CGIAR

INITIATIVE ON
Accelerated Breeding

CGIAR Initiative on Accelerated Breeding

ANNUAL TECHNICAL REPORT 2022

CGIAR Technical Reporting 2022

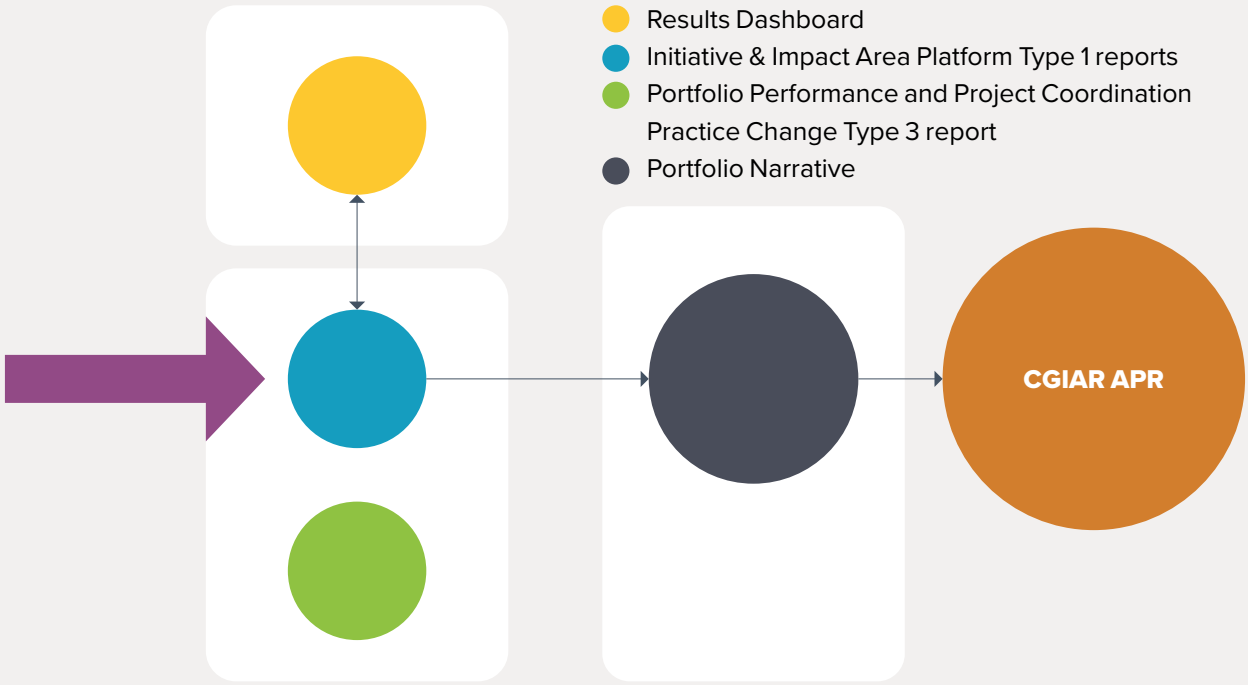
CGIAR Technical Reporting has been developed in alignment with the CGIAR Technical Reporting Arrangement.

This Initiative report is a Type 1 report and constitutes part of the broader CGIAR Technical Report. Each CGIAR Initiative submits an annual Type 1 report, which provides assurance on Initiative-level progress towards end-of-Initiative outcomes.

The CGIAR Technical Report comprises:

- Type 1 Initiative and Impact Area Platform reports, with quality assured results reported by Initiatives and Platforms available on the CGIAR Results Dashboard.
- The Type 3 Portfolio Performance and Project Coordination Practice Change report, which focuses on internal practice change.
- The Portfolio Narrative, which draws on the Type 1 and Type 3 reports, and the CGIAR Results Dashboard, to provide a broader view on portfolio coherence, including results, partnerships, country and regional engagement, and synergies among the portfolio's constituent parts.

The CGIAR Technical Report constitutes a key component of the CGIAR Annual Performance Report (APR).



US$	2022	2023	2024
Proposal Budget from initial submission	US$33,689,134	US$36,219,700	US$39,090,866
Approved 2022 Budget	US$26,784,739		

2022 Disbursement Target based on Approved FinPlan

Section 1 Fact sheet

Initiative name	Accelerated Breeding
Initiative short name	Accelerated Breeding
Action Area	Genetic Innovation
Geographic scope	**Regions targeted in the proposal:** Central and West Asia and North Africa; East and Southern Africa; Latin America and the Caribbean; South Asia; Southeast Asia and the Pacific; West and Central Africa **Countries sharing objectives/targeted in the proposal:** Afghanistan; Algeria; Angola; Argentina; Azerbaijan; **Bangladesh**; **Benin**; Bolivia; Brazil; **Burkina Faso**; **Burundi**; Cambodia; **Cameroon**; Central African Republic; Chad; Chile; China; Colombia; Congo; Costa Rica; **Côte d'Ivoire**; Cuba; Dominican Republic; Ecuador; Egypt; El Salvador; Eritrea; **Ethiopia**; Gambia; **Ghana**; Guatemala; Guinea; Guinea-Bissau; Guyana; Haiti; Honduras; **India**; Indonesia; Iraq; Jordan; Kazakhstan; **Kenya**; Kyrgyzstan; Lao People's Democratic Republic; Lebanon; Liberia; Libya; **Madagascar**; **Malawi**; **Mali**; Mauritania; Mexico; Morocco; **Mozambique**; Myanmar; **Nepal**; Nicaragua; Niger; **Nigeria**; **Pakistan**; Palestine, State of; Panama; Paraguay; Peru; Philippines; **Rwanda**; Saudi Arabia; **Senegal**; Sierra Leone; Somalia; South Africa; South Sudan; Syrian Arab Republic; Tajikistan; **Tanzania**, **United Republic**; Thailand; **The Democratic Republic of the Congo**; The Islamic Republic of Iran; **The Republic of the Sudan**; The Socialist Republic of Viet Nam; **Togo**; Tunisia; Türkiye; **Uganda**; Uruguay; Uzbekistan; Venezuela; Yemen; **Zambia**; **Zimbabwe** **Regions with results reported in 2022:** Central and West Asia and North Africa; East and Southern Africa; Europe; Latin America and the Caribbean; North America; South Asia; Southeast Asia and the Pacific; West and Central Africa **Countries with results reported in 2022:** Afghanistan; Algeria; Angola; Argentina; Azerbaijan; Bangladesh; Benin; Bolivia; Botswana; Brazil; Burkina Faso; Burundi; Canada; Chile; China; Colombia; Costa Rica; Côte d'Ivoire; Dominican Republic; Ecuador; Egypt; El Salvador; Eswatini; Ethiopia; Georgia; Ghana; Guatemala; Guyana; Honduras; India; Indonesia; Iran; Italy; Japan; Kenya; Lebanon; Lesotho; Madagascar; Malawi; Mali; Mauritius; Mexico; Morocco; Mozambique; Nepal; Nicaragua; Nigeria; Pakistan; Panama; Paraguay; Peru; Philippines; Rwanda; South Africa; Sri Lanka; Sudan; Tanzania, United Republic; Thailand; The Democratic Republic of the Congo; The Socialist Republic of Viet Nam; Togo; Tunisia; Türkiye; Uganda; United Kingdom of Great Britain and Northern Ireland; Uruguay; Uzbekistan; Venezuela; Vietnam; Zambia; Zimbabwe
Start date	Jan. 1, 2022
End date	Dec. 31, 2024
Initiative Lead	Michael Quinn – m.quinn@cgiar.org

