Advisory Services

CGIAR

CGIAR Research Program 2020 Reviews: Roots, Tubers and Bananas (RTB)

Authors: David Coombs and Jill Lenné

16 November 2020

This evaluation has been commissioned by the CGIAR Advisory Services Shared Secretariat (CAS Secretariat) Evaluation Function (CAS/Evaluation). CAS/Evaluation encourages fair use of this material provided proper citation is made.

Correct citation: CAS Secretariat (CGIAR Advisory Services Shared Secretariat). (2020). CGIAR Research Program 2020 Reviews: Roots, Tubers and Bananas (RTB). Rome: CAS Secretariat Evaluation Function. https://cas.cgiar.org/

Cover image: Banana farmer, Uganda. Credit: RTB

Design and layout: Luca Pierotti and Macaroni Bros

CGIAR Research Program 2020 Reviews: Roots, Tubers and Bananas (RTB)

Authors: David Coombs and Jill Lenné

16 November 2020

Acknowledgments

This evaluation was prepared by a team led by David Coombs, who provided senior evaluation expertise, and Jill Lenné, who was the subject matter expert.

The two-person team worked under the overall direction of Allison Grove Smith, Director, CGIAR Advisory Services Secretariat. These reviews are being led by the CAS Secretariat Senior Evaluation Manager Svetlana Negroustoueva. Ravi Ram, Senior Evaluation Consultant to CAS Secretariat, managed the first cohort of three CRP2020 Reviews – A4NH, GLDC, and WHEAT. Angela Giménez Barrera provided technical evaluation expertise for the review process. Paolo Sarfatti served as senior advisor to the evaluative reviews project 2020. Gaia Gullotta and Max Runzel provided analytical support. Carlos Iglesias served as a peer-reviewer of the preliminary findings and final report.

CAS/Evaluation and the review team gratefully acknowledge RTB CRP and the CGIAR System Organization for their support: Julien Colomer and Hector Tobon.

The review team would especially like to thank Zandra Vasquez for her invaluable support in arranging interviews with key informant interviews and also Vivian Polar and Graham Thiele for their frequent explanations about the program and rapid responses to requests for further data.

CAS Disclaimer

By design, the CGIAR Results Dashboard was a key source of data for the 2020 CRP Reviews. During the pilot phase of the CRP Reviews, issues with interoperability and resulting data quality between the management information systems (CLARISA and the Dashboard) and extracts from CRP systems (MARLO and MEL) were discovered. For harmonization, CAS engaged with the MARLO and MEL team and the CRP MEL focal points to conduct data cleaning and pre-analysis for CRP review teams. This exercise revealed the limitations of CGIAR's reporting/repository systems for evaluation purposes; these limitations were mostly due to changing reporting requirements and discrepancies in whether CRPs adopted MARLO or MEL systems. Moreover, in the case of peer-reviewed journal articles, the protocol used by the CRP review teams to identify relevant publications differed from the guidance applied by CRPs (the CRP review teams' bibliometric analysis used only publications indexed by International Scientific Indexing [ISI], available through Web of Science). Therefore, CAS acknowledges discrepancies between the CGIAR Results Dashboard and the data provided to the Review teams for their analysis, which should not be seen as a factor having influenced the analysis by the CRP review teams.

Contents

Find the Annexes and Brief here:

CRP 2020 Review: RTB | CAS | CGIAR Advisory Services

List of Tables

List of Figures

Table of Acronyms

A4NH	Agriculture for Nutrition and Health CRP
ACAI	African Cassava Agronomy Initiative
ACIAR	Australian Center for International Agricultural Research
AR	annual report
AR4D	Agricultural Research for Development
ARI	advanced research institution
Bioversity	Bioversity International
BXW	Xanthomonas wilt of banana
CapDev	capacity development
CAS	CGIAR Advisory Services Shared Secretariat
CCAFS	Climate Change, Agriculture and Food Security
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
CIRAD	Center for International Cooperation in Agricultural Research for Development France
CL	cluster leader
CMD	cassava mosaic disease
CMR	complete mat removal (of banana)
CoA	cluster of activity
CoP	community of practice
COVID-19	disease caused by novel coronavirus SARS-CoV-2
CRP	CGIAR Research Program
EGS	early generation seed
EiB	Excellence in Breeding
FBS	farmer business school
FFS	farmer field school
FLG	farmer learning group
FP	Flagship Project
FPL	Flagship Project leader
GCP21	Global Cassava Partnership in the 21st Century
HQCP	high-quality cassava peel
IAC	Independent Advisory Committee
ICT	information and communication technology
IEA	CGIAR Independent Evaluation Arrangement
IF	impact factor
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILCYM	insect life cycle modeling
INRA	National Institute of Agricultural Research France (now part of INRAE)
IP	impact pathway
IPG	international public good
IPM	integrated pest management
IRD	Institut de Recherche pour le Développement France
ISC	Independent Steering Committee
ISPC	Independent Science and Partnership Council
JCR	journal citation report
MARLO	Managing Agricultural Research for Learning and Outcomes
MC	Management Committee
MEL	monitoring, evaluation, and learning
NARS	national agricultural research system
NGO	nongovernmental organization
NPPO	national plant protection organizations
OFSP	orange-fleshed sweet potato
OICR	Outcome Impact Case Report
PD	program director
PIM	Policies, Institutions and Markets CRP
PMCA	participatory market chain approach
PMU	Program Management Unit

POWB	Plan of Work and Budget
PSMP	production system and management practice
QA	quality assurance
QoR4D	Quality of Research for Development
QoS	quality of science
RBM	results-based management
RCMT	research and communications methodologies and tools
RTB	Roots, Tubers and Bananas CRP
SDG	Sustainable Development Goal
SDSR	single diseased banana stem removal
SLO	System-Level Outcome
SME	small and medium-sized enterprises
SRF	Strategy and Results Framework
ToC	theory of change
ToR	terms of reference
TR4	Fusarium Tropical Race 4
W1	Window 1
W2	Window 2
W3	Window 3
WUR	Wageningen University and Research

Executive Summary

Background and Context of Roots, Tubers and Bananas

The main objective of the CGIAR Research Program on Roots, Tubers and Bananas (RTB) is to maximize the contribution of the vegetatively propagated staple food crops: banana, cassava, potato, sweet potato, yam, and minor roots and tubers to tackle hunger and malnutrition, reduce poverty, and make smallholder farmers more resilient to climate change. These crops provide around 15% or more of the calorie intake for the 763 million people in the world's least-developed countries. RTB is led by the International Potato Center (CIP) in partnership with Bioversity International, the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), and the Center for International Cooperation in Agricultural Research for Development France (CIRAD). RTB is structured around five interlinked Flagship Programs (FPs): FP1–Discovery Research for Enhanced Utilization of RTB Genetic Resources, FP2–Adapted Productive Varieties and Quality Seed of RTB Crops, FP3–Resilient RTB Crops, FP4–Nutritious RTB Food and Added Value through Postharvest Interventions, and FP5–Improved Livelihoods at Scale.

Purpose and Scope of the CRP 2020 Review

This review covers the RTB Phase II years of 2017 to 2019 to identify lessons for future research modalities and provide information on quality of science and effectiveness by answering the following questions:

- To what extent does the CRP deliver quality of science?
- What outputs and outcomes have been achieved, and what is the importance of those identified results?
- To what extent is the CRP positioned to be effective in the future, seen from the perspectives of scientists and of the end users of agricultural research?
- What is the added value of RTB as compared with the counterfactual?

Approach and Methodology

Sources of data and information for the review include program documents; interviews with RTB leaders, donors, and partners; staffing and financial resources; annual reporting data (2017–19), including Outcome Impact Case Reports (OICRs); and bibliometric studies of over 350 peer-reviewed journal articles. Details of analytical methods are provided within the report.

Key Findings and Conclusions

RQ 1 – Quality of Science

Inputs

RTB teams are appropriately diverse with good skill sets (except agronomy) complemented by over 350 partners with additional skills and diversity. Earmarked funds support cross-crop and cross-Center projects, while scaling funds support scaling up of innovative packages for adoption.

Management processes

Leadership and management roles and responsibilities are well defined; quality of science (QoS) processes are robust, transparent, and fair; and communication mechanisms are well developed and widely appreciated. RTB has implemented notable institutional innovations to create an integrated, coherent, and productive program, in spite of the complexities of multiple crops and funding streams.

Outputs

Many publications (57%) are high quality, appearing in Institute for Scientific Information (ISI) Web of Science core collection, and open access. They demonstrate recognition of coauthors (author collaboration index is 5.28) and international collaboration (89% are multi-country publications), and they show broader applicability (as international public goods [IPGs]), with some exceptions in low-impact journals. Good progress has been made in modernizing breeding programs. Eighty-seven varieties of RTB crops have been released in the past three years. Notable advances have been made in developing the Seed Systems Toolbox, information and communication technology (ICT) solutions for pest and disease management, methods for assessing quality traits, and ongoing advocacy to increase adoption of biofortified foods and cassava peels animal feed. Scaling approaches demonstrate sustainable intensification of RTB agri-food systems. Improved links between FP2 and FP3 will help to tackle yield gaps.

RQ 2 – Effectiveness

Achievement of results

RTB has achieved over 90% of its annual milestones together with many policies and innovations. Study of OICRs showed strong progress toward expected outcomes.

Achievements of broader goals

At the broader level, there have been many contributions to potential impact through adoption of varieties, technologies, and innovations. Because of reduced funding, program shortening, and the program dislocation caused by COVID-19, the aspirational program goals outlined in the RTB proposal are unlikely to be met. RTB has fewer projects than planned to achieve goal 5: "To increase sustainable cropping systems."

Management and governance support of effectiveness

The program has been well managed by its leadership, with the support and guidance of the Management Committee, despite complex administrative and financial arrangements, which pose many challenges. The Independent Steering Committee (ISC) has also demonstrated effectiveness as a governing body for RTB's quality of research for development.

Progress along Theory of Change

Theory of change tools have helped at the planning stage and are reviewed annually but are not commonly used as a routine management tool or for resource allocation.

Cross-cutting issues

Capacity development (CapDev) has enabled 499 students to attain higher degrees and over 340,000 people to receive training at all other levels. Although CapDev is built into the larger bilateral projects, the scope for RTB to achieve similar levels of achievement within its own projects is more limited because of funding restrictions, lack of capacity within the centers, and a reduced priority for CapDev at the CGIAR System level. **Gender** research is well integrated throughout biophysical research activities and is much appreciated by FP leaders. Research on **youth** is focused on understanding their role in agriculture. Much research on adaptation to and mitigation of **climate change** is embedded throughout FPs, however, aspirations to link more closely with CCAFS have not been realized owing to different priorities and lack of support. **Partnerships** are a key strength of RTB, enabling strong linkages among centers, advanced research institutions (ARIs), universities, and regional and national organizations. Cross-CRP partnerships with integrating CRPs could have been more effective through better harmonization of priorities and enhanced support.

RQ 3 – Future orientation

The **Golden eggs** (collective knowledge assets) position RTB to play an important role in further contributing to the SDGs over the next 10 years. RTB needs to continue important research on its clonally propagated crops and emphasize the value of keeping them together within key research areas. RTB should continue research on integrating gender with biophysical research and on scaling readiness approaches that have been recognized across the System.

Recommendations

RTB Recommendations

R#1. As far as possible, RTB should avoid publishing in journals with an impact factor (IF) less than 1 and in quartile 3 or 4 (Q3/Q4). Quality of publications should be included in the incentive system.
R#2. Opportunities should be taken to improve links between FP2 and FP3 to integrate deliverables from both efforts during 2021 to more effectively address yield gaps.
R#3. The lessons learned during the past three years should be documented to inform future multi-crop initiatives and projects.
R#4. RTB should continue to develop and add to the Golden Eggs in 2021 to position itself to play an important future role in One CGIAR.
R#5. Efforts should be strengthened through the Alliance Compact (Joint Partner Collaboration Statement) to further promote the RTB brand as an integrated global program and to position it for inclusion in One CGIAR.

CGIAR System-Level Recommendations

R#6. The System should retain clonally propagated crops together as a group within key research areas to further enhance synergies and achievements in One CGIAR.
R#7. The System should seriously consider for broader use the concept of the Golden Eggs for future initiatives and projects in One CGIAR.
R#8. Opportunities for integration between initiatives and projects in One CGIAR should not only be sought but must be better supported if cross-CGIAR contributions to the Intermediate Development Outcomes (IDOs) and Sustainable Development Goals (SDGs)—e.g., on nutrition, climate change, and policies—are to be fully captured.
R#9. One CGIAR should recognize CapDev as a core part of its role and apply sufficient resources to achieve results.
R#10. One CGIAR should recognize the key role of partnerships in its design of future initiatives to ensure that relationships (corporate, technical, and personal) built up by RTB and other CRPs are not lost.

