because of their recent posting. IITA studies reported adoption rates of technology for *Striga* management, and estimated that this improved technology was adopted by 32% of farmers in northern Nigeria.[59]

7.2.2 Impacts on income and poverty

Kostadini et al. (2013) estimated that by 2016 adoption of drought tolerant maize varieties could generate between USD 362 million and USD 590 million in cumulative benefits to both producers and consumers in SSA.[60] These benefits translate into poverty reduction in the range of 0.01% to 2% by 2016. It was suggested that development and diffusion of drought tolerant varieties could be a valuable poverty alleviation strategy. Income gains from increased outputs following adoption of drought tolerant maize have been estimated at USD 530 million.[61]

Arega D. Alena et al. (2009) estimated the economic and poverty impacts of maize research in West and Central Africa, suggesting that the number of people moving out of poverty through adoption of new maize varieties rose gradually to more than one million people per year since the mid 1990s.[62] Over half of these impacts are attributed to international maize research at IITA and CIMMYT.

Efforts of MasAgro to increase profitability of maize-based farming systems reportedly led to increased aggregate profitability of USD 105 million, reaching an estimated 150,000 farmers, although no evidence was given for the estimate.[63]

7.3 Assessment

Impact assessment is complex, requires large datasets and presents methodological challenges. In a review of social sciences in the CGIAR, it was found that many of the impact studies were of low quality and credibility, given available evidence.[64] CIMMYT and IITA impact studies mostly focused on varietal

[57] De Groote et al. 2013 Journal of Stored Products Research, 53, 27-36.
[58] Fisher et al. 2014. Food Policy 45:101-111.
[59] MAIZE Annual Report 2013
[60] Kostadini et al. 2013. Food Policy 43: 213-226.
[61] La Rovere 2014. Journal of Developing Areas 48:199-225.
[62] Arega D. Alena et al. (2009)
[63] MAIZE Annual Report 2013
[64] CGIAR Science Council (2009) *Stripe Review of Social Sciences in the CGIAR.* Rome, Italy: Science Council Secretariat

improvement using methods of economic surplus and cost-benefit analysis to estimate rates of return on research investments, with few having been able to estimate impacts on poverty. The 49 journal articles listed in the impact narrative are all in peer-reviewed journals with established reputations. Some MAIZE impact research papers have been published in top journals such as Food Policy, Agricultural Economics and Food Security. Given the stringent peer review system of these journals, the articles are assumed to have met high scientific standards. However, of the 127 studies listed in the narrative related to adoption and impact, about half were not peer reviewed. The reference to these non-peer reviewed publications was not provided. It was noted in the narrative that "Studies vary considerably in terms of quality of the data and empirical methods used". The review by the Team of papers published in journal articles confirmed their high quality. It is more difficult to judge the quality and merits of the reports that were not peer reviewed. In several sample projects that were reviewed, evidence was not provided for the impact or adoption claims made. In pre-CRP days, most impact assessment studies were funded by bilateral projects. Since the start of MAIZE, impact studies have been funded mostly through W1/W2. This allows impact assessment to be conducted at higher priority sites, and with more rigorous quality control.

In reviewing the publications and available evidence, the Evaluation Team considers that there has been widespread adoption of improved maize varieties in the developing world, especially SSA, most of which can be attributed to MAIZE outputs from CIMMYT, IITA and their partners. The results seem impressive and investments in international maize research appear to have been very profitable. There is some documented evidence of the impact on the target farming groups and poor producers and consumers. Overall adoption rates and impact on farmer income are very well documented for Africa, less so for Latin America (where impacts may have been greater in the past) and Asia (where commercial companies have been expanding for 30 years).

However, the vast majority of studies that have been conducted are adoption studies on the effects of varietal improvement, often with a fairly limited number of household samples. Generally, these adoption studies do not have impact pathways. The estimated impact of these research outputs on overall CGIAR goals is therefore somewhat speculative. Only few studies have been conducted on the impact of better agronomic practices and of policy improvements. Most impact studies are based on *ex ante* work, extrapolating data from adoption studies to a very large scale. This may be suitable as a first approximation but needs to be accompanied by impact pathways, a set of assumptions and conditioning factors and needs to be followed up with more comprehensive datasets. Credible evidence of *ex post* impact assessment at a large scale is still scarce. As impact assessment can only be conducted after the duration of the project, usually there are insufficient funds available for this task. The Team therefore suggests that every major project should commit resources for impact analysis at the end of the project.

Similar issues came to light during the Team's field visits, where in presentations on germplasm impact were frequently equated with seed production. In 2013, the largest seed production was 7300 t in Nigeria[65]. However, much of that seed was apparently purchased and stored using government subsidies and was not delivered. The most recent available maize impact studies use field level data from 2005, thus well before the start of MAIZE. The number of adoption and impact studies has increased since the start of MAIZE, but available results of impact on development goals of maize improvement research are still mostly indicative.

Yet, despite these cautionary comments, the Team considers that MAIZE appears to be on track in achieving its ambitious goals of increasing productivity by 7% in 2020. Annual sales of seed of improved varieties in Africa are now well over 30,000 t. At an average sowing rate of 15 kg/ha, this means enough

[65] Kenya field visit 1st Oct 2014 2. Tsedeke_MAIZECRPReview20140926.pdf

seed for more than 2 million ha, or 5 million ton of extra maize. This appears to meet the targets set by MAIZE, at least for Africa.