Measurable three-year End of Initiative outcomes (EOI-Os)	**EOI-O 1:** CGIAR-NARES breeding pipelines oriented toward specific market segments, enabling greater focus on farmers' needs, drivers of adoption, and impact.
	EOI-O 2: Breeding pipelines use a revised organizational framework, providing teams with operational clarity and effectiveness for pursuing breeding outputs.
	EOI-O 3: Breeding networks implement stronger partnership models where NARES and SMEs have increased contribution to the breeding process.
	EOI-O 4: Breeding pipelines are supported by TD&D programs that deliver high-impact traits within elite parental lines.
	EOI-O 5: Breeding pipelines have increased the rate of genetic gain, providing seed system actors with farmer-preferred candidate varieties, with a step change in performance under farmers' conditions.
	EOI-O 6: CGIAR breeding portfolio ensures gender inclusiveness and increases gender intentionality through the candidate varieties that are being developed.
OECD DAC Climate marker adaptation score*	**Score 2:** Principal: The activity is principally about meeting any of the three CGIAR climate-related strategy objectives — namely, climate mitigation, climate adaptation, and climate policy, and would not have been undertaken without this objective.
OECD DAC Climate marker mitigation score*	**Score 1:** Significant: The activity contributes in a significant way to any of the three CGIAR climate-related strategy objectives — namely, climate mitigation, climate adaptation, and climate policy, even though it is not the principal focus of the activity.
OECD DAC Gender equity marker score*	**Score 1A:** Gender accommodative/aware: Gender equality is an objective, but not the main one. The Initiative/project includes at least two explicit gender-specific outputs and (adequate) funding and resources are available. Data and indicators are disaggregated by gender and analyzed to explain potential gender variations and inequalities.
Website link	https://www.cgiar.org/initiative/accelerated-breeding/

*The Organisation for Economic Co-operation and Development (OECD) Development Assistance Committee (DAC) markers refer to the OECD DAC Rio Markers for Climate and the gender equality policy marker. For climate adaptation and mitigation, scores are: 0 = Not targeted; 1 = Significant; and 2 = Principal.
The CGIAR GENDER Impact Platform has adapted the OECD gender marker, splitting the 1 score into 1A and 1B. For gender equality, scores are: 0 = Not targeted; 1A = Gender accommodative/aware; 1B = Gender responsive; and 2 = Principal.
These scores are derived from Initiative proposals, and refer to the score given to the Initiative overall based on their proposal.

A list of abbreviations and acronyms used throughout the report can be found here.

CGIAR breeding expert examines new rice crop varieties at network breeding facility in Uganda.
Photo credit: Jjumba Martin, EiB/CGIAR

Section 2 Initiative progress on science and towards End of Initiative outcomes

Overall summary of progress against the theory of change

The Accelerated Breeding community is leveraging the power of One CGIAR to transform international crop breeding. 2022 progress builds upon foundations laid by the Excellence in Breeding (EiB) Platform and has solidified collaboration among Centers, the other Genetic Innovation Initiatives, partners, and funders.

One CGIAR collaborative crop breeding is already a tremendous force, as verified by a joint stocktaking. Seven Centers improve and deploy 21 crops and forages through 33 breeding networks that routinely involve over 600 public and private sector partner institutions in 135 countries. Several of them collaborate on multiple crops, altogether resulting in close to 1,200 crop-specific partnerships. These countries have 95% of the global area growing the crops and forages that CGIAR is working on. Affiliated staff produced 216 publications (208 peer-reviewed), co-authored with approximately 500 university departments and research organizations globally. Thus, affiliated scientists are at a pivotal interface between cutting-edge research and applied breeding. This benefits farmers both in lower-income countries and, through open access, the global community, and advances CGIAR's unique global mandate for developing crucial crops as international public goods.

The Accelerated Breeding community is making this tremendous breeding engine more focused, faster, more equal, and collaborative — to increase the benefits created for low-income farmers, partner countries, and civil society. CGIAR breeding efforts have historically been directed at reducing poverty and food insecurity through increasing productivity and disease resistance. This has evolved: 73% of known 2022 partner variety releases (234 of 303) also carry greater climate resilience and/or are supportive of greenhouse-gas-reducing cropping systems. This includes varieties that are tolerant to drought, heat, or flooding, fit better into sustainable production systems, reduce nitrous oxide emissions, or, in the case of rice, are suited for direct seeding. In addition, 35% of the known 2022 partner variety releases (105 of 303) are directed toward reducing malnutrition among women and young children. Collaboration with Market Intelligence and the Gender Platform systematically increases the gender relevance and intentionality of the CGIAR breeding portfolio.

Member of national breeding team in Uganda examines breeding trial results. Photo credit: Jjumba Martin, Accelerated Breeding/CGIAR

Breeding is a cyclical process, and the faster the cycle turns to combine superior genetic resources and traits (covered by 118 publications), the more superior is the genetic material and varieties developed; a concept known as the "rate of genetic gain" (covered by 86 publications). Across the 21 crops and forages, there are hundreds of examples of these changes. By working together in the Accelerated Breeding community, the pace of change is increasing. Crop breeding programs: (i) adopted precision phenotyping and genome-assisted selection for high-value traits that are relevant for increasing resilience, nutrition, and meeting end-user market demands; (ii) optimized breeding schemes; (iii) reduced breeding cycle times through genomics-supported recurrent selection; and (iv) deployed variety identification schemes that better captured candidate variety performance, gender-disaggregated farmer feedback, and market demands.

Institutional innovations included:

- Consistent CGIAR-wide approaches to identifying breeding pipelines, subregional market segments, and target product profiles (TPPs).
- A unified and standardized stage plan for breeding that covers the complete product development space.
- Greater national agricultural research and extension systems (NARES) engagement via: high-level meetings; stronger processes to define joint breeding objectives; capturing NARES strengths, improvement ambitions, and capacity development needs; understanding and systematically improving partnership approaches.
- Progress toward interrogating and refining trait discovery and deployment approaches, and their return on investment (ROI) for a CGIAR-wide portfolio of 350 activities that researches distinct disease and pest resistance traits (34%), climate resilience traits (25%), and nutritional, production, and end-use traits (28%).
- Standardizing genetic gain estimates across all crops and traits.