Background to the CRP 2020 Review

1.1 Purpose and Target Audience of the Review

The CGIAR Advisory Services Shared Secretariat (CAS Secretariat) is conducting independent reviews, commissioned by the CGIAR System, of the 12 CGIAR Research Programs (CRPs) during 2020 as part of its role in providing independent evaluation and assessments to the CGIAR System. This review of the CRP on Roots, Tubers and Bananas (RTB) will provide information on quality of science and effectiveness.

The primary purpose of the review is to assess the extent to which the RTB research program is delivering quality of science and demonstrating effectiveness in relation to its theory of change. The specific objectives of this independent review are to fulfill CGIAR's obligations around accountability regarding the use of public funds and donor support for international agricultural research; to assess the effectiveness and evolution of RTB in its second phase, 2017–21; and to provide an opportunity to generate insights about RTB's research contexts and programs of work, including lessons for future CGIAR research modalities.

The primary users of the review will be the CGIAR System Council, with insights and lessons developed from the review for use by the RTB program. Further, the review may provide lessons that inform the transition to One CGIAR in 2022. The findings, conclusions, and recommendations may be of use in refining the CRP's 2021 Plans of Work and Budget (POWBs) to the extent feasible in the remaining program year or in drawing lessons to inform future research modalities.

1.2 Overview of RTB and Its Context in Research for Development

RTB Phase II was initiated in 2017, following on from RTB Phase I and parts of CRP Humid Tropics, which were implemented from 2012 to 2016. Both Phase I CRPs were derived from pre-CRP research at four CGIAR Centers. RTB Phase I underwent a comprehensive evaluation by the CGIAR Independent Evaluation Arrangement (IEA) in 2015–16, which made 16 recommendations to inform the development of the RTB Phase II proposal. The evaluation concluded that RTB has made notable progress and is already delivering results, in spite of budget cuts. RTB is well-directed and reaching a reasonable number of its near-term milestones and is working towards achieving its goals, particularly those concerning productivity and nutritional improvement for some of its crops (IEA, 2016, Pg. 1-2).

The Phase II proposal was assessed by the Independent Science and Partnership Council as Excellent – high-quality research and a strongly compelling proposal that is at an advanced stage of evolution as a CRP, with strong leadership which can be relied on to continue making improvements (ISPC, 2016, Pg. 1).

The main objective of RTB is to catalyze research and development organizations to maximize the contribution of the vegetatively propagated staple food crops—banana, cassava, potato, sweet potato, yam, and minor roots and tubers—to tackle hunger and malnutrition, reduce poverty, and make smallholder farmers more resilient to climate change (RTB, 2016a). RTB is led by the International Potato Center (CIP) and brings together four CGIAR Centers (Bioversity, the International Center for Tropical Agriculture [CIAT], the International Potato Center [CIP], and the International Institute for Tropical Agriculture [IITA]) and the Center for International Cooperation in Agricultural Research for Development France (CIRAD) (also representing the French organizations Institut de Recherche pour le Développement France [IRD], the National Institute of Agricultural Research France [INRA], and Vitropic) with more than 300 partners. Its target crops are linked by common breeding, seed, and postharvest issues and by the frequency with which women are involved in their production and use. RTB crops are the backbone of food security for more than 300 million people living in poverty in developing countries; they provide 15% or more of the daily per capita calorie intake for 763 million people and are rich in key nutrients, such as pro-vitamin A.

RTB is structured around five interlinked Flagship Programs (FPs) including one Discovery Flagship, three Delivery Flagships, and one Scaling Flagship: FP1–Discovery Research for Enhanced Utilization of RTB Genetic Resources; FP2–Adapted Productive Varieties and Quality Seed of RTB Crops; FP3–Resilient RTB Crops; FP4–Nutritious RTB Food and Added Value through Postharvest Intervention; and FP5–Improved Livelihoods at Scale.

1.3 Scope of the Review and Review Questions

The review covers the work of RTB, guided by the CGIAR's quality of science and effectiveness criteria (see Annex 1: Terms of Reference for the CRP 2020 Review, Addendum) and its theories of change. The emphasis is on the CRP's sphere of control—that is, the quality of inputs, activities, and outputs, and its short-term and intermediate outcomes that are expected to lead to a development impact.

The CGIAR System defines outcome-level changes as Intermediate Development Outcomes (IDOs) and System-Level Outcomes (SLOs). Expectations of documented outcomes are informed by (1) the amount of time the research has been conducted by the CRP and its managing partners, including research prior to RTB in the case of legacy programs, and (2) whether the first users of research outputs are within the research community or closer to market adoption. Not all planned outcomes are expected to have been achieved, as the review is being conducted after three years of operation on a five-year research program (originally planned for six years). To the extent feasible, this review has assessed the likelihood of achieving IDOs and/or sub-IDOs based on the documented performance of the CRP in relation to their theories of change. At the request of RTB, a question related to the added value of RTB compared with the counterfactual was added. The views of interviewees and the reviewers are included jointly with lessons learned in Section Four.

1.4 Approach, Methods, and Limitations

Quantitative data were obtained from bibliometric analysis of journal publications, technical publications, the CGIAR Dashboard, and key physical outputs (including released advanced germplasm and varieties). The analysis of performance was determined by assessing contributions to milestones, sub-IDOs, and IDOs. The analysis of outcome impacts has been implemented through deep dives on Outcome Impact Case Reports (OICRs). Key program documents included annual reports (ARs) and Plans of Work and Budget (POWBs), the approved RTB proposal, evaluative documents such as reviews by the ISPC, publications, technical reports, partner reports, and websites. Dashboard data pre-analyzed by CAS was made available to the review team. Attention was also paid to the IEA Evaluation of RTB Phase I (IEA, 2016), which made 16 recommendations.

Interviews were conducted with 40 key informants, including RTB leadership and management, FP and cluster of activity (CoA) leaders, Center focal points (CFPs), CGIAR Platforms, the Independent Steering Committee (IAC) Chair, the CIP Director General, national agricultural research systems (NARSs), nongovernmental organizations (NGOs), funders, and private sector organizations. An interview guide was developed to act as an aide-mémoire for interviewers. The team selected three OICRs to be used for the deep dives: two on the adoption of cassava varieties in Nigeria and South and Southeast Asia and one on the control of banana *Xanthomonas* wilt (BXW) in Uganda.

As the review was desk based, it was not possible to carry out an assessment of infrastructure and technical outputs or to interview final beneficiaries. However, as most of the outputs of the CRP are disseminated by national authorities and other stakeholders, the feedback from those interviewees was used to judge the value of the CRP to the final beneficiaries.

1.5 Management and Quality Assurance

The subject matter specialist, who also carried out the review of the CRP on Grain Legumes and Dryland Cereals, has extensive knowledge of RTB and the methodology of current reviews. Interviews were organized by RTB; 18 interviews were carried out jointly, and the remainder by only one team member.

Quality assurance was carried out through discussions and mutual review of outputs between team members, CAS monitored progress through a midterm quality check as well as quality assurance on the preliminary findings and the draft final report with the assistance of an independent expert peer reviewer. It is noted that the subject matter specialist led the evaluation of RTB Phase I. A conflict of interest (COI) statement was signed by both team members, and the responsibility of team lead was allocated to the Senior Evaluation Specialist as a mitigation measure.

2 Findings

2.1 Quality of Science

Quality of science in RTB is firmly anchored in its unique design. Cross-cutting clusters feature in all FPs, while in FP5 all clusters are cross-cutting. This approach facilitates coherence, integration, and enhanced ability to take advantage of synergies and complementarities. It is a generic structure that can be effectively applied to different sectors—e.g., breeding, seed systems, nutrition, and pest management. The design of RTB should be considered for future multi-crop initiatives and projects.

2.1.1 Quality of Research Inputs

2.1.1.1 Skills

RTB is implemented through a core partnership of four Centers—CIP, IITA, CIAT, Bioversity International[1]—and CIRAD/IRD. Core partners contribute a wide range of disciplinary skills. Many key members are internationally recognized scientists. Skills vary among FP teams. They include crop breeders and genomics and germplasm scientists in FP1; crop breeders and seed system scientists in FP2; pathologists, entomologists, and agronomists in FP3; biofortification and postharvest scientists in FP4; and economists, social scientists, and gender experts in FP5. The skills are appropriate for the planned activities and skills work across FPs. RTB complements these internal skills through high-quality external partnerships. Partners include Royal Holloway University London for metabolomics, Cornell University for genomics and gender research, University of Florida for network analysis and seed degeneration, and Wageningen University for seed systems and scaling research. Over 350 partners including advanced research institutions (ARIs), NARSs, NGOs, and the private sector contribute a wide range of skills to RTB. The only skill area where RTB is lacking is in crop management research, where, apart from IITA, agronomy expertise is limited both in RTB and in partners.

2.1.1.2 Diversity

The scientist diversity available to RTB is largely under the control of Center partners. In this context, the diversity of skills required for delivery of outputs and outcomes appears to be adequate with the exception of agronomy. However, future uncertainties and funding availability have led to the loss of some skills. The available disciplinary diversity and the RTB structure create opportunities for cross-fertilization of ideas and learning. RTB is also a global program working across five continents. With regard to gender diversity, 30% of RTB scientists are female (of 161 listed). The Gender-Related Development Index guidelines indicate that 35% should be aspired to, but this includes all staff at the Center level not at the CRP level.

2.1.1.3 Infrastructure and Funding

Funding for upgrading or additional infrastructure is limited. Partner participation agreements, especially with well-endowed ARIs, improve access to infrastructure and specialized equipment for research. Some equipment can be purchased through W3/bilateral funds, but there are examples where field trials, e.g. phenotyping research, are negatively impacted by lack of uniformity at trial sites.

RTB has control over W1/W2 funds, which account for 20% (about US$20 million) of the annual budget. About $8 million of this is allocated to earmarked and scaling funds through internal competitive calls. These funds provide opportunities to foster cross-crop and cross-Center collaborative projects and seed funding for foundation research to develop proposals for W3/bilateral funding. Scaling funds support scaling of innovative packages for adoption through FPs.

[1] From 2020, Bioversity International and CIAT became the Alliance of Bioversity International and CIAT.

2.1.2 Quality of Processes (including Partnerships)

2.1.2.1 Roles and Responsibilities

Leadership and management of RTB are implemented at multiple levels—Program Director (PD), Program Management Unit (PMU), FPs, clusters, and RTB and cluster-level Center focal points. The roles and responsibilities of all RTB leaders and managers are well defined through individual terms of reference (TORs). This responds well to Recommendation 15 (IEA, 2016). Leadership performance is evaluated annually and feeds into the Center-level performance evaluations for CIP and IITA. Financial incentive rewards are given to the best-performing clusters while financial penalties may be imposed on poor-performing clusters. RTB has regular meetings and interactions at all levels of leadership and management. For example, the Management Committee (MC) meets five to six times each year; the PD meets with FPs three to four times each year; FP leaders and cluster leaders regularly meet with each other and with scientists in their groups, while Center Focal Points (CFPs) meet with their Center members of RTB. At an annual meeting, FP leaders present achievements to management and the Independent Steering Committee (ISC) for feedback on the quality of science (QoS). Uniquely, RTB has a science officer who provides input on the QoS, including the standard and quality of reporting and the quality of publications and research on crop breeding. This responds to Recommendation 6 (IEA, 2016).

2.1.2.2 Control, Mentoring, Communication, and Partnerships

Cluster leaders have most control over the QoS through the earmarked funds and, to some extent, W3/bilateral projects housed in their clusters (80% of RTB budget). At the same time, new projects provide opportunities for FP leaders to influence the QoS, especially on design, selection of tools, and partners. Mentoring of junior researchers is achieved through the embedding of MSc and PhD students in projects (see section 2.4.1 on capacity development), building capacity in global skills for RTB crop research. The good communication between PD/PMU and RTB scientists as well as management support is much appreciated and facilitates QoS. Although the quality of research for development (QoR4D) Framework has not been formerly used by RTB for monitoring QoS, wider awareness of it would foster a culture that enables the highest standard of research during the last year of Phase II.