The Evaluation Team could not find a comprehensive strategy for MAIZE impact assessment. It seems that planning of studies is somewhat *ad hoc* and determined by availability of funds. There also is not a uniform approach as to the issues and questions to be addressed in adoption studies, and mechanisms for feedback to technology design are not clear.

MAIZE has initiated several interesting and high quality studies on the effects of gender on adoption of maize technology. This is still largely unexplored territory, and the Team encourages MAIZE to increase the number of such studies.

There is also a further methodological issue. Nearly all studies use cross-sectional, observational data so that special econometric approaches are needed to enable assessment of causal effects, which is particularly important in the case of impact assessment as stated in the impact narrative. As a consequence, the results of many studies, even within the same country, cannot be compared. MAIZE should develop a uniform set of questions to measure adoption and impact. This would also allow generation of comparative datasets across countries. In the impact narrative it is recommended that MAIZE collect longitudinal data and Randomized Control Trial data (RCT) to increase the quality of impact assessments. They acknowledge however that such RCT approaches are costly and time demanding. One donor representative in an interview with the Team also expressed concern at the high cost of RCT approaches and noted that criteria for publication in peer reviewed journals did not necessarily equate with good impact assessment. Planning of RCT approaches therefore needs to be done with care. Because of ethical considerations, RCT's are also not appropriate in certain situations.

Finally, it is unclear as to how adoption and impact studies have resulted in improving breeding and agronomy programs, such as in the use of farmer preferences for grain quality traits. Feedback mechanisms for results of adoption and impact research should be strengthened. This is also a challenge that hopefully will be addressed in the continuous improvements of the M&E framework.

7.4 Future impact assessment

MAIZE has presented very ambitious plans for impact assessment in its 2015–2016 Extension Proposal. In 2015, new adoption studies are planned for South Asia, Mexico, Nigeria, Uganda and Malawi. Impact pathway case studies are foreseen in Ethiopia, Kenya, Malawi and Asia. Furthermore, *ex ante* studies on MLN and mechanization will be conducted in ESA, and of heat tolerant maize in South Asia. In 2016 additional impact studies are planned on DT maize in SSA, grain storage in ESA and *Striga* resistance in ESA. The Evaluation Team encourages MAIZE to consider common approaches and sets of research questions in these studies to ensure that they provide large sets of baseline data that enable upscaling of research results. These new adoption and impact studies should have impact pathways supported by a theory of change, to link generation of outputs with broader development objectives. This would also facilitate identification of data needs, and improve transparency. MAIZE already makes considerable investments in impact assessment, the quality of the work is good and results are encouraging. Major efforts will also be required in capacity building in national programs to conduct this type of research. Continuous investments will also be required in sustainability of partnerships with NARS and ARIs, who play key roles in impact assessment. NARS Capacity development in this type of work is generally weak and continuous investment in capacity building will be required to assure sustainability of efforts. Finally, in line with earlier observations in other chapters, MAIZE should also invest in the development of manuals and protocols to facilitate mentoring of newly recruited scientists, and to ensure development of common data sets and research approaches.

7.5 Conclusions and recommendation

The Evaluation Team concludes that MAIZE has invested considerable resources in adoption studies and impact assessment over the past three years. The number of studies and publications has increased over the last three years and the 2015 - 2016 Extension Proposal outlines an ambitious program of adoption and impact activities. Overall, the Team considers that the quality and the relevance of this work can be judged as good.

Recommendation 9: MAIZE should develop a strategy for impact assessment that sets clear priorities for focusing such assessments, provides an analytical framework and elaborates on the use of impact pathways in planning and documenting scaling up of results and impact.

Recommendation 10: MAIZE should enhance the conduct and use of impact assessment. The steps to be taken include:

- Adequate resources are allocated in major project proposals to enable *ex-post* impact assessment at the end of project support and strengthen feedback to MAIZE for portfolio development.
- Proactive planning is done to ensure that results from adoption and impact studies feed back to specification of desired technology characteristics in project design.
- More systematic studies are conducted on the impact of gender on technology adoption and its implication for technology design.

8. Governance and management

8.1 Introduction

In this Chapter, the Evaluation Team assesses governance and management (G&M) arrangements of MAIZE, their evolution over the course of the evaluation, and the extent to which they influence the efficiency and effectiveness of G&M.

The Team's main findings, conclusions and recommendations on MAIZE G&M are based on presentations to the Team during its inception meeting at CIMMYT in May, 2014, a desk review of available documentation (including the 2011 MAIZE proposal), the minutes and background documents for the MAIZE Stakeholder Advisory Committee (M-StAC), MAIZE Management Committee (M-MC), and CIMMYT BoT meetings since MAIZE inception, direct observation of the M-StAC and BoT meetings in September 2014 in Beijing, informal conversations with meeting participants in Beijing, written responses received, interviews with senior management and scientists, leader of M&G and selected stakeholders, and interactions by various Team members during field visits to project sites in several countries.