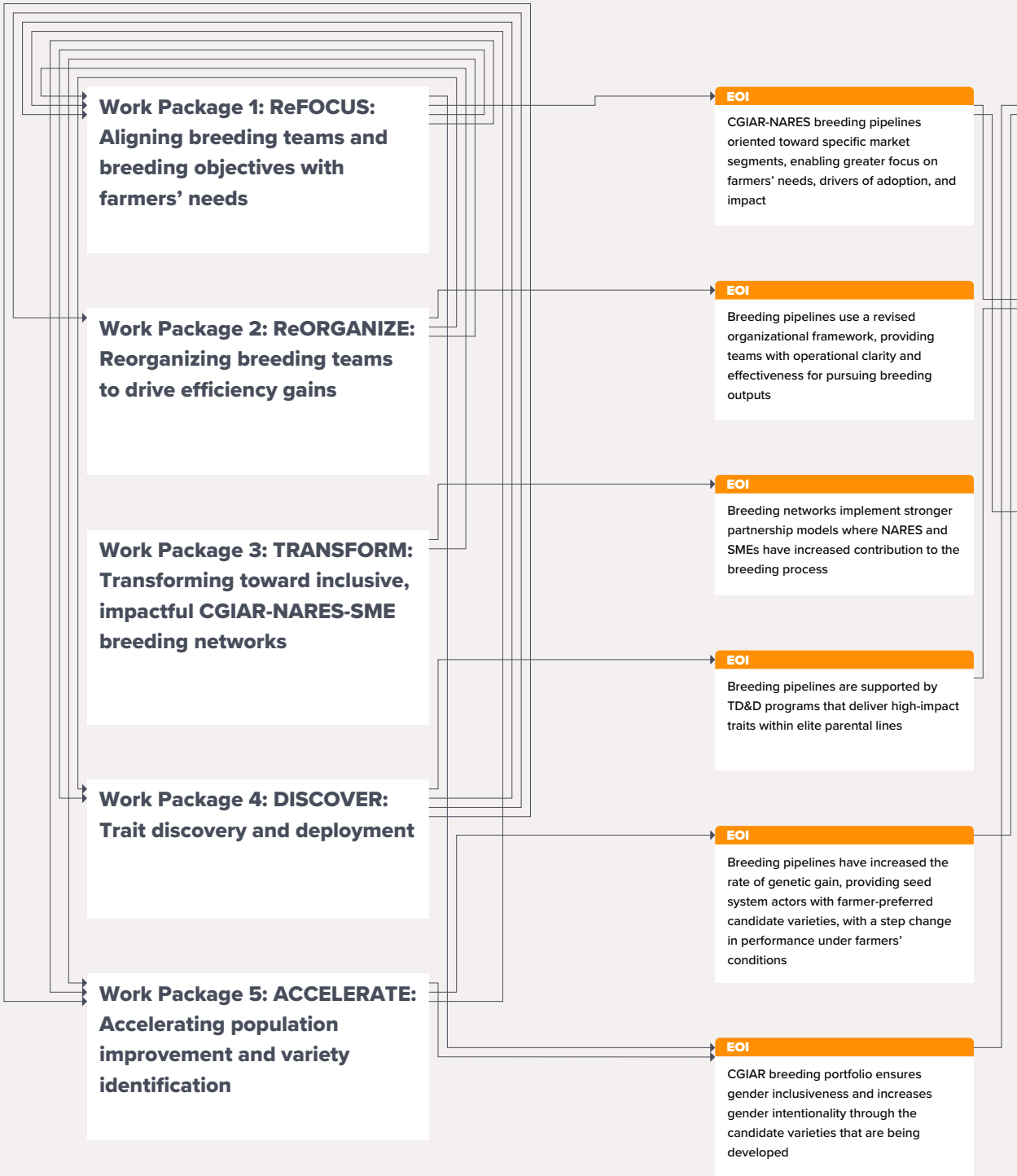
Pioneering a two-dimensional theory of change, Accelerated Breeding distinguishes between outputs that drive the main impact pathway — germplasm development by CGIAR-NARES partners through 33 crop breeding networks — and scientific and institutional innovations that increase their capabilities to execute breeding and develop new candidate varieties, so breeding becomes:

- More focused: through ReFOCUS and DISCOVER, in collaboration with Market Intelligence.
- Faster: through ACCELERATE and DISCOVER, in interaction with Breeding Resources.
- More equal and collaborative: through TRANSFORM and ReORGANIZE, in interaction with all Genetic Innovation Initiatives.

Regular dialogues with crop leads and teams, along with 125 capacity-sharing opportunities involving over 7,600 participants, have enabled Accelerated Breeding to engage with 21 crops and forages, 60 breeding programs, 33 networks, approximately 200 CGIAR scientists, and institutions in many partner countries. The greatest support is flowing to breeding activities directed toward 20 networks and 26 countries in Africa and South Asia. Benefits can widen if all CGIAR regions and countries increase aligned investments. A partner strategy is in internal review to further strengthen high-quality, impact-oriented, mutually beneficial engagements at scale.

Initiative-level theory of change diagram

This is a simple, linear, and static representation of a complex, non-linear, and dynamic reality. Feedback loops and connections between this Initiative and other Initiatives' theories of change are excluded for clarity.