There is a clear recognition of partners' roles and contributions, which again facilitates QoS. The recognition of partners as coauthors on most publications also demonstrates legitimacy. Cross-CRP partnerships with the CRPs Agriculture for Nutrition and Health (A4NH), Climate Change, Agriculture, and Food Security (CCAFS), and Policies, Institutions, and Markets (PIM) have been productive, but differing priorities limit opportunities for more comprehensive links. This is a CGIAR-wide issue and is addressed later in section 2.4.5 Partnerships.

2.1.3 Quality of Outputs

2.1.3.1 Publications

Quantum and quality of research publications 2017–19: The quantum and quality of research publications were analyzed using the QoR4D Framework for scientific credibility (International Scientific Indexing [ISI] journal impact factor, number of citations, Altmetrics, and h-index); legitimacy (acknowledgment of coauthors); and relevance (international public goods [IPG] rating). A total of 371 publications were analyzed from over the three years. There were noted improvements in the share of publications in ISI (83 to 96%) and open access (78 to 85%) journals between 2017 and 2019 (Annex 6a: Number of peer-reviewed publications 2017–19). Of cited publications, 52% (179) met the quality criteria for citations (2017–18, 5 or more; 2019, 2 or more) and 32% for Altmetrics (10 or more) (Annex 6b: Analysis of peer-reviewed articles in ISI journals from 2017–19). The h-indices of first authors ranged from 2 to 83, with 58% of first authors with 10 or more. The h-indices of 62 authors were not found, possibly as they are young scientists still to meet the h-index citation threshold. More than 93% of publications were multi-authored and multi-institute, with a high author collaboration index of 5.28, demonstrating excellent legitimacy. An analysis of 271 publications from the 12 most productive countries found that 89% were multi-country publications, again supporting high levels of international collaboration (Annex 6g: Most productive countries for publications). Most of the 179 publications analyzed in Annex 6b presented broader applicable knowledge—i.e., international public goods relevant to agriculture and climate change. This responds well to Recommendation 5 (IEA, 2016).

Annex 6c presents the 25 most productive authors, with 7 to 21 publications each, and good to high h-indices. Most authors were from CIP, IITA, and Bioversity International; 11 were members of FP3, reflecting a highly productive flagship with quality partners. This was also recognized by the ISC. Table 1 presents the most popular journals used by RTB with IFs and JCR rankings and categories. Ten journals have IFs of 2 or more, and 12 rank in Quartiles 1 and 2 of their journals grouping. However, two popular journals have IFs less than 1 and rank in Quartile 4. These are low-quality journals that should be avoided, especially if there are higher-quality journals available in their journal groupings. Table 2 presents an analysis of 179 publications by IF with examples of journals in each category. Fifty-seven percent of publications were in good to excellent journals with IFs greater than 3, including *Science* (IF 41.8) and *Nature Genetics* (IF 28).

In-depth analysis of selected RTB publications from each FP: Twenty-seven publications were selected at random across FPs (FP1 = 5; FP2 = 5; FP3 = 7; FP4 = 4 and FP5 = 6) for an in-depth assessment of the appropriateness of journal, IF, coauthorship, contribution of CRP, and overall quality (Annex 6d: Assessment of the quality of selected RTB research publications). For FP1, four of five papers were in appropriate ISI journals with high IFs, including *Nature Genetics*; the contribution of RTB and coauthorship were high with single exceptions; broader applicability (IPGs) was noted in all but one publication; and the overall quality was good to high, with important advances made in genomics and metabolomics research. For FP2, all but one paper were in moderate- to poor-quality journals based on IF, but all were open access. Higher-quality journals should have been sought for some of these papers, although this is more difficult for papers on seed systems. Coauthorship was limited in two of five papers; the contribution of RTB was generally high; broader applicability (IPGs) was noted in all but one publication; and overall quality was moderate to high, with seed system papers making key contributions on a framework, early generation seed production, and understanding farmer demand for quality seed. For FP3, four of seven papers were in appropriate, high-IF journals, including *Science*, *Annual Review of Phytopathology*, and *Proceedings of National Academy of Sciences*; coauthorship was high to very high; and the contribution of RTB was generally good, with one paper attributed to an external partner. Broader applicability (IPGs) was also noted, with three papers showing significant international applicability. Overall quality ranged from exceptionally high to moderate. For FP4, two papers were in high-IF journals for the group, while two were in moderate-IF journals; coauthorship was adequate in all but one paper; the contribution of RTB was moderate; and broader applicability (IPGs) was noted in all but one paper, while two showed significant international applicability. For FP5, three papers from a special issue of *Agricultural Systems*, published in 2020, were selected, as these papers were based on research done during 2017–19. These papers were in a high-IF journal, while two others should have sought higher-IF journals. The paper on gender was in an appropriate journal for the topic although of low IF, again reflecting the journal grouping (Mudege et al., 2017). Five of six papers showed good recognition of coauthors; the contribution of RTB was high; and broader applicability was demonstrated in all papers, with one paper having significant international applicability. Three papers demonstrated important contributions to scaling science across RTB; other papers provided insights on innovation platforms, gender norms in training programs, and the use of DNA fingerprinting in adoption surveys.

Table 1*: *Top journals, impact factor (IF) 2018, and journal citation reports (JCR) ranking and category

Journal	No. articles	IF 2018	JCR ranking[a]	JCR category[a]
1. *Frontiers in Plant Science*	19	4.4	Q 1	Plant sciences
2. *PLOS One*	17	2.7	Q 2	Multidisciplinary sciences
3. *Open Agriculture*[b]	15	0.4	Q 4	Agriculture, multidisciplinary
4. *Phytopathology*	9	3.2	Q 1	Plant sciences
5. *Plant Pathology*	9	2.2	Q 2	Plant sciences
6. *Fruits*	8	0.6	Q 4	Horticulture
7. *Scientific Reports*	8	4.0	Q 1	Multidisciplinary sciences
8. *Sustainability*	8	2.6	Q 2	Environmental sciences
9. *WUR Journal of Life Sciences*	7	1.6	Q 2	Agriculture, multidisciplinary
10. *Plant Disease*	7	3.8	Q 1	Plant sciences
11. *Agricultural Systems*	6	4.2	Q 1	Agriculture, multidisciplinary
12. *Food Security*	6	2.1	Q 2	Food science and technology
13. *Experimental Agriculture*	4	1.4	Q 2	Agronomy
14. *Food and Energy Security*	4	5.2	Q 1	Food science and technology
15. *Food Science and Nutrition*	4	1.8	Q 3	Food science and technology

Note: All papers were open access.
[a] From Web of Science.
[b] Workshop proceedings.

Quality and relevance of technical publications: Eleven technical publications, including working papers, project reports, and manuals, were selected from the five FPs for analysis of quality and relevance to next-stage users as well as potential for capacity development (Annex 6e: Assessment of selected technical publications generated by Flagships). Four working papers demonstrated relevance to next-stage users through comprehensive assessment of the technologies, advantages, and limitations; lessons learned; and areas of further research. Some working papers generated journal publications of use to next-stage users. One mentioned potential for capacity development (CapDev), and another reported on several training sessions undertaken. Two workshop reports looked at developing the topic further for the attendees and for next-stage users as well as sharing findings with a wider audience. The importance of capacity-building tools, materials, and methods was highlighted. Two project reports documented successes and insights into best practices for next-stage users as well as the importance of understanding expectations and demands. Significant CapDev was embedded in both. Two high-quality, well-illustrated training manuals were produced: one directed at researchers and private sector next-stage users and one at extension agents and farmers. Finally, one well-illustrated report described a tool for promoting youth engagement with RTB crops, focusing on myth-busting to better engage youth, and mentioned the importance of capacity. Overall, quality (clarity and usability) was mostly high; suitability for next-stage users was demonstrated, and the importance of CapDev was included or highlighted.

Table 2: Analysis of publications by journal impact factor (IF), 2017–19

IF	% publications (n = 179)	Examples of journals, with IF
IF = 10+	6.0	*Science* (IF = 41.8) *Nature Genetics* (IF = 28.0) *Communications in Biology* (IF = 12.1) *Molecular Biology and Evolution* (IF = 11.1) *Annual Review Phytopathology* (IF = 10.4) *Nature Plants* (IF = 10.3)
IF = 5–9.9	8.9	*PNAS* (IF = 9.4) *Plant Biotechnology* (IF = 6.3) *The Plant Journal* (IF = 6.1) *Global Food Security* (IF = 6.0) *Current Opinion in Virology* (IF = 5.4) *Food and Energy Security* (IF = 5.2)
IF = 4–4.9	22.8	*Frontiers in Plant Science* (IF = 4.4) *The Plant Genome* (IF = 4.3) *Field Crops Research* (IF = 4.3) *Agricultural Ecosystems and Environment* (IF = 4.2) *Agricultural Systems* (IF = 4.2) *Science Reporter* (IF = 4.0)
IF = 3–3.9	18.9	*Theoretical and Applied Genetics* (IF = 3.9) *European Journal of Agronomy* (IF = 3.4) *Phytopathology* (IF = 3.0) *Plant Disease* (IF = 3.0)
IF = 2–2.9	20.4	*PLoS One* (IF = 2.7) *Sustainability* (IF = 2.6) *American Journal of Agricultural Economics* (IF = 2.5) *Agricultural Economics* (IF = 2.3) *Archives in Virology* (IF = 2.3) *Plant Pathology* (IF = 2.2)
IF = 1–1.9	17.3	*Food Science and Nutrition* (IF = 1.8) *Journal of Agricultural Economics* (IF = 1.3) *Experimental Agriculture* (IF = 1.3) *Journal of Nutrition* (IF = 1.2) *Outlook on Agriculture* (IF = 1.1)
IF < 1.0	5.7	*Plant Genetic Resources* (IF = 0.9) *Journal of Agricultural Science* (IF = 0.8) *Fruits* (IF = 0.6) *Open Agriculture* (IF = 0.4)

Quality of communication products: Ten communication products—including mobile phone apps, web portals, web-based tools, newsletters, leaflets/brochures, design, and databases—were analyzed for relevance to target audiences (Annex 6fi: Assessment of newsletters and leaflets generated by RTB research). Newsletters, brochures, and leaflets detail concepts, activities, and learning processes for target audiences emphasizing key messages. A design was launched for the small-scale high-quality cassava flour dryer that has already attracted many small- and medium-sized enterprises (SMEs) in Nigeria. Databases are providing easy access to next users on a range of topics, e.g., cassava genomics, Musa knowledge, and potato varieties.

Two mobile phone apps—Cassava Seed Tracker and Akilimo—are already being widely used by target audiences in Sub-Saharan Africa (Cassava Seed Tracker, 2016; Akilimo, 2020). Cassava Seed Tracker has generated a related app for seed certification while Akilimo provides site-specific recommendations to extension officers and farmers on optimal cassava agronomic practices (Annex 6fii: Assessment of digital innovations generated by RTB research). Two web portals—on scaling readiness and sweet potato knowledge—are also widely used. The first provides decision support for developing action plans for scaling while the latter builds a community of practice among sweet potato researchers, practitioners, and farmers for sharing knowledge. Web-based tools, such as the seed systems toolbox and the intersectional gender tool for breeders, help inform decision-making in breeding and seed systems research. Significant CapDev was embedded in activities and case studies to develop the tools. The Insect Life Modelling software was used to produce the Insect Pest Distribution and Risk Atlas for Africa to inform target audiences of the risks of the spread of insect-vectored viruses.

2.1.3.2 Research outputs

A comprehensive list of RTB research outputs is given in Annex 6h: Assessment of physical outputs and services including varieties, digital innovations, methodologies, and tools for IPG value. The quantum of outputs is impressive. As far as possible, the most important outputs are summarized and assessed for each FP. Some of these outputs have been repackaged as Golden Eggs—RTB's collective knowledge assets to take into One CGIAR (see section 3.3).

FP1: Discovery research for enhanced utilization of RTB genetic resources. The Breeding Community of Practice (CoP) facilitates communication and sharing among the breeders supporting cross-crop collaboration and quality outputs from RTB research activities. This output responds well to Recommendation 9 (IEA, 2016). The modernization of breeding programs through Breeding Program Assessment Tool (BPAT) in collaboration with CGIAR Excellence in Breeding (EiB) Platform has been transformational for RTB and contributed to the development of 47 product profiles (CGIAR, n.d.). This output responds well to Recommendations 7 and 9 (IEA, 2016). The Gender in Breeding Initiative oversees the integration of gender approaches and preferences into these profiles. Significant advances in genomics research have been made across all RTB crops, especially for sweet potato, cassava, and banana, including the identification of markers for important traits and candidate genes. Progress has been made in the application of metabolomics to identify compounds possibly linked to pest and disease resistance and quality traits (Price et al., 2020). Global *in situ* information systems have been developed for banana and potato, and on-farm diversity hot spots have also been identified for collection and integration with *ex situ* conservation.