The Team also reviewed documents related to MAIZE: Program Implementation Agreement (PIA) between the Consortium Board and CIMMYT (as the Lead Center for MAIZE), Program Participant Agreement (PPA) between CIMMYT and IITA, and the annual reports of MAIZE. Reference is made to the IEA commissioned Review of CGIAR Research Programs Governance and Management (RPGM; 2014), and selected documents related to the Fund Council (FC), Consortium Board, and the CGIAR reform program, including the December 2014 CRP Governance Agreement/ recommendation of the FC's Evaluation and Impact Assessment Committee, which was endorsed by the FC and Consortium Board in January 2015.

8.2 MAIZE governance and management

MAIZE is governed according to a set of formal agreements. According to the PIA, signed between the Consortium Board and CIMMYT after the approval of MAIZE by the Fund Council in 2011, CIMMYT as the Lead Center is accountable to the Consortium for the use of the W1/2 funds that are transferred to CIMMYT, and for the satisfactory performance of MAIZE. The PPA, signed by CIMMYT and IITA outlines the IITA use of W1/2 funds. The CIMMYT BoT has the fiduciary and legal responsibility for the use of funds it receives from the Consortium, Fund donors and bilateral funders; and it has the ultimate responsibility for approving workplans and budgets related to MAIZE.

The M-StAC has an advisory role. It makes recommendations to the CIMMYT BoT and the M-MC. M-StAC has seven members, including the DGs of CIMMYT and IITA and is chaired by an external member. One of the M-StAC members is also on CIMMYT BoT. The RPGM considered that the institutional overlap between the M-StAC and M-MC was considerable. Currently only two M-StAC members are from institutions not represented in the M-MC.

The M-MC is the formal leadership mechanism of MAIZE and is responsible for program implementation. The M-MC has ten members and is chaired by the CIMMYT DDG for Research and Partnerships (who at the time when the evaluation begun was leader of both MAIZE and WHEAT). Its membership consist of CIMMYT global program directors (four), two members from IITA (including DDG-R) and three members from MAIZE partner organizations that are also represented in the M-StAC (INIFAP-Mexico, KARI-Kenya and Syngenta Foundation). All decisions on fund allocations, choice and allocation of competitive partner grants are done by the M-MC within the FC approved budget.

Decisions cannot be made by one institution alone and have to be supported by the non-CGIAR partners. The M-MC also reviews annual workplans and reports.

In sharp contrast with other CRPs (with the exception of WHEAT), MAIZE is coordinated by an administrative manager, supported by small management team, who coordinates W1/2 related activities, facilitates information exchange, takes care of reporting to donors and the consortium office, and provides support in the areas of communication, fund raising and other administration. The manager reports to the CIMMYT DDG for Research and Partnerships while the CIMMYT global program directors, including the director of the CIMMYT GMP report to the CIMMYT DG.

Since the evaluation commenced in May 2014, much discussion took place on the G&M arrangements of MAIZE by the M-StAC and CIMMYT BoT. The RPGM concluded that "Leadership and reporting of the MAIZE Stakeholder Advisory Committee and Management Committee are consolidated within CIMMYT and duplicative. The CIMMYT BoT has limited independent oversight of the program." In its meeting in September 2014, the M-StAC (which considers itself to be an independent advisory committee) discussed the recommendations of the RPGM. The minutes state that the M-StAC supports the idea of one global program between CIMMYT and IITA. This Evaluation Team supports such development.

In its meeting, the M-StAC decided to revise its TOR in line with the PRGM and develop TOR for an independent M-StAC Chair. In CIMMYT BoT meeting held back-to-back with the M-StAC meeting, the MAIZE leadership and reporting arrangements were discussed. The BoT agreed to better align the CIMMYT practice with the recommendations of the PRGM review. Proposals from CIMMYT BoT will be discussed by the IITA BoT in May 2015.

The Evaluation Team considers that the CIMMYT BoT has been proactively involved in MAIZE governance, and has taken its oversight and fiduciary responsibilities seriously. In response to the RPGM, and based on its own experience of MAIZE governance, it has taken the lead in further strengthening governance in collaboration with the IITA BoT and the M-StAC.[66] The proposed changes specifically seek to strengthen strategic and programmatic collaboration and joint action between CIMMYT and IITA, and accountability and "management for results" at all levels. The Evaluation Team agrees with this vision.

The changes to MAIZE G&M initiated in September 2014 also include nominating a director to MAIZE. The M-StAC accepted the TOR for the MAIZE director and will advise CIMMYT BoT on the selection. The Evaluation Team believes that an appointment at the level of director gives the position greater authority and resources for delivery of results, and strengthens its reporting relationship to the CIMMYT BoT and management, and the IITA PC.

The Evaluation Team considers that the planned changes have a good potential to lead to a closer partnership in a global, better-integrated MAIZE CRP, including for its planning, implementation, monitoring and oversight. An integrated CRP on maize could manage for results by monitoring progress on agreed deliverables, and would act if deliverables are not likely to be met, including by shifting budgets and human resources, with M-MC endorsement. The follow-up, expected in 2015, includes the development of rules of cooperation between the two centers, development of benchmarks/milestones for the next five years for both BoTs to monitor progress of the MAIZE related collaboration, and detailed planning for the preparation and implementation of MAIZE Phase II

[66] the BoT's letter of April 2014 to the Consortium Board, and subsequent follow-up action by the BoT with IITA

activities. The Evaluation Team considers the proposed direction and scope of these modifications in MAIZE G&M to be appropriate for the current circumstances and anticipated needs.