EOI — End of Initiative outcome

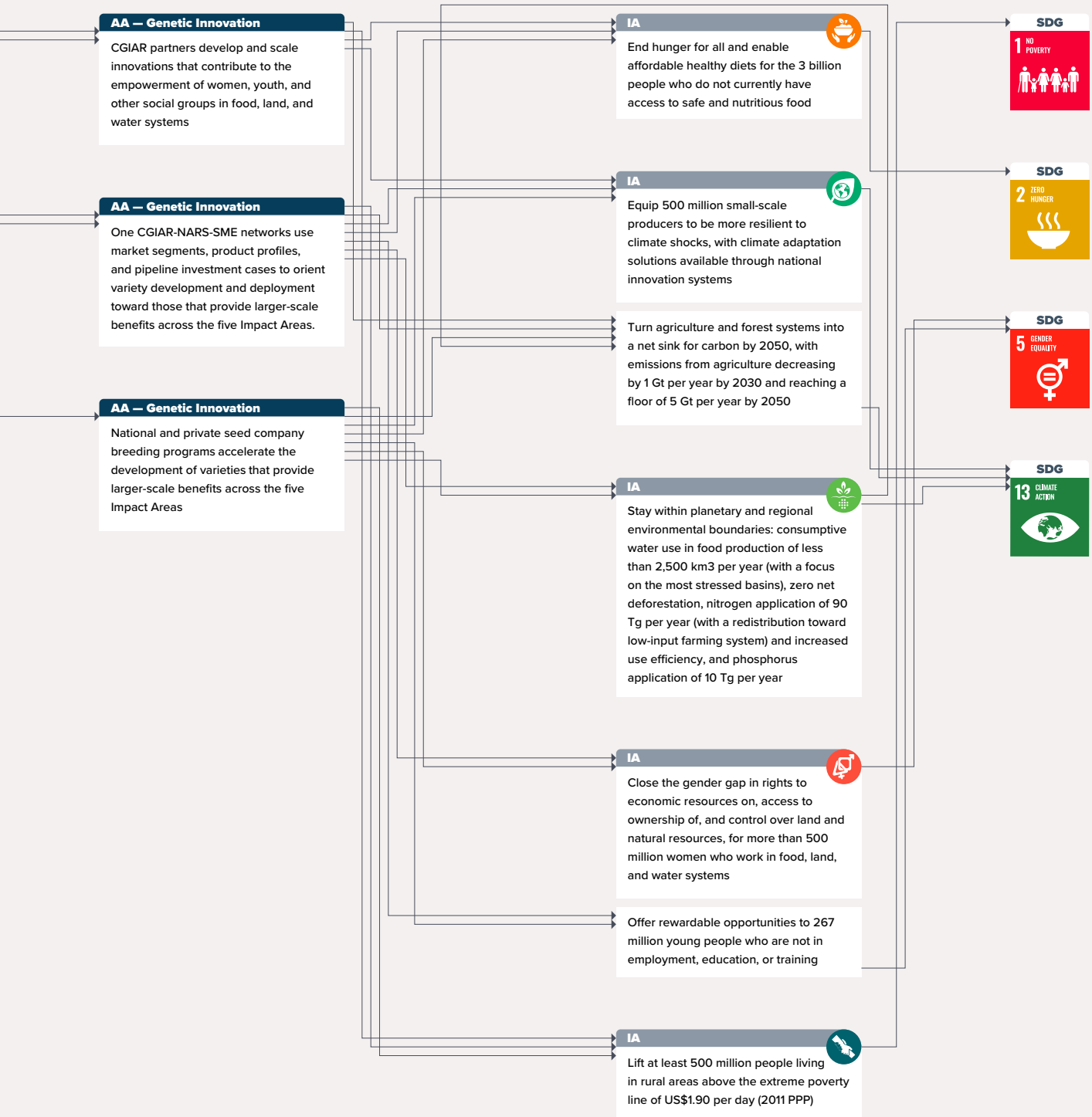
AA — Action Area

IA — Impact Area

SDG — Sustainable Development Goal

- Nutrition, Health, and Food Security
- Poverty Reduction, Livelihoods, and Jobs
- Gender Equality, Youth, and Social Inclusion
- Climate Adaptation and Mitigation
- Environmental Health and Biodiversity

Teams from CGIAR's three Action Areas — System Transformation, Resilient Agrifood Systems and Genetic Innovation — worked to develop an improved set of Action Area outcomes in October 2022. Since this was near the end of the reporting cycle for 2022, it was decided not to update the theories of change based on these new Action Area outcomes.
The exception to this is Genetic Innovation — for this Action Area, as the new outcomes had already been widely discussed among the relevant Initiatives, and with its advisory group of funders and other stakeholders, the decision was made to update their outcomes in time for the 2022 reporting cycle.