FP2: Productive varieties and quality seed. Over the past three years, 87 varieties of sweet potato (60), potato (15), cassava (5), and yam (7) have been released in 14 different countries. The Seed Systems Toolbox, with 10 tools for designing, implementing, and evaluating RTB seed system interventions, was finalized and validated (RTB, 2020b). The Triple S method is ensuring a consistent supply of sweet potato seed for farmers while reducing costs and is particularly beneficial in areas with long dry seasons. RTB-Action Malawi disseminated high-quality planting material of improved varieties of cassava, potato, and sweet potato to over 90,000 households. Gender issues are well integrated into all breeding and seed systems research. Commercial entities are producing early generation seed (EGS) using rapid multiplication technologies for cassava in Nigeria and Tanzania, yam in Nigeria and Ghana, and potato in Rwanda and Kenya, and providing seed to commercial growers. Through RTB influence, Nigeria's National Agricultural Seeds Council Act, 2019 decentralized seed certification by authorizing private entities to certify seed, and Malawi started using certification standards for cassava seeds. Achievements in seed systems research respond well to Recommendation 10 (IEA, 2016).

FP3: Resilient crops. There has been a notable increase in capacity of FP3 to utilize big data on pest and disease incidence and distribution as well as climate change since Phase I with the CGIAR Platform for Big Data in Agriculture (BDP, 2020) and to develop ICT tools and artificial intelligence to improve diagnosis and monitoring of cassava diseases in Sub-Saharan Africa with potential to spill over to other RTB crops. Insect life cycle modeling has strengthened the capacity to perform risk assessment under climate change and global pest movement (e.g. Pest distribution and Risk Atlas for Africa). Removal of single diseased banana stems has been recognized as the most effective method for restoring productivity of BXW-affected banana fields in Burundi, DR Congo, Rwanda, and Uganda (see OICR deep dive, section 3.2.2; Kilkulwe et al., 2019)). Cassava virus disease management was strengthened through scaling out of the PlantVillage Nuru app. Partnerships with 17 national plant protection organizations (NPPOs) allowed for addressing the spread of major diseases supported by ICT tools. The African Cassava Agronomy Initiative project has developed demand-driven support tools for cassava agronomy in Nigeria and Tanzania, including Akilimo, an ICT platform that provides site-specific recommendations to extension officers and farmers on optimal cassava agronomic practices. There have also been advances in the sustainable use of natural resources in potato and banana systems in Kenya. Gender issues are well integrated in pest and disease management and agronomy and cropping systems management activities. Even with the limitations of lack of RTB skills for agronomy and crop management research, these achievements are responding to Recommendation 11 (IEA, 2016).

FP4: Nutritious RTB food and added value through post-harvest intervention. High throughput tools such as near-infrared spectroscopy are being successfully used to determine quality traits for improved efficiency in breeding programs with FP2. Commercialization of storable orange-fleshed sweet potato

(OFSP) puree was shown to be economically viable in Kenya and Rwanda. Advocacy demonstrated that increased adoption and diffusion of OFSP can be achieved through intensive agriculture-nutrition education and extension programs. Progress was made in the inclusion of biofortification as a national and regional priority in African agriculture (Douthwaite, 2020). A prototype small-scale dryer was developed that demonstrated improved energy performance for producing high-quality cassava flour in Nigeria and Tanzania. Integration of high-quality cassava peels (HQCPs) and sweet potato silage in animal feed was demonstrated in Nigeria and Uganda, respectively (RTB, 2020a). In Nigeria, an enhanced value chain was developed with more than 1,000 small- and medium-scale cassava-processing centers, about 25 small- and medium-scale enterprises processing HQCP, 4 major millers producing animal feed, and more than 10,000 fish and livestock producers purchasing HQCP products. Scaling funds were important to the rapid development of this value chain. This achievement responds well to Recommendation 12 (IEA, 2016). This success is already generating attention in other Sub-Saharan African countries with potential links to the Livestock and Fish CRPs.

FP5: Improved livelihoods at scale. Successful pilot testing of the innovative scaling readiness approach and the implementation of the scaling fund has attracted the attention of other CRPs, such as MAIZE and WHEAT, and the System as a whole. These achievements respond well to Recommendation 14 (IEA, 2016). Guidelines were developed for innovation platforms in agricultural R&D, (Schut et al., 2019) and a social network analysis of multi-stakeholder platforms in agricultural R&D was implemented. Partnership management has proven to be a key factor for scaling of innovations in such platforms. The effectiveness of farmer field schools (FFSs) was clearly shown to enhance innovation in Africa and Latin America, while the participatory market chain approach (PMCA) in Latin America and farmer business schools (FBSs) in Asia also made important contributions to value chain development and showed potential to enhance gender equality (Kawarazuka and Kharchandy, 2019). The CGIAR gender in agricultural change project, GENNOVATE, contributed significantly to developing tools and approaches for more inclusive innovation in farming communities. Gender is covered in more detail in section 3.2.2. Ongoing analysis of programmatic research priorities was supported by foresight and ex-ante analysis of potential impacts of RTB innovations. Trade-offs between diversification and intensification in areas affected by BXW using whole-farm model FarmDESIGN was effective for decision-makers and could be more widely applied.

Annex 6h analyzes the broader applicability (IPGs) of the physical outputs relevant to agriculture and climate change. All outputs demonstrate either potentially broader applicability or demonstrated broader applicability (see Annex 2: CRP specific methodology). Several have already shown wider international applicability), including the Breeding CoP and modernization of breeding programs in FP1; the application of ICT tools for pest surveillance and partnerships with 17 NPPOs in FP3; and the scaling readiness approach in FP5. In addition, implementation of the scaling readiness approach has further facilitated measurable impact at scale—for example, in the adoption of SDSR for managing BXW in East Africa and the Great Lakes region and the rapid development of the enhanced value chain for high-quality cassava peel feeds in Nigeria. In addition, the development of the Golden Eggs with embedded, demonstrated, broader applicability integrates RTB's high-quality outputs into packages for wider impact at scale.

Although physical outputs are attributed to specific FPs, the reality is that more than one FP may have contributed to individual outputs. This is explicitly considered in the design of RTB. Many of the methods and outputs from FP1 are used by FP2 in developing improved varieties, and all breeders are part of the CoP, which fosters cross-fertilization of knowledge. FP2 and FP4 work closely together in developing biofortified RTB varieties. FP5 works closely with FP2, FP3, and FP4 to assess scaling readiness and to participate in scaling activities realized in these FPs. FP3 works closely with FP2 in seed systems for addressing degeneration of planting material due to diseases. These links and flows of outputs capture synergies and complementarities for higher-quality outputs and outcomes. Links between FP2 and FP3 could be strengthened to advance efforts to tackle yield gaps through better integration of crop improvement, agronomy, and management.

2.2 Effectiveness

2.2.1 Achievement of Planned Outputs and Outcomes

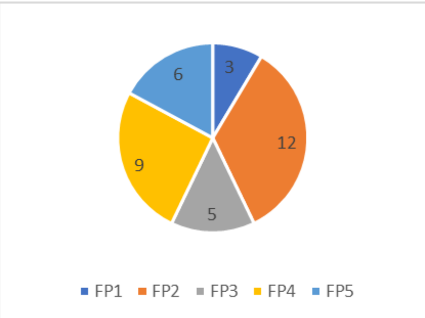
The dashboard data include **quantitative results** for milestones, OICRs, innovations, and policies as reported by RTB and included in the annual reports.

RTB has recorded 108 **milestones** over the three-year period. Of these, 77 (71%) have been completed, 30 (28%) extended, and 3 (3%) changed. FP5 has been most successful in completing its milestones, with an 86% success rate, while FP2 completed only 54% of its targets. RTB reports that 18 of the 30 "extended" milestones will be reported as complete in the 2020 annual report. The CRP reported that some of these were completed on time, but they were described as "extended" to incorporate additional work. The rate of completion of the milestones has improved slightly, from 67% to 77% over the three years, while the number extended has dropped from 12% and 13% in 2017 and 2018 to 5% in 2019.

Of the 57 milestones that were allocated a risk level, 27 were assessed as low risk, 24 as medium, and 6 as high. The completion rate for the three categories did not vary greatly and ranged from 75 to 83%; risk assessment does not seem to be a good predictor of completion. Of the 51 milestones without risk ratings, the completion rate was lower (61%), with 35% of these milestones being extended, suggesting that these milestones may not have been adequately assessed at the outset. The number of milestones without risk-level allocation fell from 36 in 2017 to 0 in 2019, reflecting better control of the process in Phase II.

It is important to note that **Outcome Impact Case Reports (OICRs)** do not cover the whole program but include the best examples of outcome/impact and are assured by the CGIAR system quality assurance (QA) process. OICRs were not formally part of the reporting system in 2017, but the AR for 2017 includes outcome case studies that are equivalent to the OICRs in the following two years. These are included in this analysis. A total of 21 OICRs have been included in the annual reports, and these are evenly distributed by year. The number of OICRs varies widely by FP. Figure 1 shows the percentage of OICRs per flagship. It should be noted that an OICR may represent the involvement of more than one FP.

Figure 1 OICRs per Flagship Program (%)



The low number of OICRs for FP1 reflects the fact that FP1 is discovery, and its products (breeding lines and new varieties) mostly pass to FP2 before release. FP3 (resilient crops) has a relatively low number of OICRs, perhaps because of its lack of RTB skills for agronomy and crop management research (see section 3.1.3.2).

The geographic location of the outcomes is noted in OICR reports. Twelve are multinational, 6 are national, and 5 are regional. Outcomes are reported in 31 different countries. While OICRs from FP1, FP3, and FP5 are spread quite uniformly across regions, OICRs deriving from the work of FP2 and FP4 are concentrated in Eastern and Western Africa, with a total of 22 (45%) out of 48.

OICRs include markers for key cross-cutting issues. Of the 21 OICRS, 13 included capacity development at the highest level, and 15 included youth at the lowest level (Table 3). Gender was ascribed as at a "significant" level in 10 OICRs, but only 2 at the highest level.

Table 3: Relevance of three cross-cutting issues in OICRs

Relevance level	Capacity Development	Youth	Gender
Not targeted	4	15	9
Significant	4	3	10
Principal	13	3	2
CRP level	**21**	**21**	**21**

The climate change cross-cutting theme was not requested in 2017 but was reported as a significant factor in 10 of the 14 OICRs reported in 2018 and 2019.

Innovations are described by "type" as shown in Table 4. The most numerous innovations were production systems and management practices (PSMPs) and research and communications methodologies and tools (RCMTs). PSMPs were contributed by FP2, FP3, and FP4, while RCMTs were contributed by FP1, FP2, and FP3. As might be expected, almost all of the genetics (varieties and breeds) were contributed by FP2, and FP5 is linked mostly with social science innovations.

The stage of innovation is also reported in four categories from "End of research phase" (stage 1) to "Uptake by next user" (stage 4). Reporting a stage 4 innovation triggers an OICR. Forty-three percent of the innovations fall into stage 3 ("Available/ready for uptake") while the other stages are more evenly spread. Innovations from FP1 are mostly at stage 1—these will be taken on by FP2 before uptake. The other FPs have innovations from stage 1 to 4. Notably, few innovations at stage 1 (2 out of 23) were reported in 2017, while few innovations at stage 4 were reported in 2019. It may be that work that had been started in RTB Phase I was reaching the more advanced stages at the beginning of Phase II and was reported in 2017, while new work was not yet ready for reporting, and few new projects may have been set up in the second half of RTB as there would be insufficient time to take the innovations through to fruition.

Table 4: Number of innovations by type and flagship program

Type	FP1	FP2	FP3	FP4	FP5	CRP level
Biophysical research	1	2	2	0	0	5
Genetic (varieties and breeds)	3	18	2	1	0	24
Production systems and management practices	0	13	9	14	1	37
Research and communication methodologies and tools	8	9	18	1	2	38
Social science	0	7	0	4	16	27
Total	**12**	**49**	**31**	**20**	**19**	**131**

The geographical scope of innovations covers 33 countries as well as those described as global or regional. FP1 and FP5 report mostly global innovations. Relatively few innovations (8%) are described as regional. As with the OICRs, many more innovations are reported as relevant to Africa (118) than Asia (18) or South America (27). Reported innovations have 78 different external partners; almost all innovations (97%) involve other CGIAR Centers, and 43% are with academic or research organizations. Partnerships with development organizations, government, and the private sector were less important for innovations (16%).