8.3 Governance processes

The Evaluation Team assessed the manner by which the bodies involved in MAIZE G&M operate. The M-StAC, M-MC, and CIMMYT BoT and PC hold open meetings regularly, with participation by stakeholders, trustees, managers, and staff. Currently, three of the seven M-StAC members are non-CGIAR (including CIMMYT BoT); only one is a woman. Three of the nine elected (i.e., non ex-officio) CIMMYT BoT members are women. The information provided for the meetings is adequate and easily accessible. Background documentation is comprehensive and thorough, briefing notes and power-point presentations are relevant and useful, and various documents and minutes of meetings are posted on the CIMMYT and MAIZE websites. At the meetings observed by the Team, discussions, led by the respective committee chairs, were open and in-depth, with good participation. CIMMYT trustees and senior management, MAIZE leaders and committee members, and center and MAIZE staff seek consensus and are responsive to diverse views. The meetings provide useful updates, including on program issues and G&M.

In light of the documentation provided to the Evaluation Team and the direct observation of committee meetings in Beijing in September 2014, the Evaluation Team considers the inclusiveness, transparency, and responsiveness of the various G&M bodies to be good.

Communication and collaboration between the CO and MAIZE governance bodies (i.e., the CIMMYT BoT and M-StAC) are perceived by CIMMYT to be somewhat unsatisfactory. This is mainly due to the unpredictability and insufficient transparency of W1-W2 funding, the CO's changing requirements for monitoring and reporting of MAIZE activities and expenditures, and continuing uncertainties and administrative process-overload relating to the preparation and approval of plans for MAIZE Phase I Extension (2015–2016) and Phase II (2017–). These concerns are shared by all involved in MAIZE and have been discussed by the various parties, including the CO, and have been highlighted in the MAIZE annual reports. The issues call for solutions that go beyond the relationships between the CO and MAIZE G&M. The Team hopes that the current discussion concerning CGIAR System-level governance options will result on better functioning relationships at all levels.

The leadership changes anticipated in CIMMYT (new DG, DDG-CS and HR Director), the unusual circumstances in parts of Africa affecting MAIZE, the continuing discussions of the CGIAR concerning System governance, new SRF, and the 2nd call for CRP proposals will need to be carefully considered when plans for MAIZE governance are fine-tuned and implemented. The lead center BoT and M-StAC will also need to respond appropriately to the FC and Consortium Board's recommendation for the MAIZE governance structure after 2017. Evaluation Team expects that MAIZE governance bodies (i.e., the lead center BoT, its PC, and the M-StAC) will continue to give high priority to MAIZE and CIMMYT management processes for ensuring effective and efficient program implementation during the transition currently underway in CIMMYT and the CGIAR.

8.4 Institutional oversight and resource management

Board oversight of institutional and HR issues. At the CIMMYT BoT meeting observed by the Evaluation Team, issues related to MAIZE included updates regarding MasAgro, Seeds of Discovery, GMO release and risk analysis, financial and budget update, financial forecast, internal audit, corporate services (including financial management, HR, ICT, IP, legal, communications, and institutional risk and business continuity), and the proposed CIMMYT Strategic Plan for 2020. Updates also included

improving IT services and systems at CIMMYT, including for the RMS, based in part on recommendations of the recent internal audit of IT.

HR issues with relevance to MAIZE included: strengthening of staff performance management system to include scientists' KPIs; greater reliance on the project-oriented database generated by the RMS; improvements in procurement workflow, standardization, and segregation of duties. As discussed in Chapter 5 and reflected in Recommendation 6, there is also a need to improve processes for mentoring, training and lateral learning of staff. A revised HR policy handbook has been recently approved. Other issues discussed by the CIMMYT BoT related to growth and staffing at HQ and outside Mexico, the need for greater attention to gender and diversity issues, the relatively high turnover of staff during the first few years of employment, and issues relating to recruitment, job grading, training, career development, succession planning, and the performance management system. Due to changes in CIMMYT leadership these issues are expected to be given high priority in 2015 by the reconstituted CIMMYT management team.