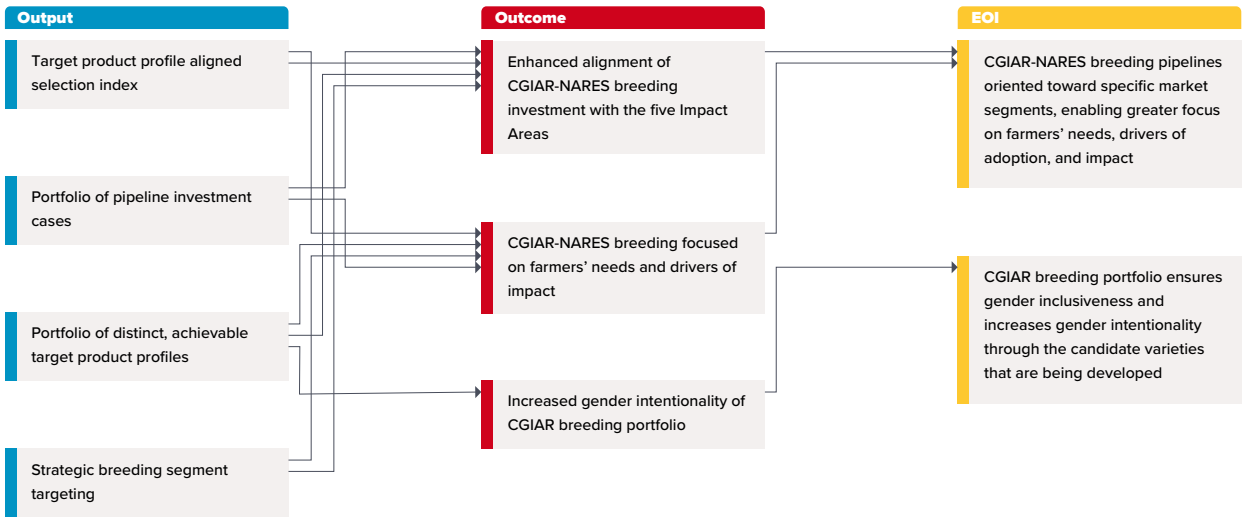
Progress by End of Initiative outcome

EOI-O 1: CGIAR-NARES breeding pipelines oriented toward specific market segments, enabling greater focus on farmers' needs, drivers of adoption, and impact.	In 2022, all breeding pipelines established their current TPPs, linked to distinct market segments and breeding pipelines. During 2023, NARES will develop market segments and TPPs at country level, to support systematic dialogues on the most impactful TPPs and market segments, including how to increase gender relevance and intentionality. These dialogues are conducted in close collaboration with Market Intelligence, which is developing methods for gender relevance and pipeline investment case assessments. An information system is in development to manage the linkages between files and allow easy updating, communication, and reporting. In 2023, TPPs will also be reviewed for technical feasibility — how can the traits be measured, is there variability for the traits in elite/non-elite germplasm, what is time to success? These efforts will focus and provide direction for CGIAR-NARES breeding pipelines and trait research to develop in-demand products for the most impactful market segments.
EOI-O 2: Breeding pipelines use a revised organizational framework, providing teams with operational clarity and effectiveness for pursuing breeding outputs.	A 2022 baseline assessment indicated wide heterogeneity in the definition and use of stage plans across CGIAR breeding programs. Throughout 2022 a multi-Center and multi-Initiatives team developed and interrogated a variety of draft plans, incorporating feedback from team members and breeding program leads. The final plan incorporated the complete product lifecycle, provided harmonization of terms, defined common stage gates, and mapped stages to innovation readiness levels of CGIAR. The plan was approved by breeding leads and Genetic Innovation leadership. For the first time, CGIAR breeding has a common, unified stage plan, enabling effective communication and operational clarity among teams involved in the breeding process. 2023 and 2024 efforts will be directed at establishing completion criteria for each stage and handover between teams, and key performance indicators (KPIs) that can be used to increase the effectiveness of the development process, as a whole and for its segments.
EOI-O 3: Breeding networks implement stronger partnership models where NARES and SMEs have increased contribution to the breeding process.	TRANSFORM builds stronger, more collaborative breeding networks that are inclusive and capitalize on the comparative advantages and strengths of CGIAR, NARES, and the private sector. A high-level stakeholder consultation in Nairobi, involving leadership from One CGIAR, NARES, and subregional organizations, openly discussed and captured improved partnership approaches in an aide memoire, and committed to champion these approaches among leaders and implementers. During 2022, four subregional (maize, groundnuts) networks intensely reviewed network partner breeding programs and infrastructure to jointly identify roles and responsibilities for network members, which in turn provides greater operational clarity. Greater ownership was established by ensuring national partners lead the setting of collaborative breeding priorities through the definition of national market segments and TPPs, and take ownership of final stage advancement decisions. These approaches were piloted through 25+ meetings, with a view to scaling across a wider range of crops and networks in 2023.

EOI-O 4: Breeding pipelines are supported by TD&D programs that deliver high-impact traits within elite parental lines.	For the first time ever, a comprehensive and standardized portfolio of trait discovery and deployment (TD&D) and phenotyping assay development projects was defined across CGIAR breeding. The portfolio documented traits of focus, intended geography/market segment/TPP, investment envelope for the projects, and expert estimated contribution of the trait-to-yield if successfully deployed in a variety and grown by farmers. This information will be used in 2023 to begin to detail scientific approaches within each project and assess opportunities to optimize trait delivery. Furthermore, the information will be used to conduct initial assessment of ROI of the portfolio components using a pilot approach collaboratively determined by DISCOVER and Market Intelligence. The DISCOVER team initiated the mapping of all portfolio traits to the TPPs and will complete the initial ROI assessment of yield traits in 2023, providing the first data-driven framework for trait prioritization based on market requirements and expected benefits.
EOI-O 5: Breeding pipelines have increased the rate of genetic gain, providing seed system actors with farmer-preferred candidate varieties, with a step change in performance under farmers' conditions.	All breeding pipelines calculated their realized rate of genetic gain in 2022, using CGIAR-wide standardized methods developed in 2021 by EiB. The rates of realized genetic gain across crops and traits were significant and positive in 74 of 134 pipelines. Genetic trends are expected to be pushed higher during and beyond the investment period through accelerating breeding cycles, continued pipeline optimization, and improved capabilities to use genomic-assisted breeding — coupled with improved data quality. Breeding regularly provides seed system actors with new candidate varieties. By establishing TPPs, aligning breeding schemes with TPPs, and increasing on-farm trialing at scale, CGIAR-NARES networks are establishing systematic feedback loops driven by on-farm performance and gender-disaggregated farmer feedback. This will help to increase TPP alignment with drivers of adoption, ensure candidate varieties provided to seed system actors confer greater value to farmers, and enable systematic improvements in the gender relevance of the portfolio.
EOI-O 6: CGIAR breeding portfolio ensures gender inclusiveness and increases gender intentionality through the candidate varieties that are being developed.	In collaboration with Market Intelligence, preliminary criteria for gender intentionality were established. At this stage, twenty-two percent of all CGIAR breeding pipelines were defined as gender intentional. They resulted in partners releasing over 100 crop varieties that could lower malnutrition among women and children. A pilot study with cassava in West and Central Africa evaluated each trait in current Target Product Profiles for gender relevance and intentionality. Four crops captured gender-disaggregated farmer-feedback to new varieties at large scale. Such research gives insight into where perspectives and needs differ, and how to successfully increase the gender relevance and intentionality of the breeding portfolio. This type of research will be extended to other crops in 2023. Internally, a common stage plan has been developed. Among other uses, it forms the basis for gender mapping in breeding teams and assessing approaches to understand and improve gender equality in breeding and decision-making.

Section 3 Work Package-specific progress

Work Package 1:
ReFOCUS: Aligning breeding teams and breeding objectives with farmers' needs



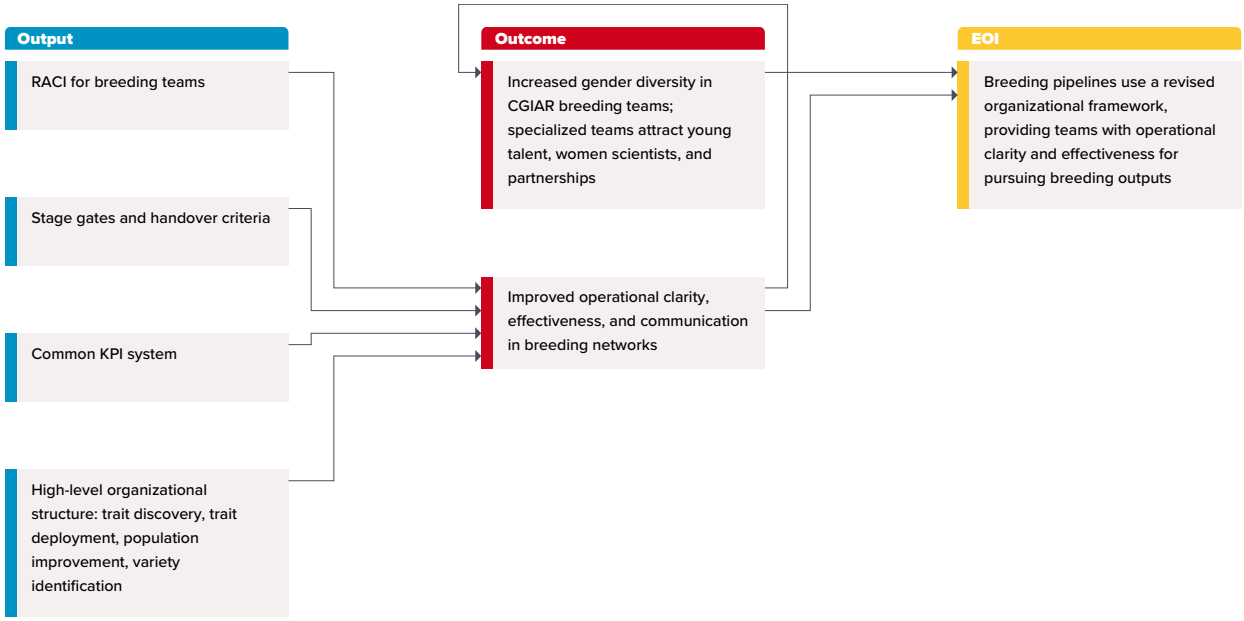
Work Package 1 progress against the theory of change