A total of 21 **policies** have been reported; 11 (52%) were initiated in 2018. Eighteen (86%) policies are from FP2 and FP4 and mostly relate to seed production and disease control. The policies from FP2 are spread between 2018 and 2019, while those from FP4 are from 2017 and 2018. Policies are assigned a numeric level: 1 = "research taken up by next user"; 2 = "policy enacted"; and 3 = "impact on people, natural environment, or investment policy." Seven policies fall into level 1 and 14 into level 2. There are no level 3 policies. No policies changed level during the period, indicating the time it takes for policies to be enacted and to take effect. Nearly all (86%) of the policies are at the national level in nine countries. Nineteen of the 21 policies are in Africa; the remainder are regional. Governments that implement seed regulations and disease control strategies are the most frequent partners for RTB policies, with 10 out of the 21 policies (47%).

Qualitative data from interviews with stakeholders were, in general, strongly supportive of the performance of RTB and highlighted many examples of high-quality work. One example from each FP is highlighted below (more details are noted in section 2.1.3.2 above):

- FP1 – RTB breeding programs at Sub-Saharan African NARSs were modernized to incorporate genomic tools through work with the EiB platform and ARIs.
- FP2 – New RTB varieties were released in several African countries, including potatoes in Rwanda and Kenya and yams in Nigeria.
- FP3 – Partnerships with national plant protection organizations were established in Southeast Asia to mitigate the spread of cassava mosaic disease (CMD).
- FP4 – Small-scale flash drier technology was developed and disseminated for flour production.
- FP5 – The science of scaling in AR4D was developed and promoted.

Although each of these will almost certainly have significant impact in the future, they are projects developed in the lifetime of Phase II and have not yet reached that stage where an OICR would be triggered.

The CRP proposal contains five goals relating to the program impact which relate to the Strategy and Results Framework (SRF):

1. 20 million people with increased income
2. 30,000 SMEs operating profitably in RTB sector
3. 8 million farm households have increased crop yields
4. 10 million people have improved diets
5. 1.9 million ha of current RTB crop production converted to sustainable cropping systems

These goals were referred to as "aspirational" during the initial presentation by the RTB team. Limited data are available yet to assess the progress toward these goals at the program level, and impact is not likely for 5–10 years. The likely impact will be affected by the CRP's reduced budget, its shortened lifespan, and the effects of COVID-19. Despite this, it is clear from the OICRs and from key informant interviews with partners that progress has been made toward these goals. Linkages exist between RTB projects and each of the above goals, although the number of projects/clusters contributing to achieving goal 5 is lower than for the other goals, and progress toward this goal is likely to be significantly less than projected in the proposal.

2.2.2 Demonstrated Importance of Outcomes

2.2.2.1 Deep Dive on Outcome Impact Case Reports

Deep dive on OICR MEL ID 197 – Ugandan farmers adopting techniques to control Xanthomonas wilt of banana (BXW) have restored the productivity of their fields and incomes: The OICR on BXW was reported in 2019 as a new outcome with maturity level 3. Although the adoption study (Kilkulwe et al., 2019) is reported from Uganda, this research is part of a much wider effort to control the disease in East Africa and the Great Lakes region (Burundi, DR Congo, Rwanda, and Uganda). The OICR links to the SRF through sub-IDO 3.3.1 (Increased resilience of agroecosystems and communities, especially including smallholders). Annex 5.1 (OICR Banana BXW – Uganda) provides a comprehensive assessment of this OICR, including input from eight RTB members through a guided discussion.

BXW was first detected in Uganda in the early 2000s. Given that it had similarities to other bacterial wilts of banana in Latin America (Moko disease) and Southeast Asia (Blood disease), a logical first step was to implement research on BXW based on control measures developed for those two diseases. This was begun in the region in 2004. The package included complete mat removal (CMR) of diseased banana plants, sterilization of tools, and removal of male buds, a target for insect vectors. These measures were successfully applied in Uganda and DR Congo. Further research revealed that systematic infection of banana was incomplete—that is, parts of diseased banana plants were relatively disease free. Single disease stem removal (SDSR) was then logically studied as an alternative control method to CMR and achieved success. SDSR has the advantage of minimal disruption to banana production and minimizes the erosion that can occur if banana plants are completely removed. SDSR was then incorporated into the control package and out-scaled in Uganda and DR Congo. The OICR adoption study (Kilkulwe et al., 2019) in Uganda indicated that 600,000 of 800,000 farmers—both smallholder and commercial—had adopted all or part of the control package. Further scaling in Uganda, DR Congo, and Burundi reached another 64,865 farmers, including women. The RTB FP3 impact pathway was used to track outcomes. Adoption of the whole three-part package increased farmers' incomes by $462/ha, whereas adoption of only two parts increased incomes by $343/ha.

NARS and extension agencies in the region carried out CapDev on applying the BXW management package with hundreds of thousands of male and female farmers. Farmer learning groups (FLGs) were formed, and fact sheets were produced in three languages. Theatrical messages, a song, and a video were also part of the scaling effort. Adopting farmers trained in BXW management achieved 176% higher value of matoke production compared with 113% higher production for non-trained, adopting farmers.

To assess the role of women in managing BXW, it was first necessary to understand that in banana systems their role is subsidiary to men's, as women rarely own land. Studies in Uganda and Burundi found that men are primarily involved in implementing the BXW package, but men and women had differential ratings of the different package components. And, although women had less participation in the FLGs than men did, trained women were more likely to implement all or parts of the control package.

Lessons learned from research were used to modify the control package during its development and during the scaling process. For example, SDSR replaced CMR as it was shown to be just as effective and less disruptive. Significant CapDev was critical for adoption. The involvement of women as well as men also facilitated adoption. Community-based management gave recognition to women and built community cohesion. Engagement with policymakers was essential to foster national support to replace CMR with SDSR in Uganda and Rwanda and the process has also begun in Burundi.

The modified control package was relevant to management of BXW and proved useful in the problem context. Research findings were credible and based on proven control measures in similar diseases of banana. Recognition of the important roles of partners—NARSs, extension agencies, NGOs, and policymakers—demonstrated legitimacy. And, as shown by the levels of adoption in the region, the research product—the control package for BXW—was effective. It was also demonstrated that the leadership and engagement with partners to achieve the outcome were appropriate. There is clear evidence that the QoR4D was implicitly used.

Cassava variety adoption in Nigeria (MEL ID 78) and South and Southeast Asia (MEL ID 127) is discussed in detail in Annex 5. The two OICRs are the following:

- "Adoption of improved cassava varieties in Nigeria gives 64% productivity gain as a result of adoption of improved cassava varieties," Annual Report 2017
- "Adoption estimates of improved cassava varieties in nine countries in South and Southeast Asia indicate that 2.7 million hectares are grown using CIAT-related varieties," Annual Report 2018

Both reports cover high-impact cases with strong effectiveness, and both are mature programs that have not been specially featured in RTB annual reports. The work in South and Southeast Asia was the subject of a Standing Panel on Impact Assessment (SPIA) impact study in 2015. This report covers new outcomes that have been achieved since then. Both reports involve work that is closely linked to national research institutions and have strong gender elements.

Adoption surveys were carried out using DNA fingerprinting to provide accurate information on the varieties grown by farmers. The surveys were implemented by RTB as part of the close long-term partnerships between IITA and the National Root Crops Research Institute (NRCRI) in Nigeria and CIAT and several research stations in Vietnam.

Besides providing socioeconomic data, both surveys show that farmers have adopted improved varieties with CIAT/IITA germplasm. The adoption level of new varieties in Vietnam is between 80 and 90%, while in Nigeria it is around 60%. The situation in Nigeria contrasts strongly with that in Vietnam: rates of adoption are lower and slower in Nigeria, where crops are commonly grown for domestic use; in Vietnam, the crop is commercially processed for starch, and buyers demand the new, high-starch varieties. Cassava mosaic disease (CMD) has recently spread to South and Southeast Asia and is now the focus of intensive work to mitigate losses and introduce resistant varieties. Data are drawn from the OICR reports, reports, and articles written about the studies, and interviews with RTB team members and national partners.

From the two surveys and the associated work, a number of conclusions affecting policy were drawn (Table 5).

Table 5: Policy-related conclusions for Nigeria and Vietnam

Conclusions for Nigeria	Conclusions for Vietnam
• Farmers are unaware of what varieties they are growing and widely misclassify traditional varieties as improved and vice versa.	• New varieties with high starch levels are rapidly adopted—even before official release.
• The seed supply chain is weak and does not provide good-quality seed.	• The long-term presence of CIAT, and close relations with local partners in the region, has enabled RTB/CIAT and national authorities to respond rapidly to CMD.
• The seed regulations did not allow the development of a thriving seed market.	• It is unclear why CMD has spread to South and Southeast Asia in the past 5–10 years; it may be linked to the susceptibility of CIAT germplasm. Study of this issue may ensure that the introduction and rapid uptake of germplasm does not compromise the principle of "do no harm."
• Farmers were wasting money on inputs for traditional varieties with low yield potential and, conversely, not applying inputs on improved varieties that would increase profitability.	• Several Southeast Asian countries have developed major starch industries based on cassava production as a result of the introduction of RTB/CIAT germplasm. This has major positive socioeconomic effects on the rural population. It introduces many issues for trade policy in the region while the spread of CMD adds many complications to these relationships.
• The best varieties were not being multiplied in sufficient quantities to meet demand.	

The high adoption rates contribute strongly to Sub-IDO 1.4.3 ("Enhanced genetic gain") and Sub-IDO 1.4.2 ("Closed yield gaps through improved agronomic and animal husbandry practices"). Both reports also show contributions to Sub-IDO 1.3.1 ("Diversified income opportunities"). In the case of Vietnam, this is due to the doubling of the cassava crop area, which results from the profitability of starch production from the new varieties. In Nigeria, the outcome is at an earlier stage; jobs in the nascent private seed sector are developing as a result of the change in seed regulations, which resulted in part from the conclusions of the survey that little high-quality seed of identified, improved varieties is available to farmers. The surveys themselves have both contributed to Sub-IDO C.1.3 ("Conducive agricultural policy environment") through the learning they have brought regarding the deficiencies in the current seed systems.

Cross-cutting issues were demonstrated in both OICRs. In the Nigeria survey, the socioeconomic section explored trait preferences by gender and region and revealed the complex and variable nature of the preferences. This is providing strong feedback to FP1 and FP2 for the development of appropriate breeding material. It also contributed to the development of opportunities for women to participate in the new seed trade. The Vietnam survey revealed the extent to which women involved in growing improved cassava crops have higher incomes and greater employment opportunities. Young people in highland areas where cassava is grown are unable to attend good schools or go to university; the increase in profitable cassava production has given uneducated youths greater job opportunities.

Both OICRs include a strong element of capacity development. Research institutes have been supported through training, together with some direct financial assistance to breed and select new varieties for their target markets. Substantial financial assistance has been provided in Nigeria through the bilateral funding to the RTB BASICs project, which RTB coordinates, and the NextGen projects. The surveys themselves both involved national partner organizations and contributed to an increased ability of these institutions to carry out surveys of their own in the future.

2.2.3 CRP Management and Governance

2.2.3.1 Management

RTB has a complex structure for individual reporting and for managing the scientific program. RTB directly employs only the program director, the members of the PMU, and support staff. Research staff members are contracted through and managed by the Centers. RTB has some input into staff reviews but no formal authority. FP leaders, cluster leaders, and Center focal points are research staff who spend a substantial amount of their time on program oversight and coordination within RTB and with external partners. The CFP's role is to communicate between RTB and its Center management and to ensure that the reporting is on time and meets the required standards. The number of clusters is quite high (25). RTB would have liked to include fewer clusters but was unable to reach agreement on this with the Centers. The program director and PMU are guided by the MC and report to the ISC, and thence to the CIP Board of Trustees. The quality of PMU leadership has been highly praised in key informant interviews with internal and external stakeholders for its transparency, openness, accessibility, supportiveness, and inclusiveness.