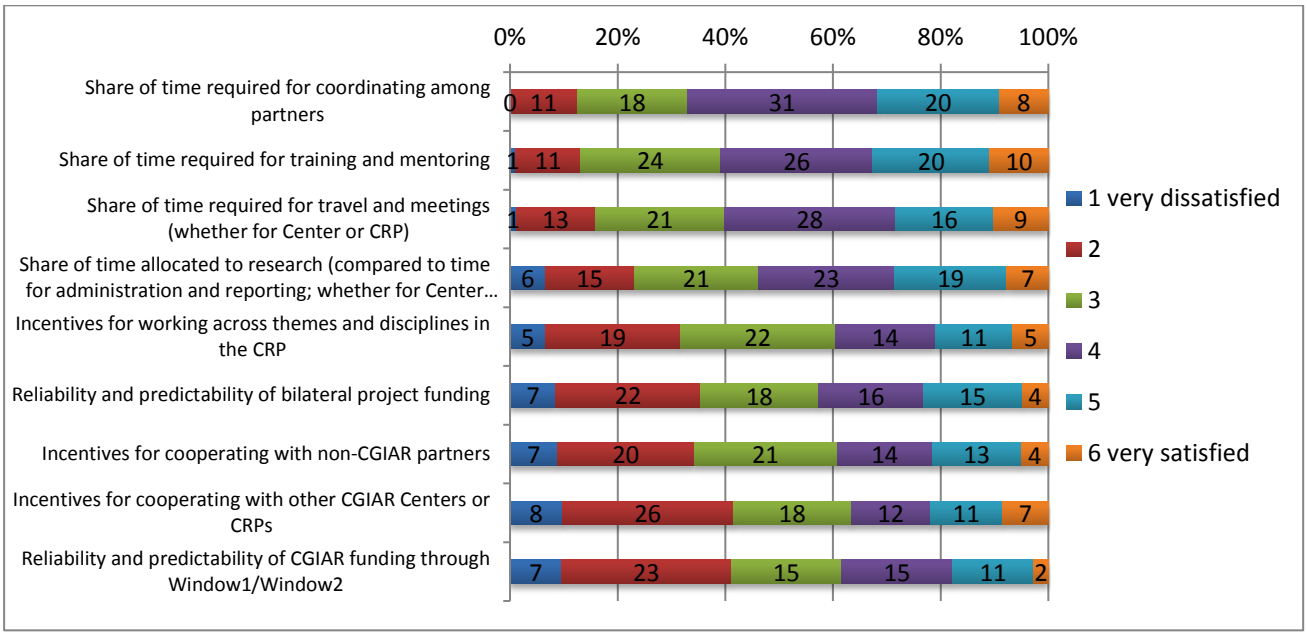
The Evaluation Team concludes that collectively these governance bodies provide essential and appropriate oversight, guidance and advice to MAIZE. CIMMYT and MAIZE leaders and staff work well together, and share information, concerns, and suggestions openly. Furthermore, as noted earlier, relationships between various CRP-related governance bodies (i.e., the BoT, PC, and M-STaC) are collaborative and collegial. Communication and discussions are open, though additional and more frequent information would be shared with the M-StAC in the coming years, as was agreed at the Beijing meetings. This would enable this important committee to provide more timely advice to the CIMMYT BoT/PC and to M-MC, based on an independent stakeholder perspective.

Risk management. Based on the 2013 audit by the CGIAR-Internal Audit Unit and consultations in February 2014 with MAIZE Manager, CIMMYT identified 20 specific risks related to the two CRPs it leads and transgenic research. Six of the risks relate to general management, five to change management, four to financial management, and three to compliance. The risks have been categorized on a 4-point scale ranging from "very high" to "low". A risk assessment process, identifying the ten specific CRP-related risks, internal controls, risk leaders, actions, and deadlines was agreed with all concerned, including the CIMMYT board. Based on the update submitted to the CIMMYT BoT by the CIMMYT Risk Management Unit in September 2014, and the follow-up actions currently underway or planned, the Evaluation Team considers the MAIZE risk management system appropriate.

Human resources management. CIMMYT has gone through a period of major staff increases that affect also MAIZE. The Evaluation Team notes that management of the significant staff growth in CIMMYT, and the proper utilization, assessment, and development of staff at different locations has not been easy, especially since CIMMYT operates in many countries in a decentralized mode. An organizational culture survey by an independent external consultant to CIMMYT was planned for mid-2014, but is pending.

The researcher survey revealed relatively high levels of dissatisfaction across the aspects explored related to working conditions (Figure 8-1). Satisfaction was highest (around 60% of respondents) in areas concerning the share of time spent on research, coordination, travel and training. A large proportion of respondents were dissatisfied or very dissatisfied with funding, and incentives for cooperation and working across research themes. While funding and its predictability are largely outside the control of MAIZE, management needs to address the issues hindering cooperation and integration.

Figure 8-1: Researcher survey results regarding satisfaction with working conditions in MAIZE67



Source: MAIZE researcher survey

Opportunities for career development in MAIZE are impacted by organizational differences among Africa, Latin America and Asia. There are also differences in HR management systems between CIMMYT and IITA, but the impact of these on program performance is not easy to discern. There seem to be no clear and formal development opportunities for education and training of MAIZE scientists, and this makes it harder to develop new skills to conduct modern breeding and research, particularly for research that requires a high level of statistical and data management expertise.

For assessing the performance of individual scientists, the procedure includes an assessment of project deliverables and accomplishments. However, the Evaluation Team's field visits indicated an uneven record of regular meetings for mid- and end-year assessments. Performance management seems to give undue emphasis to preparation of project proposals and fund mobilization. The Evaluation Team suggests that MAIZE enhance the annual assessment process through better communication of HR policies for performance management, the systematic setting of goals for all scientists, and regular follow-up visits between managers and scientists.

Financial management. The W1/2 allocations by the CO to MAIZE were among the lowest of all CRPs approved by the FC in 2011. Since then, based in part on concerns repeatedly expressed by the MAIZE and CIMMYT management and the 2015-2016 Extension Proposal the W1/ W2 allocations for 2015–2016 are expected to be higher, pending on availability of W1/2 funding.