During 2022, **ReFOCUS** supported all CGIAR crops to make the focus of their current breeding activities transparent — the current TPPs and associated market segments. This ensures programs increase focus on farmers' needs, drivers of adoption, and impact. Each TPP is a unique combination of productivity, adaptation, resilience, quality, processing, and consumer traits. The combined efforts by 21 crops and 60 breeding programs resulted in an inventory of 375 TPPs that are being delivered by 121 breeding pipelines across CGIAR, i.e., through pooled and non-pooled funding. In addition, 11 of 20 crops reviewed breeding schemes and associated selection indices to ensure that: (i) the selection of parental germplasm and candidate varieties are systematically aligned with the TPPs; and (ii) breeding ambitions and associated timelines are realistic. Also, establishing current TPPs and linking them to distinct market segments stimulated crops to reassess strategic breeding pipeline segmentation. These results enable CGIAR breeding to systematically: (i) incorporate new/forthcoming Market Intelligence; (ii) increase effectiveness and likeliness of success; (iii) increase gender intentionality; and (iii) increase alignment with NARES breeding.

Gender achievements

In collaboration with Market Intelligence, preliminary criteria for gender intentionality were established. Twenty-two percent of all breeding pipelines were defined as gender intentional. A pilot study with cassava in West and Central Africa evaluated each trait in the TPP for gender relevance and intentionality. This will develop more in-depth understanding and allow further augmentation of gender relevance and intentionality within the CGIAR breeding portfolio.

Work Package 2:
ReORGANIZE: Breeding teams to drive efficiency gains



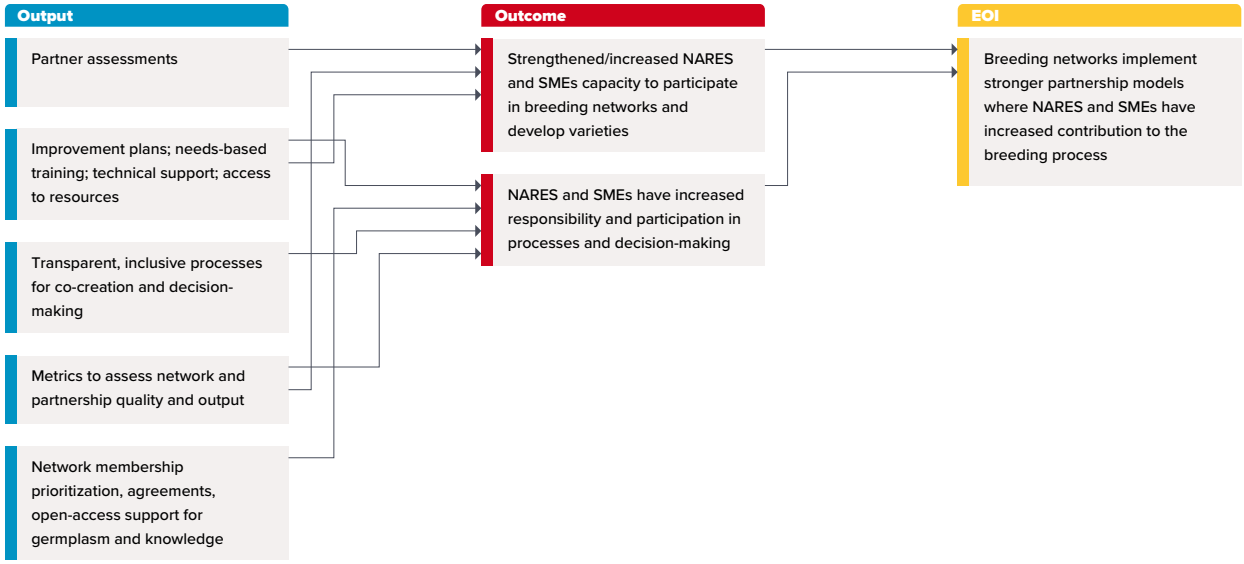
Work Package 2 progress against the theory of change

Capitalizing on the One CGIAR transformation, and in interaction with the other Genetic Innovation Initiatives, **ReORGANIZE** realigns breeding activities and teams along agile "form follows function" lines — trait discovery, trait deployment, population improvement, and variety identification — to accelerate genetic gains and consistently pursue the prioritized TPPs. Building upon work by EiB, a cross-Center, cross-Initiatives team developed, discussed, reconciled, and agreed on a unified and standardized stage plan of breeding, while also establishing the current baselines for each Center and crop breeding team. The unified stage plan not only spans the active breeding activities but also covers the complete product development space, from market segmentation and product concept definition to variety lifecycle management and product retirement. The stage plan and associated stage gates were also aligned with the innovation readiness and use levels that are used across CGIAR. The stage plan was approved for implementation by crop breeding program leads and Genetic Innovation leadership. It provides common nomenclature, definition of stages, and stage gates, therefore enabling effective communication and harmonized operational clarity across CGIAR-NARES breeding networks. It forms the basis for: (i) enhancing alignment and making transparent individual teams' contributions towards the overall breeding success; and (ii) the evolution towards high-performing specialized teams that will attract young talent, women scientists, and partnerships.

Gender achievements

The common stage plan forms the basis for gender mapping in breeding teams and assessing approaches to understand and improve gender equality in breeding and decision-making.

Work Package 3:
TRANSFORM: Transforming toward inclusive, impactful CGIAR-NARES-SME breeding networks