The program has **adapted well to changes**: these changes include the reduction in funding, a new competitive grants program, including the scaling fund, and a breeding fund to respond to a funding shortfall. The program has also had to deal with COVID-19 and the shortening of the program by one year. Although it falls outside the review period, the response to COVID-19 has required a lot of time for planning and administration, including reallocating resources for training programs, saving germplasm in sites that are inaccessible, and moving training online. The development of the Golden Eggs is also a response to the end of RTB, bearing in mind the uncertainty of future programs and the lack of any firm agreement yet on the structure of One CGIAR and a timetable for transition. With the support of the MC and ISC, the program has managed the risks of the program while maintaining good relations with Centers, donors, and partners.

The **Management Committee** (MC) has been active throughout the program, with good attendance and clear records kept of decisions and actions. The MC has supported the PMU in responding to changes in funding. It has covered staff issues, including the replacement of Flagship Project leaders (FPLs), where necessary, and reviewed the ToRs of FPLs and cluster leaders (CLs). The MC has also overseen the development of the principles of the scaling fund and the selection process.

The **program budget** in the initial proposal was US$817 million over six years. In practice, the final budget is likely to be closer to US$422 million (this consists of 2017–19 actual, 2020 budgeted, and 2021 projected spending for the five-year CRP lifespan). Although the overall budget was cut at the beginning of the program, funding has been relatively stable through the years of implementation. About 80% of the funding is W3/bilateral, over which the program has little control. Although its expenditure is mapped by the Centers onto RTB projects, RTB is not responsible for program design or management. Over the three years, RTB has spent about 88% of its budget in each year. It would be difficult to reach a higher percentage than this given the uncertainties regarding funding that extend nearly to the end of the year of expenditure. In practice, the funding is not lost as it can be carried over to the following year.

RTB Phase I had no comprehensive program to manage project results and monitor information. The **Monitoring Evaluation and Learning** (MEL) program was developed for Phase II with the GLDC. Other CRPs and Centers have since started to use the program. Under Phase I two sets of reports had to be prepared for bilateral projects (system and donor), imposing a considerable burden on research staff and PMU. Reporting is now more integrated, with less special reporting and improved ability of RTB to monitor the progress of projects—both W1/2 and W3/B. In the absence of a unified system within CGIAR, another system (MARLO) was developed by CIAT; this system is operated by several of the larger Centers.

2.2.3.2 Governance

The Independent Steering Committee (ISC) provides oversight over RTB's research and development activities and reports to the CIP Board annually. It meets virtually four times each year, including a face-to-face meeting with key RTB members, including management and research leaders. The face-to-face meeting provides ISC members with the opportunity for direct input into RTB's QoS and effectiveness as a committee and based on their individual expertise. The minutes of the ISC meetings show comprehensive engagement and interest in RTB's research, including the design of RTB Phase II, the inclusion of FP5, enhanced integration of gender, support for the earmarked and scaling funds, the Golden Eggs, and annual review of POWBs and ARs. The ISC has aligned its risk mitigation strategy with that of CIP, and risk assessment is a priority agenda item at most meetings. Recently the ISC highlighted the level of uncertainty facing RTB during the next year and the importance of keeping RTB teams engaged to deliver on agreed plans. The ISC also highlighted the opportunities for RTB to promote the relevance of its program in the future One CGIAR context. The minutes clearly show that the ISC is a professional body cognizant of correct procedures and practice. Regular self-evaluation suggests that the level of monitoring and oversight is sufficient. In the past year, the ISC has been active in promoting RTB to the One CGIAR process and plans to continue to do this.

In response to Recommendation 16 (IEA, 2016), the ISC established an Alliance Compact (Joint Statement for RTB Partner Collaboration)—a soft contract between partner Centers, with agreed ToRs—to further foster collaboration among key partners. ISC members are working together more effectively and promoting RTB where relevant, but they have not yet reached the point where sourcing W3/bilateral funds is done in the name of RTB rather than by individual Centers.

2.2.4 Progress along ToC (CRP and Flagships)

During Phase I, RTB was a key part of the CGIAR pilot results-based management (RBM) program. This included work on a theory of change (ToC) for the CRP. During the preparation of Phase II, impact pathways (IPs) were prepared for 15 of the proposed 25 clusters as part of "business cases." These IPs covered the expected stages from research to outcome but did not include external factors and assumptions. Since the start of Phase II, five cluster-level ToCs have been developed where there have been significant changes in the structure or program.

At the project level, IPs are included in all RTB-funded project proposals. For W3/bilateral projects the inclusion of a ToC depends on the donor requirements; the UK Department for International Development (DFID), the Australian Center for International Agricultural Research (ACIAR), the International Fund for Agricultural Development (IFAD), and others require ToCs of IPs while other donors do not.

At the FP and CRP level, ToCs were developed for the Phase II proposal with input from the ISC. These are reported to be a synthesis upward based on the available IPs and ToCs from clusters and project proposals.

The use made of the ToCs at the FP level varies according to individual FPLs. Responses ranged from "drives all activities—all deliverables must contribute" to "not used routinely—as need arises." Feedback from an online ToC training exercise suggested that ToCs are difficult to apply for complex systems such as those managed by CRPs and Platforms that have multiple lines of work and funding lines. The issue of how they should be followed up was also raised, given that planning and budgets change every year. Although the CRP- and FP-level ToCs are reviewed annually, there is little time for reflection on the need for adaptation.

During the annual reviews of the ToC, no major changes have been noted in the POWBs, although observations are made regarding new programs and activities. There is no evidence that the ToCs were used as a driver of resource allocation.

2.3 Future Orientation

About 300 million poor people in developing countries depend on RTB value chains for food and nutrition security and income. As populations in Sub-Saharan Africa, Asia, and the Americas rise, RTB crops will be vital for feeding many millions more in future. Significant and measurable progress has been made by

RTB during the past three years as presented in this report. Of note, the Golden Eggs represent a set of collective knowledge assets developed through RTB partnerships during its lifetime (see Annex 6h: "Assessment of physical outputs and services including varieties, digital innovations, methodologies, and tools for IPG value"). They include packages of some of the program's most productive outputs and position RTB to play an important role in further contributing to the SDGs over the next 10 years. It is therefore critical that RTB continues to develop and expand these packages to cover the full program achievements—e.g., plant health, biofortification, animal feed, and cropping systems management, to name a few.

In spite of the complex program structure, multiple crops, and problematic funding scenarios, RTB has been able to establish an integrated and well-functioning program founded on its design and interlinkages as well as an appreciated management and governance system that contributes to its effectiveness. Many lessons have been learned from this effort. RTB should document these lessons to inform future multi-crop initiatives and projects. In addition, it would be worthwhile for the System to consider this coherent and efficient model in the process of establishing future management and governance regimes.

CRPs and Centers are already forming alliances in preparation for One CGIAR. RTB is the only global program working on clonally propagated polyploid crops for developing countries. During the program's history, it has amassed considerable knowledge and developed useful tools and methods for research on these complex crops with notable spillovers of knowledge and methods across crops. RTB needs to continue this important research and emphasize the value of keeping the crops together in specific research areas.

Research on agronomy and crop management in RTB has been limited by a lack of skills in both Centers and partners, with the exception of IITA. The recent ACAI project has developed a proven ICT tool for decision support in cassava agronomy in Sub-Saharan Africa that has potential to spill over to other RTB crops such as potato and banana. RTB should continue to support this important research, which is likely to contribute to the development of the planned platform on Excellence in Agronomy.

RTB research on integration of gender with biophysical research and scaling readiness approaches has been recognized across the CRPs and System. RTB needs to continue this important research and to promote its value for future activities in these areas.

Although the decision to terminate the CRPs one year early has had a negative impact on initiating new research, it provides an opportunity to reevaluate past work, hold useful discussions on results, consolidate, write papers for international journals, and capture lessons from Phases I and II. RTB is urged to remain committed to this task, as the outputs will be of value to both next users and future research.

2.4 Cross-cutting Issues and Partnerships

2.4.1 Capacity Development

Capacity development was a clear element in the RTB proposal for Phase II. The ToC included areas where it would be required, and 10% of RTB funds were earmarked to CapDev. Figure 2 summarizes the CapDev activities carried out during the period under review.

Figure 2 shows that 499 MSc or PhD students conducted research at an RTB partner Center. In each case, the research was relevant to their national research program and to the work of RTB. In addition, 113 Individual non-degree activities or internships were carried out. These include post-docs, visiting scientists, CGIAR scientist placements in partner organizations, and short-term visits to gain experience and knowledge of the professional work environment. Individual's gender is not presented as the MIS protects personal data in accordance with EU General Data Protection Regulation (GDPR).

Group training includes seminars, workshops, and training courses. The total number of participants was 87,446, with 38,089 identified as female and 45,423 identified as male. Of the 119,318 participants who attended non-formal training (including many other types of activities), 56,997 were identified as female, and 52,470 were identified as male. Field training/farmer field schools were attended by 136,249 individuals: 62,320 females and 54,468 males.

Reports from partners and other stakeholders were favorable about the quantity and quality of the CapDev received from RTB. The work on gender through the Gender-Responsive Researchers Equipped for Agricultural Transformation (GREAT) program was particularly highly valued, as were the opportunities for national students to participate in individual degree courses. These students can carry out research at the Centers and ARIs. At the same time, ARI students were given the opportunity to carry out fieldwork at Centers and with national programs.

Figure 2 RTB capacity development activities by group type and gender, 2017–2019

It was noted that a major element of CapDev should be to enable national organizations to cooperate directly with ARIs and universities. The exchange of students facilitates long-lasting linkages, especially for students spending more than one year of study abroad. It was noted, however, that it is difficult to ensure that students return to national programs. While many of them return to their institution, some are soon promoted into management positions with mixed benefits for research while others stay abroad after their study.

Constraints

RTB's ability to implement CapDev has been limited by two major factors. First, CapDev has received lower priority from the System office over recent years, and as a result funding for CapDev, and in particular for specialist staff to carry out CapDev, has been reduced. For example, CIP used to have a training unit, but this was closed when the last person was laid off seven years ago. Of the four RTB Centers, only IITA has dedicated CapDev staff.

Second, CapDev is central to many large W3 and bilateral projects, and much of the work noted above is locked into the project outputs and funding. For W1/2 projects, over which RTB has much greater control, the overall level of funding is insufficient to include the level of CapDev needed to really have an impact on national institutions and partners. RTB has to choose between funding the science program or building the capacity of partners. RTB ensures that there are sufficient funds available to carry out joint projects but is unable to make substantial contributions for new equipment and infrastructure.

Although not in the reference period, the COVID-19 pandemic has had a major effect on training at the field level and in workshops in 2020 and will affect the final level of achievement. The CRP is doing its best to set up remote training, and, in some cases, more participants have been able to attend training than would have been possible otherwise. However, remote training works better for some topics than others.

2.4.2 Climate Change

Significant climate change research is embedded in RTB's foresight studies, genomics, breeding, agronomy, pest management, and seed systems research. Much effort is given to developing varieties with higher levels of heat, drought, and salinity tolerance. Impact network analysis is addressing the effects of climate change on seed degeneration. Modeling approaches assess threats from emerging diseases and pests. Studies in India and Kenya have shown that adapting smallholder farming to climate change can be achieved by growing varieties that can cope with high temperatures, erratic rainfall patterns, and even drought (Pradel et al., 2019; Gitaria et al., 2018). RTB has also contributed to a cross-CGIAR workshop to identify concrete actions linking foresight modeling, future climate modeling, and breeding. This work resulted in a call for innovative holistic breeding strategies for multiple traits that will embrace the full pipeline from trait discovery to varietal deployment and seed system development. In addition, RTB participated in a CCAFS workshop to develop a framework for priority setting in climate-smart agriculture (Thornton et al., 2018). Hence much research on adaptation to and mitigation of climate stresses is embedded within RTB. However, aspirations to link closely with CCAFS for climate change research, as outlined in the Phase II proposal, have not been realized, mainly as a result of different priorities, as discussed above under cross-CRP partnerships.