The system for controlling budgets and monitoring expenditures is in place and is integrated with the RMS being used in CIMMYT (a somewhat different system is being used in IITA, but these systems are compatible for financial reporting purposes). As discussed in previous sections, the processes for research management could, however, be further improved. Some issues relate to instructions received from the Consortium Board on management and reporting of CRP finances. For example, there is ongoing (as yet unresolved) dialogue between CIMMYT management and the CO over

[67] Survey Question 27. Please indicate how satisfied you are with the following working conditions for your work.

discrepancy in the definition that donors or the CO apply for a project to be part of a CRP or not. The Evaluation Team found the CRP-related reporting requirements to be onerous.

Another issue is the unpredictability and uncertainty of W1/2 allocation, which also affects researchers' working conditions and motivation (see Figure 8-1). The Evaluation Team appreciates the concerns about the continuing negative consequences from the situation regarding the core-type funding and hopes that it can be improved and allocation made more transparent in the next CRP funding phase.

With regard to financial audits, besides the annual external audits of CIMMYT and MAIZE finances by a reputable firm of external auditors, the CIMMYT Internal Audit Unit is undertaking an audit on governance, risk management and control processes for financial recording and reporting process. The internal audit will also evaluate the controls to mitigate any potential fraud risks.

The external audit of the MasAgro project by the Mexican government raised certain concerns. Discussions to resolve this issue are ongoing, with substantive guidance from the BoT. A new Framework Agreement is in preparation. The Evaluation Team considers these audit and control mechanisms for financial management of MAIZE and CIMMYT finances useful, and expects continuing close oversight of financial management by the BoT.

IP management. At the BoT meeting in September 2014, the head of the CIMMYT legal department presented an update on IP issues to the BoT. In the case of GM research, CIMMYT is striving to adhere to the globally adopted standard represented by the Excellence Through Stewardship approach.[68] The PIA, and PPA with IITA, give details of the provisions expected to be followed in IP management and publicity and branding of the MAIZE CRP.

8.5 Conclusions

The Evaluation Team concludes that the CIMMYT BoT has provided appropriate oversight to MAIZE. It has been proactively involved in MAIZE governance, and has taken its oversight and fiduciary responsibilities seriously and recently initiated important changes that will lead to improved collaboration with IITA and will strengthen the management of MAIZE. The recent discussions between CIMMYT and IITA regarding greater integration of MAIZE efforts are highly commendable. Nomination of a director for MAIZE is likely to enhance the efficiency and effectiveness of MAIZE leadership and coordination.

[68] www.nas-sites.org/ge-crops

9. Conclusions and way forward

9.1 Conclusions

Maize is one of the three most important staple crops for poor producers and consumers in the developing world. It provides at least 30% of food calories for nearly 5 billion people in 94 developing countries. Between now and 2050, it is estimated that the demand for maize in those countries will double, particularly in South Asia and Africa. The challenges for international maize research to meet that demand are enormous. In 2011, the CGIAR endorsed the proposal for a MAIZE CRP that would combine the efforts of CIMMYT, IITA and about 350 partners worldwide from the public and private sector, to implement a new strategy for international maize research. The Evaluation Team will now, based on the analyses reported in previous chapters, draw conclusions on the overarching evaluation questions that were posed.

1. Is the CRP evolving in such a way as to demonstrate added value to research on maize and maize-based systems, in comparison with the research done through two Center mandates as previously?

After only three years of operations, MAIZE has to be considered as work in progress. Through its strong and effective partnerships, and ability to mobilize substantial additional resources, the organization of international maize research, through a CRP, can be seen as a success. Although CIMMYT administers 84% of the budget and accounts with its partners for the largest share of MAIZE projects, and IITA and partners for only 16% of budget, the organization of the research through a CRP demonstrates an added value in comparison with the research done through the two center mandates. Both centers collaborate well, and MAIZE provides an excellent framework to integrate their programs further, to strengthen G&M and to benefit from further synergies. It has already been demonstrated in MAIZE that the new programmatic approach of the CGIAR can lead to higher efficiency, more coherent programs, a results and impact oriented framework and greater effectiveness. In response to the overarching question #1, the Team concludes that the added value from MAIZE compared to the center-based approach in the past is clear and becoming more evident as MAIZE matures.

The question of MAIZE added value was also explored in the researcher survey (Figure 9-1). The respondents showed relatively highest level of agreement with statements concluding that MAIZE was adding value in focusing research strategically better towards development outcomes, rationalizing research better at individual researcher level with the program objectives and providing a results framework that adds value to research. There was least agreement with the statements that MAIZE had good potential to help streamline administrative procedures and that capacity development was addressed more strategically due to MAIZE.

Figure 9-1: Researcher survey results regarding added value from MAIZE69

2. Is MAIZE priority setting effective in terms of program coherence and focus of research on its intended objectives, given the relatively small proportion of unrestricted (W1/2) funding and the historic mandates of the two participating Centers?

MAIZE has a coherent program with a strong comparative advantage that is consistent with its goals, SLOs and the SRF of the CGIAR. MAIZE has had a relatively low level of W1/2 funding, and a high share of bilateral funding. Some of the bilateral funding has a strong delivery component for which the CRP may not have a comparative advantage. Funding has been variable and slightly lower than was initially planned for. Nevertheless, the Evaluation Team considers that despite funding gaps and the high share of bilateral funding, overall priority setting has generally been effective, and research has been able to focus on program objectives. Program coherence could be further strengthened by considering the evolving role of the private sector as addressed in Recommendation 1, by improving impact pathways in situations of interlinkages.