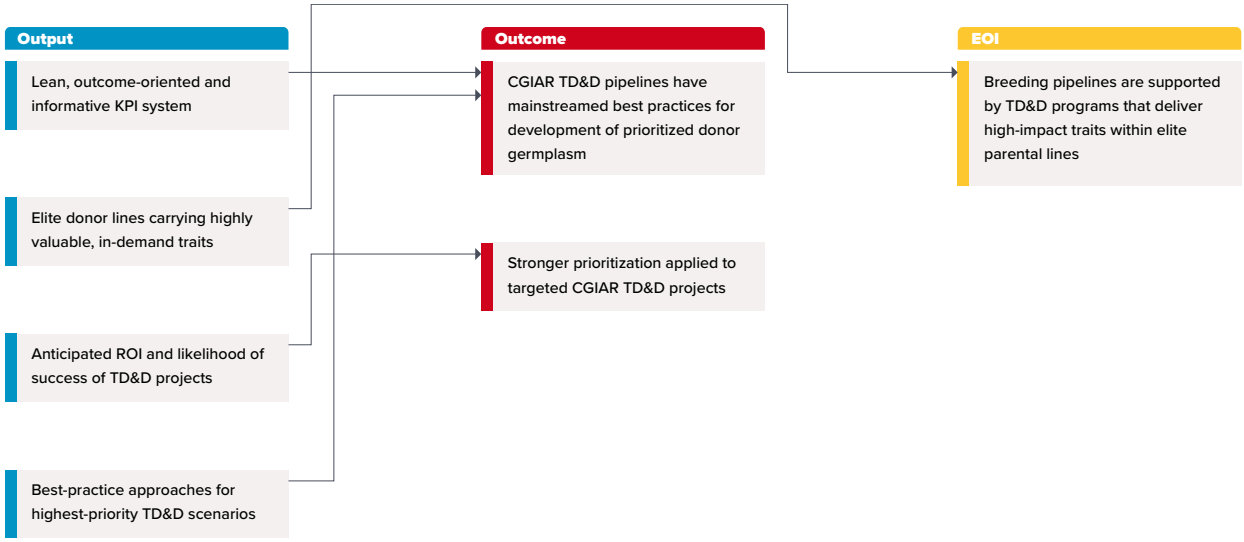
Work Package 3 progress against the theory of change

TRANSFORM works toward partnership models that foster stronger engagement by NARES and seed companies. This challenge was tackled in 2022 in two high-level meetings, involving NARES, subregional organizations, and Genetic Innovation leaders. The meetings established partnership and technical goals. Follow-ups were through 25+ crop-specific meetings reviewing and discussing CGIAR and NARES breeding targets, and approaches to co-creation, joint decision-making, and roles of partners. To enable NARES partners to take on greater roles in implementation, 38 national crop breeding programs have been reviewed and improvement plans developed since 2019. They inform crop-specific and cross-cutting capacity development efforts. In 2022 alone, breeding-related capacity-building included 7,636 participants, the majority executed in collaboration with several Initiatives. Changes of breeding collaborations need to be seen in the context of current CGIAR Center germplasm development that routinely collaborates with an estimated 600 institutions in 135 countries, as a common stocktaking across 36 (>90%) of all collaborative breeding networks revealed. It demonstrates CGIAR Centers' highly relevant breeding agenda and that open access is routinely practiced, including beyond the immediate CGIAR target countries. Therefore, a draft partnership strategy and draft partnership standards were developed to make transparent, equitable, and mutually beneficial partnership models that consider the diversity of regions, crops, and needs; they are in internal review.

Gender achievements

In collaboration with Market Intelligence, all breeding targets (TPPs) will be reviewed for gender relevance and intentionality. TRANSFORM promotes greater female participation at product design meetings.

Work Package 4:
DISCOVER: Trait Discovery and Deployment



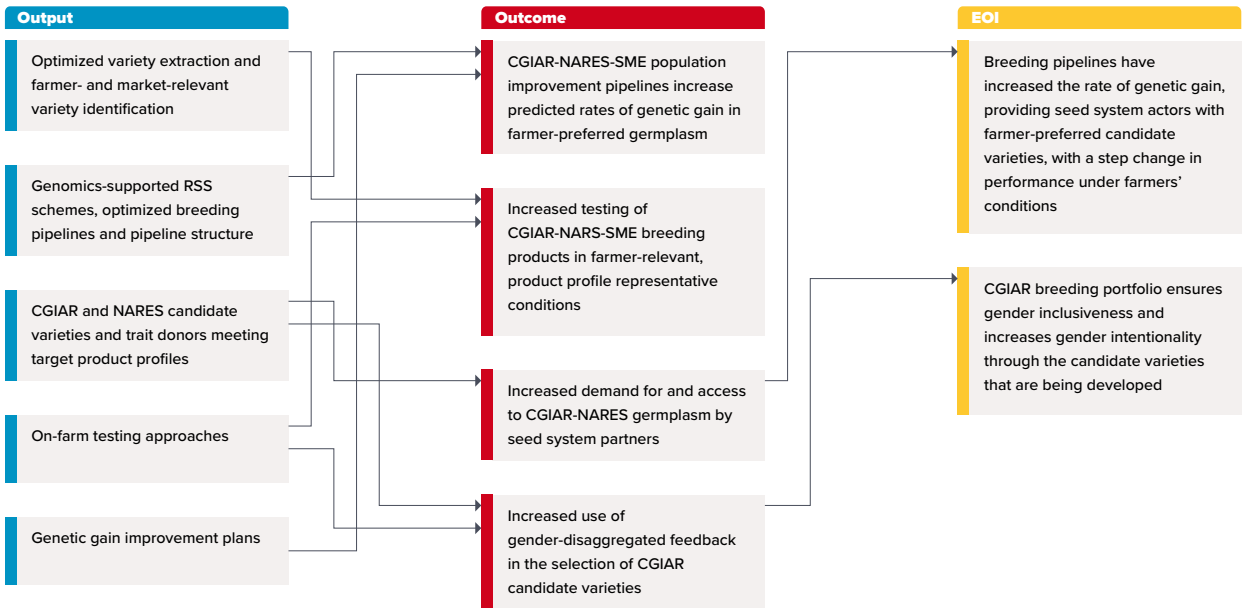
Work Package 4 progress against the theory of change

DISCOVER aims to ensure that CGIAR-NARES breeding pipelines are supported by TD&D pipelines that deliver high-impact, in-demand traits via elite donor lines and other approved germplasm types. TD&D research is an important source for CGIAR publications, producing 118 publications in 2022 alone. It is critical that these efforts are effectively connected to breeding pipelines. In 2022, the first comprehensive portfolio of CGIAR TD&D and phenotyping assay development projects was documented. Across 350 ongoing activities, 34% were on biotic stresses, 25% on abiotic stresses, and 28% on nutritional, production, and end-use traits. Portfolio characterization is key to enabling both interrogation of current scientific practice and refinement toward optimal approaches, and the definition of ROI opportunity. A pilot process was agreed among the DISCOVER team, with representatives from each crop and Center, and Market Intelligence colleagues, to assess ROI. It is being implemented for yield-related traits across crops as a first step. Calculation of ROI will be based on trait-mapping to TPP and market segment information, cost of trait work, and expert estimates of gain in farmers' fields resulting from successful trait use in variety development. The portfolio definition and ROI activities provide a first step in the transparent assessment and data-driven prioritization of TD&D projects.

Gender achievements

Market Intelligence pilot-tested an approach in 2022 to define gender intentionality and gender relevance at the trait level. This approach to rating traits will be applied in 2023 to TD&D portfolio traits.