2.4.3 Gender

Gender is well integrated in all FPs, with strategies designed around key FP activities. Ten percent (10%) of W1/W2 funds support gender activities, and additional support is available in W3/bilateral projects. There is a gender focal point in each partner Center. More could be accomplished in RTB with additional gender skills, as the time of existing gender scientists is fragmented across many activities. The cross-cutting cluster CC5.3 "Gender equitable development and youth employment" in FP5 implements strategic research. Gender-responsive breeding is part of FP1 and FP2 through the development of tools for gender-responsive innovation. RTB also leads the "Gender in Breeding" initiative across the CRPs, working closely with the EiB for input into product profiles. In FP3 there are gender inputs into pest and disease management practices (this is reviewed further in the deep dive on the SDSR for BXW OICR in section 3.2.2). In FP4 gender research is integrated with processing of OFSP puree and development of animal feeds from cassava peels and sweet potato silage. Gender is also incorporated into FP5 CC5.1 "Foresight and impact assessment" and FP5 CC5.4 "Scaling RTB food systems," which is implemented through FP2, FP3, and FP4. The progress made in integrating gender with biophysical research in RTB has been noted by an independent modalities assessment and by the System. The previous Gender Platform housed in PIM provided space for gender scientists to interact as well as support for gender work in RTB with limited funds. RTB has higher expectations from the new independent Gender Platform. With the shortening of the Phase II CRPs by a year, RTB revised its gender strategy, giving priority to breeding, seed systems, and scaling innovations.

The physical outputs and publications of the gender group in RTB are summarized in the ARs 2017–19 and listed in Annex 6h ("Assessment of physical outputs and services including varieties, digital innovations, methodologies and tools for IPG value"). These include development of analytical approaches and tools for gender-responsive innovation; development of a "Decision checklist and tools for gender-responsive breeding"; the seed systems toolbox gender lens; guidelines and protocols to strengthen IPM research and dissemination strategies; advocacy and promotion of consumption of OFSP to women and children; gender analysis of the farmer business schools (FBSs) for women in India and Vietnam; and 79 publications on gender and youth, produced during 2017–19, including 18 journal articles. Two Golden Eggs are focused on gender: gender+ breeding tools and the gender-responsive AR4D portal

2.4.4 Youth

Research on understanding the role of youth in agriculture is a new endeavor for RTB and CGIAR. Most effort is currently focused on how to engage youth in agriculture—what motivates them—rather than on efforts to engage them. In general, young people look at agriculture as an opportunity when there are no others. There is a need to understand why they enter and how to encourage them to stay. Generation of income is a key incentive, and policies are needed to support youth in agriculture.

Some outputs from activities on youth in agriculture during 2017–19 are listed in Annex 6h. These include understanding youth issues and opportunities in scaling agricultural innovations; involvement of young women and men in local production of high-quality cassava flour in DR Congo; pilot studies on the interconnections between gender and youth; youth in conflict, post-conflict, and risk situations; youth in ethnic minorities; the importance of role models engaging in RTB crops and access to markets as factors promoting young people's work with RTB crops in Nigeria; tool to provide recommendations to foster effective youth participation in agriculture and in RTB crops specifically; and a literature review on youth engagement in agri-business.

2.4.5 Partnerships

Over 350 partner organizations are linked to RTB projects, including CGIAR Centers, CRPs, platforms, networks, ARIs, universities, NARSs, and other governmental organizations, private companies, and NGOs. Partners strongly appreciate the relationships, finding them equitable and mutually beneficial. Benefits to partners include funding (particularly ARIs and NARSs) and opportunities for CapDev for institutions and individual scientists. Partnerships also bring access to cross-crop, cross-Center research, and, for ARIs, they bring access to activities and institutions in developing countries that would otherwise be difficult to set up.

Better links have been made under RTB between historically "rival" Centers, such as the joint work between IITA and CIAT on banana bunchy top disease and Fusarium TR4, and on CMD-resistant cassava germplasm for Asia. Other examples of strong partnerships include the development of crop-breeding programs in Africa where all breeding is done by NARSs and the work with 15 national plant protection organizations to strengthen and develop plant protection strategies.

One partnership of particular note that is different from others is that with CIRAD. Both partners contribute and gain. CIRAD contributes strong food science know-how that is not available in the CGIAR Centers and leads the RTBFoods project with W3 funding, which works on linking user preferences for quality traits to breeding programs. It also brings a long-term commitment to national programs and constant and reliable (government) funding. RTB provides a wide range of research, including germplasm, and many connections to other partners.

Despite the range of partners, RTB is limited in its ability to define and control its relationships in W3/bilateral projects, where control over funding lies with the Centers. Under W1/2 funding RTB has more control but always has to balance the level of funding that goes to partners against the needs of its own scientists. Funding is of particular benefit to NARSs, where national sources of funds even for routine work are often very limited.

Cross-CRP partnerships: Portfolio integration was a pillar of the Phase II CRP process, especially between the agri-food system and integrating CRPs. The RTB Phase II proposal, Volume 3, Annex 6, lists comprehensive aspiration links (RTB, 2016b). Annual Reports and discussions with RTB and integrating CRPs demonstrated that useful partnerships with PIM, A4NH, and CCAFS have contributed to some outputs and outcomes. Examples include:

- foresight studies with PIM
- regulations for seed-quality systems with PIM
- work with PIM on making seed systems and markets for vegetatively propagated crops work for the poor
- studies on intake, nutritional status, retention, bioavailability, efficacy, and effectiveness of OFSP and biofortified cassava with A4NH
- advocacy for biofortified foods, especially OFSP and biofortified cassava with A4NH
- harmonization of monitoring and evaluation systems to track biofortification impacts at scale with A4NH
- with CCAFS, measurements of greenhouse gas emissions in cassava systems
- a cross-CGIAR workshop to identify concrete actions linking foresight modeling, future climate modeling, and breeding
- publication of a framework for priority setting in climate-smart agriculture and improvements in scaling readiness of climate-smart nutrient management decision support tools in different institutional environments with CCAFS.

In addition, good links have been made with the platforms, including EiB, Big Data, Genetic Resources, and Gender. Linkages are possible only where priorities align, and funding is available. As a result, much policy and markets research embedded in RTB is not linked to PIM; a lot of biofortification and nutrition research is not linked to A4NH; and a lot of climate change work is not linked to CCAFS. The outputs from this research effectively contribute to RTB's outcomes and its designated sub-IDOs. However, there does not appear to be a mechanism to aggregate all the contributions on these important topics across the CRPs to the IDOs and SDGs.

3 Conclusions and Recommendations

3.1 Quality of Science

3.1.1 Quality of Research Inputs

RTB teams are appropriately diverse with good skill sets complemented by over 350 partners that bring additional skills and diversity as well as infrastructure and equipment needs. Through using existing skills and seeking complementary skills as needed, RTB's approach is pragmatic and efficient. Agronomy is the only skill area where RTB is lacking; apart from IITA, expertise in agronomy is limited in both RTB and partners. The available multidisciplinary diversity and the RTB structure create opportunities for cross-fertilization of ideas and learning from each other. Earmarked funds provide opportunities to foster cross-crop and cross-Center collaborative projects while scaling funds assess the readiness of scaling options and support scaling of innovative packages for adoption. The RTB model fosters integration, collaboration, and portfolio coherence.

3.1.2 Quality of Process (including Partnerships)

Leadership and management roles and responsibilities are well defined; quality of science processes are robust, transparent, and fair; communication mechanisms are well developed and widely appreciated; and strong, often long-term partnerships have been developed that are critical for delivery of outputs and outcomes. Established processes demonstrably contribute to QoS. Although the QoR4D Framework is not formally used by RTB for monitoring QoS, it is clear that wider awareness has the potential to contribute even more to quality of processes for the remainder of the program.

3.1.3 Quality of Outputs

Analysis shows a high quantum and quality of publications and RTB's efforts to improve the quality of publications during the past three years. Most publications are high quality. A good number show appropriate choices of journals based on IF, demonstrate recognition of coauthors, and show both measurable contributions by RTB members and broader applicability (IPGs), with some exceptions. Table 1 highlights two popular journals with poor IFs and 4th-quartile rankings. Such journals should be avoided. Deeper analysis of 27 publications also supports generally high quality across FPs with some room for improvement in FP2, bearing in mind that some disciplinary areas do not have high-IF journals to target. The quality of technical reports is mostly high; the suitability for next-stage users was demonstrated, and the importance of CapDev was included or highlighted. In addition, impressive communication products have been generated and are already widely used.

Notable progress in modernizing breeding programs is well regarded by a donor and noted by the EiB (CGIAR, n.d.). The Seed Systems Toolbox will strengthen and enable seed system development after further validation (RTB, 2020b). ICT solutions for reaching farmers at scale will enhance crop, pest, and disease management. New methods for assessing quality traits will allow more rapid and accurate screening for nutritious foods, and ongoing advocacy will increase adoption and diffusion of biofortified foods. Scaling approaches will enable further sustainable intensification of RTB agri-food systems. The Golden Eggs position RTB to play an important role in further contributing to the SDGs (especially 2, 3, 5, 13, and 17) over the next 10 years. Improved links between FP2 and FP3 will help to tackle yield gaps.

3.2 Effectiveness

3.2.1 Achievement of Planned Outputs and Outcomes

RTB has achieved a good overall rate of attainment of annual milestones (71%). Most of the remainder were extended, and there is evidence that at least some of these were completed as planned but extended for new work (e.g., more countries and crops).

The risk level attributed to a milestone has not been a good predictor of reduced completion rate. Nevertheless, the allocation of a risk level may be an important stage in the planning process and encourage the project to ensure that the risks are overcome or avoided.

OICRs are an important record of outcomes achieved by the project. There are 21 OICRs in total, with the largest number relating to the adoption of new breeding material by FP2. The reports cover work carried over from Phase I and new work from Phase II and, as expected, are widely spread over the RTB target countries, particularly in Africa.

Capacity development is frequently a high priority of the OICRs, while gender is frequently significant but not the highest priority. The reason for this apparent difference in emphasis is not clear, but the difference is large enough to have a real effect. It may be that the marker for gender to reach the "high" category is harder to achieve than for capacity development.

Innovations are reported from all FPs. More innovations are at stage 3 ("Available/ready for uptake") than other stages. The move from stage 3 to stage 4 ("Uptake by next user") is a major step and is not within the control of RTB. Although there is no evidence of this in these data, it is clearly important that research does not get stuck at stage 3. If this were the case, it would indicate a failure of the explicit or implicit assumptions of the ToC (e.g., end-users may not be willing or able to implement). It is important for RTB to follow these stage 3 innovations and push for them to be taken the final mile.

3.2.2 Demonstrated Importance of Outcomes

Deep dive on OICR – Ugandan farmers adopting techniques to control Xanthomonas wilt of banana (BXW) have restored the productivity of their fields and incomes: The OICR on BXW management with SDSR was reported in 2019 as a new outcome with maturity level 3. Adoption studies have shown that it has benefited at least 600,000 farmers in Uganda, increasing their production and profits, and over 65,000 farmers in the wider East Africa and Great Lakes region. Lessons learned were used to modify the control package during its development and during the scaling process. Significant capacity development was critical for adoption. The involvement of women as well as men also facilitated adoption. Community-based management gave recognition to women and built community cohesion. Engagement with policymakers was essential to foster national support to replace CMV with SDSR.

Both OICRs based on *cassava surveys* were successful in determining adoption levels and showed strong contributions to sub-IDOs. Beyond that, they revealed many insights into seed systems, the weakness of seed regulations designed for seed-propagated crops, gender trait preferences, contrasting levels of farmer knowledge in different countries, and inefficiencies of input use due to lack of knowledge of the genetic potential of varieties. Both have contributed to policymaking—in Vietnam for the mitigation of crop losses due to CMD and in Nigeria on seed policy and regulations.

3.2.3 CRP Management and Governance

The structure of all CRPs is highly complex, by design of the CGIAR, with split responsibilities, funding, and loyalties between CRP and Centers. Despite this, the management team has made RTB work effectively within the constraints it faces. Program leadership is very well respected internally and externally. Fewer larger clusters might have more critical mass but may also suffer from lack of focus. It is noted elsewhere that the cross-cutting clusters brought strong benefits within the program.

The program has adapted well to external factors. There is little time for RTB to plan for project closure, and little can be done about handover of complex programs until the structure of the follow-on phase is agreed.

Funding has been a constant source of concern to the program owing to the uncertainty of the amount and timing of funding and to the difficulty of working with two separate streams of funding with very different levels of control from RTB.

The MEL system has improved project monitoring and program management within RTB and is a valuable resource for CGIAR in future. However, it would have been better if the System Office had ensured that a single monitoring and evaluation system had been developed for use within Centers and CRPs. Having parallel systems inevitably limits the utility of the systems and the ease of collating systemwide data. At this stage, integrating the two systems would not justify the disruption involved.

The MC has provided valuable support to the PMU and facilitated smooth running of the project while the ISC has demonstrated effectiveness as a governing body for RTB's quality of research for development. It is a professional body cognizant of correct procedures and practice. It has also been active in promoting RTB in the One CGIAR process and plans to continue to do this. The Alliance Compact (Joint Partner Collaboration Statement) has been effective in fostering closer working relationships among members, but further effort is needed to fully operationalize it.