However, MAIZE may need to look again at its priorities in FP4 and FP5, particularly in areas where its comparative advantage is changing, in view of the increasing importance of the private sector. In some geographic areas, MAIZE may have to reconsider its role in breeding of, for example, hybrid products. This could strengthen global leadership of MAIZE in maize breeding in its target areas for smallholder farmers. MAIZE should also consider whether social science should not be a crosscutting theme that

[69] Researcher Question 28. Please indicate your agreement with the following statements related to the value MAIZE has had or is likely to have influencing the success of your research compared to past Center-based implementation of the research.

strengthens coherence of each of the RSs, rather than be a separate theme integrated with post-harvest management in RS3. The rationale for the five FPs and two of the three RSs appears to be transparent and well argued. In operational plans and realization of projects and partners, the CRP has carefully targeted W1/W2 funds internally and via competitive partner grants.

3. Is MAIZE designing and shaping future partnerships to articulate a sustainable research project portfolio?

MAIZE has effective partnerships with many institutes from the public and private sector, seed sector, universities and ARIs, which appear to be effective, and ensure state-of-the-art science and research approaches, and downstream delivery. Partnerships are complementary, well managed and much appreciated by stakeholders. In general, research approaches in MAIZE reflect high quality thinking and involve excellent partnerships with NARS, ARIs and universities.

Major investments have been made by MAIZE in capacity development. Innovation platforms and field days have attracted thousands of farmers; hundreds of national program collaborators have been trained, and the numbers of scientists that have been able to pursue their doctoral research through MAIZE is impressive (>100 per year). National programs look very favorably at these efforts.

4. Is the CRP managing well the very high and increasing level of restricted funding in terms of program quality and effectiveness (including high-quality staff), sustainability and administrative load?

Quality of MAIZE science ranges from good to very good, and MAIZE has a generally good publication record. Outputs of RS2 on stress-resilient and nutritious maize are impressive, and scientists and their processes are of high quality. The quality of RS1 and RS3 is also good, with pockets of improvement required. The implementation of integrated molecular breeding, new trait phenotyping technologies and “big data” approaches in all three RSs are challenges for MAIZE in developing its best practices. MAIZE will need to continue to invest in data and information management in all research areas in order to accelerate research feedbacks (whether they are based on farm technologies or germplasm or impact reports) and to comply with CGIAR obligations on open access data.

MAIZE has relatively high transaction costs, and scientists spend a considerable amount of their time attending planning, consultation and evaluation meetings, including for this evaluation. Donor and CGIAR reporting requirements are considerable. The Evaluation Team hopes that the time dedicated to reporting can be streamlined and processes standardized, so that more attention can be given to research and publishing results in peer reviewed journals.

Overall MAIZE has good research staff, appropriate organization, and a comprehensive project portfolio. One area that clearly needs investment is recruitment and retention of women scientists who are relatively under-represented. Furthermore, the Evaluation Team considers that MAIZE has to make additional investments in more clearly defining processes, protocols and working methods and to document these thoroughly. This is important to articulate common understanding across projects. Internal training should be provided for the implementation and application of these procedures. Such an effort is particularly important considering the rapid increase in numbers of new scientists (nearly double both at CIMMYT and IITA in three years), who sometimes are inexperienced and need mentoring. It would also give greater support to field staff in remote areas.

MAIZE has made considerable efforts to incorporate gender considerations in research design. Progress is particularly strong in generating gender-disaggregated data and in initiating gender research projects. More work is needed on the implications of gender for technology adoption and its

feedback to research, strategic gender research for proactive research prioritization, and development of quality standards for gender analysis.

The Evaluation Team has indicated two models (one each for RS1 and RS2) that aim to guide MAIZE by developing a complete R4D stage plan for the strategies. The stage plan, together with documented policies and protocols, should increase synergy across projects and ensure rapid engagement of new staff and projects into the MAIZE "delivery system".

5. Are the impact pathways in the new CRP structure sufficiently specified regarding target beneficiary groups and alternative research and industry providers, and are they clearly formulated and used in program monitoring and management?

Impact pathways are well-defined at the project and program level, and link CoAs with outputs, outcomes, IDOs and SLOs. Greater attention should be given to specifying the target groups and domains, particularly regarding poor consumers and the market outlook for maize. Measurable targets and outputs are well defined in annual project proposals, but the assumptions should be made more dynamic. Indicators are still being designed for progress towards and results at IDO level. Good efforts have generally been made and over the years and research plans have been refined as more experience is gained.

The five FPs are interlinked, but impact pathways do not illustrate this. More attention should be given to impact pathways of outputs that contribute to several IDOs and where there are strong inter-linkages between FPs. Impact pathways also come with a set of assumptions, but this approach could be strengthened by carrying out sensitivity analysis and visioning exercises. Thus the ToCs that underpin the impact pathways, need to be used in a dynamic way in research planning and monitoring. This will improve MAIZE prediction and response capacity in a rapidly changing world that includes disease outbreaks and swings in markets.

MAIZE has made good efforts in defining measurable targets and milestones, which are to be reached to ensure progress toward outcomes and goals. Every year, MAIZE reports on progress achieved, and overall 80–90% of milestones are reached. Due to funding limitations and shortfalls, and sometimes due to overambitious goals, some projects were not initiated as planned. Nevertheless, the Evaluation Team believes that MAIZE is on target in reaching its goals for productivity improvement.

From the outset MAIZE initiated a M&E system, which is adequate but needs to be strengthened for greater results orientation and feedback. The newly appointed M&E officer has already taken steps in the appropriate direction.

Considerable efforts have been made to carry out adoption and impact studies in a large number of countries and their number has increased since the start of the CRP. However, it seems that these studies are not sufficiently used for feedback into research design and specification of desired technology characteristics. Most adoption studies are also about the effects of varietal improvement, and evidence is still limited on the effects of improved agronomic practices, conservation agriculture, and post-harvest technology. This will require greater interdisciplinary efforts, as understanding of farmer practices is more complex than tracking genetic crop improvements. Adoption and impact studies should take gender differences into account as part of gender mainstreaming.

It is too early to assess the impact of MAIZE after only three years of operation. The adoption and impact studies undertaken provide substantial evidence that adoption of improved varieties has been widespread across the developing world, with adoption rates of more than 60% in many African countries. More than half of this achievement can be attributed to CIMMYT and IITA efforts. However,

evidence of impact on the higher system level goals has been patchy and generally based on *ex ante* extrapolations from adoption evidence based on sometimes limited samples and a large number of assumptions. MAIZE should invest more project resources in *ex post* impact assessment and develop an impact assessment strategy. Impact pathways should be strengthened in adoption studies.

MAIZE has an ambitious program in its extension proposal 2015–2016 that may address some of the concerns presented above.

9.2 The way forward

The Evaluation Team's overall assessment of MAIZE is positive. The evidence from senior-level meeting minutes and actions is that management is geared towards learning from experiences so that potential weaknesses are addressed appropriately. The rapid and efficient response to the outbreak of the MLN virus, involving effective resource mobilization, illustrates the dynamic nature of MAIZE.

MAIZE is still based on the two parallel maize research programs of CIMMYT and IITA. In contrast to other CRPs, MAIZE has a manager/coordinator rather than a director. MAIZE has been managed through the M-CM, and this model has generally worked well. Since the start of MAIZE, collaboration between CIMMYT and IITA has improved considerably. Both centers have joint projects on DTMA, Maize stress, *Striga* resistance, TAMASA (on agronomy), and Integrated *Striga* Management, and QPM. There have also been joint efforts in breeding for resistance to maize streak virus disease. However, there are still different cultures in the two centers. There is a need to accelerate the process by which the separately run projects are aligned within the program and to increase the spillover of research results and experiences across research projects and centers. Setting research priorities program-wide will also allow shifting funding towards areas of greater comparative advantage, investments in protocol development, and in training to implement protocols. These are essential steps for a future where systematic protocols for data set development and open access data are standard operating procedures.

The Evaluation Team believes that the integration of both the maize programs of CIMMYT and IITA into a single program would increase the efficiency and effectiveness of MAIZE at all levels. This would be enhanced by the appointment of a MAIZE director with increased authority over program and management matters, and reporting directly to the CIMMYT BoT (and the PC of IITA). This would improve mutual accountability and allow for better program integration, more efficient use of resources, common RMS systems, more effective monitoring and evaluation procedures, enhanced collaboration with other CRPs and greater emphasis on common methods and research protocols.

The Evaluation Team has been informed that CIMMYT and IITA have already discussed the needs and merits of proceeding towards the CRP as a single integrated maize program. These discussions were ongoing while the Evaluation Team was drafting its report. A formal agreement needs to be endorsed by the BoTs of IITA and CIMMYT. The IITA BoT will discuss the proposal at its May meeting of 2015. The CIMMYT BoT reportedly endorsed the proposal at its meeting during the last week of February 2015.

Recommendation 11: CIMMYT and IITA should agree on the establishment of a single global maize program in the CGIAR that integrates efforts of the two centers. This MAIZE program should be led by a director.

Once the newly integrated program is in place and the MAIZE director appointed, it should be possible to address the concerns expressed in this report efficiently. The development and implementation of common research protocols and approaches will enhance effectiveness of research efforts, and the

availability of common data sets will allow for better spillover of research results. These actions will substantially enhance the sustainability of MAIZE efforts.

In conclusion, the Evaluation Team stresses the importance of MAIZE for the 140 million poor smallholder farmers and 900 million poor consumers for whom maize is the preferred staple crop. Investments in maize research have had high returns, and MAIZE is well on target in its efforts to increase maize productivity in its two target groups by 7% in 2020 and 33% in 2030. This would provide sufficient maize grain to meet the annual food demand of an additional 135 million poor consumers in 2020 and of 600 million consumers in 2030. MAIZE leaders, scientists and partners can be commended for the progress in planning and implementing this program. MAIZE learns from experiences gained, is dynamic and takes adequate steps to move in the right direction. The Evaluation Team is confident that MAIZE is ready to meet the challenges of the future and will contribute substantially to the goals of the CGIAR for poverty alleviation, food security and sustainable management of natural resources.