3.2.4 Progress along ToC (CRP and Flagships)

The development of theory of change models has proved useful for the design of individual projects and for enabling the integration of FPs at the CRP level. The CRP- and FP-level ToCs are reviewed annually, and no major changes have been noted. It is clearly important for the CRP to ensure that assumptions made in all its programs remain valid and to adapt its ToCs if there are significant changes. It is also important that project, cluster, and FP leaders review activities regularly and adapt them according to internal and external changes.

A high investment of resources would be required to carry out a full reevaluation of the ToCs at the project, cluster, FP, and CRP level every year and to integrate the levels with each other. This does not seem necessary, provided that programs are monitored and adapted as mentioned on an annual basis.

The ToC is used predominantly as a planning rather than a management tool. Resources are not directly allocated using the ToC, but they are linked indirectly through the planning process.

3.3 Future Orientation

The Golden Eggs represent collective knowledge assets developed through RTB partnerships during Phases I and II. They position RTB to play an important role in further contributing to the SDGs through to 2030. RTB should continue to develop these assets and add more where relevant. RTB has established a well-functioning and well-appreciated management and governance system that contributes to its effectiveness. It will be useful for RTB to document these lessons learned from its institutional innovations. During the program's history, it has amassed considerable knowledge and developed useful tools and methods for research on complex clonally propagated crops with notable spillovers of knowledge and methods across crops. RTB needs to continue this important research and emphasize the value of keeping the crops together. RTB should also build on the recent advances made in agronomic research through the ACAI project. Furthermore, RTB should continue the important research on integration of gender with biophysical research and scaling readiness approaches have been recognized across the CRPs and CGIAR System. Finally, during the remainder of Phase II, RTB should take the opportunity to consolidate past work into usable outputs to the benefit of next users and future research.

3.4 Cross-cutting Issues and Partnerships

3.4.1 Capacity Development

RTB has carried out a large amount of CapDev activity during the period, with nearly 350,000 training events, 499 MSc or PhD students, and more than 340 participants recorded at other trainings. Much of the training is through large W3/bilaterally funded projects, with limited resources available through W1/2 funding. The capacity of centers to organize specialized CapDev programs has been much reduced owing to funding cuts over many years and a reduction in priority given to CapDev by the System Office.

3.4.2 Gender and Youth

RTB gender research is well integrated throughout biophysical research activities and is much appreciated by FP leaders. RTB has been recognized as a leader in design, deployment, and scaling of integrated gender work, adding value to biophysical outputs through an independent modalities assessment and to the System. Research on understanding the role of youth in agriculture is a new area of endeavor for RTB and the CGIAR as a whole. Most effort is currently focused on how to engage youth in agriculture. Generation of income is a key incentive, and policies are needed to support youth in agriculture.

3.4.3 Climate Change

Much research implemented in RTB on adaptation to and mitigation of climate change is embedded throughout the FPs. However, the aspirations to link this research more closely with CCAFS for climate change research as outlined in the Phase II proposal have not been realized, mainly because of different priorities, as discussed above under cross-CRP partnerships.

3.4.4 Partnerships

Closer relationships have developed between IITA and CIAT on cassava research and between Bioversity and IITA on banana research. RTB's mutually beneficial relationship with CIRAD needs careful management to ensure the continued development of synergies, as CGIAR and CIRAD are very different types of organizations with a historically different approach to development.

The strong links with non-CGIAR organizations, particularly in developing countries, have taken a long time to build. The joint progress and relationships must not be lost in the transition to One CGIAR.

Work under W1/2 has maximum flexibility for RTB but little funding for partners. Trade-offs are important within the WI/2 envelope—a limited amount of funding may make a lot of difference to the operational efficiency of national partners but is also needed for RTB science. The larger W3/bilateral programs have more funding for partners but are not within the control of RTB.

Cross-CRP partnerships: RTB's work with integrating CRPs (A4NH, PIM, CCAFS) could have been more effective through more comprehensive discussion of priorities at the beginning of Phase II, better indicator harmonization, agreed tracking methods, oversight at the systems level, and support from donors. Wherever possible, attempts should be made to aggregate the overall contributions of all CRPs to important research outcomes on biofortification and nutrition, and climate change.

3.5 Recommendations

3.5.1 RTB Recommendations

R#1. Notable improvements have been made by RTB in the quality of publications, many of which are in high-impact journals and open access. **As far as possible, RTB should avoid publishing in journals with an IF less than 1 and in Q3 or Q4. Quality of publications should be included in the incentive system.**

R#2. Efforts to modernize breeding across crops and in agronomy in Sub-Saharan Africa are showing good progress. **Opportunities should be taken to improve links between FP2 and FP3 to integrate deliverables from both efforts during 2021 to more effectively address yield gaps.**

R#3. RTB's design, in particular the cross-cutting clusters, as well as the science officer and ISC Alliance Compact (Joint Partner Collaboration Statement) are key institutional innovations that have made an important contribution to achieving programmatic integration, coherence, quality of science, and effectiveness. **The lessons learned during the past three years should be documented to inform future multi-crop initiatives and projects.**

R#4. The RTB Golden Eggs represent a set of collective knowledge assets (frameworks, approaches, and tools) developed through RTB partnerships during its lifetime. **RTB should continue to develop and add to the Golden Eggs (collective knowledge assets) in 2021 to position itself to play an important future role in One CGIAR.**

R#5. The ISC has been effective as a governing body for RTB, especially in its contributions to improving the QoS and effectiveness. **Efforts should be strengthened through the Alliance Compact (Joint Partner Collaboration Statement) to further promote the RTB brand as an integrated global program and to position it for inclusion in One CGIAR.**

3.5.2 CGIAR System-Level Recommendations

R#6. RTB's crop portfolio comprises clonally propagated crops with complex breeding systems. RTB has amassed an impressive body of knowledge and methodologies to address breeding difficulties and establish viable seed system models. Lessons learned have contributed to spillovers of methodologies across crops. **The System should retain clonally propagated crops together as a group within key research areas to further enhance synergies and achievements in One CGIAR.**

R#7. The RTB Golden Eggs represent a set of collective knowledge assets (frameworks, approaches, and tools) developed through RTB partnerships during its lifetime. These valuable assets position RTB to play an important role in further contributing to the SDGs over the next 10 years. **The System should seriously consider broader use of the concept of Golden Eggs (collective knowledge assets) for future initiatives and projects in One CGIAR.**

R#8. Portfolio integration was an important pillar in Phase II. Opportunities for integration have been missed because of differing CRP priorities and partly because of lack of oversight by the System and lack of support from funders. **Opportunities for integration between initiatives and projects in One CGIAR should not only be sought but must be better supported if cross-CGIAR contributions to the IDOs and SDGs—e.g., on nutrition, climate change, policies—are to be fully captured**.

R#9. In spite of being an important part of the proposal, RTB has been unable to carry out the planned level of CapDev owing to lack of funding and specialized staff at the Centers. Although partners have benefited from training and inputs for the joint programs, there has been no coordinated attempt to raise the technical and human capacity of national partners. **One CGIAR should recognize this as part of its role and apply sufficient resources to achieve results.**

R#10. Strong linkages with partners were built up under RTB. These can easily be lost if care is not taken in the design of One CGIAR. **One CGIAR should design future initiatives and projects to ensure that existing relationships (corporate, technical, and personal) are not lost.**

4 Lessons Learned and Added Value

The added value of managing research on RTB crops through the CGIAR Research Program, and the lessons learned, consists of the following:

- The design of RTB, with cross-cutting clusters, has enabled cross-crop and cross-Center collaborative research and facilitated cross-fertilization, spillovers, and learning that would have been difficult if Centers had worked independently. It has reversed the trend of Centers working on individual crops in silos.
- RTB has brought together and built communities of scientists (CoPs) across Centers for breeding, seed systems, gender, and postharvest and quality research.
- RTB has enabled improved integration of crop programs across Centers—e.g., IITA and Bioversity for banana, and IITA and CIAT for cassava.
- Integration of gender with biophysical research has added value to research outputs for end users, especially women.
- The cross-cutting design of FP5 and the scaling readiness approach has facilitated the integration of scaling research into activities in FP2, FP3, and FP4.
- The existence of RTB helps to promote clonally propagated crops as a group to an international audience as important food crops.

Find the Annexes and Brief here:

CRP 2020 Review: RTB | CAS | CGIAR Advisory Services

References

Akilimo. (2020). https://www.akilimo.org/

BDP (CGIAR Platform for Big Data in Agriculture). (2020). https://bigdata.cgiar.org/

Cassava Seed Tracker. (2016). https://seedtracker.org/cassava/

CGIAR. (n.d.) Crops to End Hunger. https://www.cgiar.org/excellence-breeding-platform/crops-to-end-hunger/

Douthwaite, B. (2020). *Mainstreaming of biofortification in the African Union: Evaluation of CGIAR contributions to a policy outcome trajectory*. Lima, Peru: CGIAR Research Programs on Roots, Tubers and Bananas (RTB) and Agriculture for Nutrition and Health (A4NH).

Gitaria, H. I., Gachenea, C. K. K., Karanja, N. N., Kamaua, S., Nyawadea, S., Sharma, K. and Schulte-Geldermann, E. (2018). Optimizing yield and economic returns of rain-fed potato (Solanum tuberosum L.) through water conservation under potato-legume intercropping systems. *Agriculture Water Management* 208: 59-66. IEA (CGIAR Independent Evaluation Arrangement). (2016). *Evaluation brief: CGIAR Research Program on Roots, Tubers and Bananas (RTB).* Rome: IEA. https://cas.cgiar.org/sites/default/files/pdf/Evaluation-Brief-RTB.pdf

ISPC (CGIAR Independent Science and Partnership Council). (2016). *ISPC Assessment of the Roots, Tubers and Bananas (RTB) CRP-II revised proposal (2017–2022)*. Rome: ISPC. https://www.rtb.cgiar.org/publications/ispc-assessment-of-the-roots-tubers-and-bananas-rtb-crp-ii-revised-proposal-2017-2022

Kawarazuka, N. and Kharchandy, B. (2019) A rapid assessment of Farmer Business Schools from a gender perspective in Meghalaya, India. Food Resilience Through Root and Tuber Crops in Upland and Coastal Communities of the Asia-Pacific (FoodSTART+) Project. Lima (Peru). CIP.

Kikulwe, E., Kyanjo, J., Kato, E., Ssali, R., Erima, R., Mpiira, S., Ocimati, W. et al. (2019). Management of Banana Xanthomonas Wilt: Evidence from Impact of Adoption of Cultural Control Practices in Uganda. *Sustainability*, 11(9): 1-18.

Mudege, N. N., Mdege, N., Abidin, P. E., & Bhatasara, S. (2017). The role of gender norms in access to agricultural training in Chikwawa and Phalombe, Malawi. *Gender, Place, and Culture*, 24(12), 1689–1710.

Pradel, W., Gatto, M., Hareau, G., Pandey, S. K. and Bhardway, V. (2019) Adoption of potato varieties and their role for climate change adaptation in India. *Climate Risk Management* 23:114-123.

RTB (CGIAR Research Program on Roots, Tubers and Bananas). (2016a). *Roots, Tubers and Bananas (RTB) full proposal 2017–2022*. Lima: RTB. https://cgspace.cgiar.org/handle/10947/4286

RTB. (2016b). *Roots, Tubers and Bananas (RTB) proposal, Vol. III, 2017–2022*. Lima: RTB. https://cgspace.cgiar.org/bitstream/handle/10947/4415/4.%20RTB-Annexes_16_07_27.pdf?sequence=1&isAllowed=y

RTB. (2020a, April 16). Scaling up the use of cassava peel as animal feed in Nigeria. https://www.rtb.cgiar.org/news/scaling-up-the-use-of-cassava-peel-as-animal-feed-in-nigeria/

RTB. (2020b). Seed System Toolbox. https://www.rtb.cgiar.org/seed-system-toolbox/.

Schut, M., Kamanda, J., Gramzou, A., Dubois, T., Stoian, D., Anderssen, J., Dror, I. et al. (2019) Innovation platforms in agricultural research and development. *Experimental Agriculture* 55: 575-596.

Advisory
Services

CGIAR Advisory Services (CAS) Secretariat
Via dei Tre Denari, 472/a, Maccarese (Fiumicino), Italy
tel: (39) 06 61181 - email: cas@cgiar.org
https://cas.cgiar.org/