Work Package 5:
ACCELERATE: Accelerating population improvement and variety identification



Work Package 5 progress against the theory of change

ACCELERATE captures the efforts of CGIAR's collaborative breeding networks (33 in 2022) to increase genetic gains and deliver candidate varieties with a step change in performance under farmers' conditions to collaborators in target and non-target countries. During 2022, genomics-supported recurrent selection was implemented in 35% of all breeding pipelines, reducing cycle time in cereals, common beans, root, and tuber crops to an average of 45 months, with further scope for improvement. Breeding schemes were optimized in 11 crops based on principles of quantitative genetics and stochastic simulation. These tools are also made publicly available and used externally. Fourteen crops reviewed and/or altered selection intensities to better align with TPPs. Ten crops reported progress in improving variety identification schemes based on more accurate phenotyping and genotype by environment (GxE) analyses. Four crops used large-scale evaluations at 30 to over 400 locations to capture candidate variety performance and gender-disaggregated farmer feedback. Each pipeline assessed and reported its rate of genetic gain, using standardized approaches. Statistically significant, positive realized genetic gains were reported in 55% of pipelines. Through partnerships, 303 crop varieties were released in 45 countries, 77% of them carrying climate-relevant traits and/or 35% of them carrying traits that lower malnutrition among women and children. Crop-specific improvement plans were documented in a "single-source-of-truth" project management center. Important results and insights were published through 86 peer-reviewed publications and book chapters linked to ACCELERATE. Monthly cross-commodity dialogues exchange learnings and stimulate further progress among over 100 CGIAR and NARES breeders.

A farmer in Malawi checks her maize crop that is struggling as a result of the worst drought in three decades. Photo credit: ©2016CIAT/NeilPalmer

Work Package progress rating

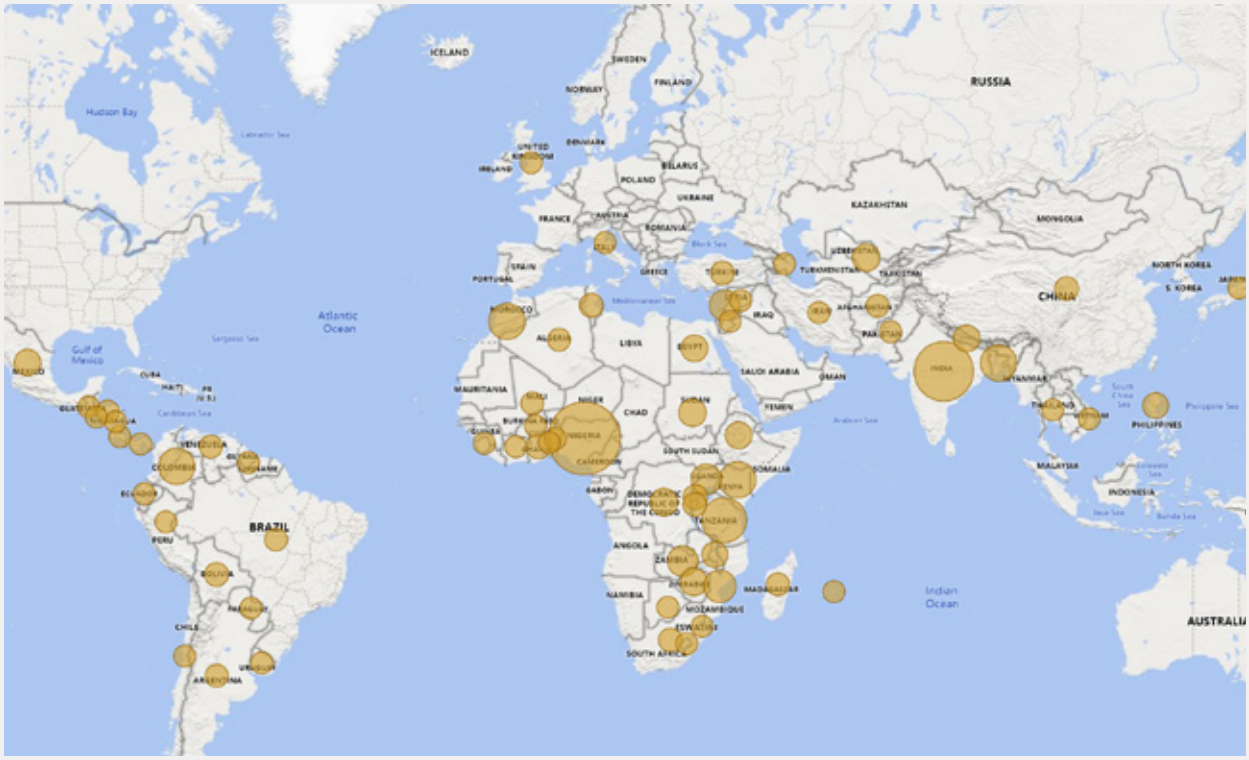
WORK PACKAGE	TRAFFIC LIGHT / RATIONALE	
1		Progress aligns with the annual Plan of Results. Crops progressed in proportion to support received. The results are evidenced by Dashboard Results 348 and 350. Result 350 reports on progress towards three interrelated outputs. The CGIAR Seed Product Market Segment Database can be found at https://excellenceinbreeding.org/toolbox/tools/cgiar-seed-product-market-segment-database
2		The results are reported and evidenced in Dashboard Results 367 and 369. Baseline information is available. The definition of the unified stage plan took longer than anticipated; however, the resulting harmonization provides a firm foundation to build from. Teams now work on RACI, handover criteria, and KPIs, and progress as planned.
3		The results are evidenced in Dashboard Results 351–355 and 1015. The work is on track. The sensitive nature requires extensive review and consultation with CGIAR-coordinated crop breeding networks and partners. This review process is systematically sequenced to include TRANSFORM informants, leaders, and partners.
4		118 Accelerated Breeding publications map to DISCOVER, evidence of the highly relevant role of TD&D research to CGIAR publications. The other DISCOVER Results are evidenced in Dashboard Result 372 and 1241. Portfolio documentation and ROI assessment are ahead of schedule. Definition of KPIs is slightly delayed with no risk to delivery.
5		Progress was made against all planned results as evidenced in Dashboard Results 17, 28, 30–49, 53–62, 187, 188, 305, 340, and 342–347. Being the first year of implementation, a few issues arose regarding work plans, budget, and understanding the new working model through the Initiatives. Many were anticipated, and appropriately mitigated.

KEY		
On track		• Annual progress largely aligns with Plan of Results and Budget and Work Package theory of change • Can include small deviations/issues/ delays/risks that do not jeopardise success of Work Package
Delayed		• Annual progress slightly falls behind Plan of Results and Budget and Work Package theory of change in key areas • Deviations/issues/delays/risks could jeopardise success of Work Package if not managed appropriately
Off track		• Annual progress clearly falls behind Plan of Results and Budget and Work Package theory of change in most/all areas • Deviations/issues/delays/risks do jeopardise success of Work Package

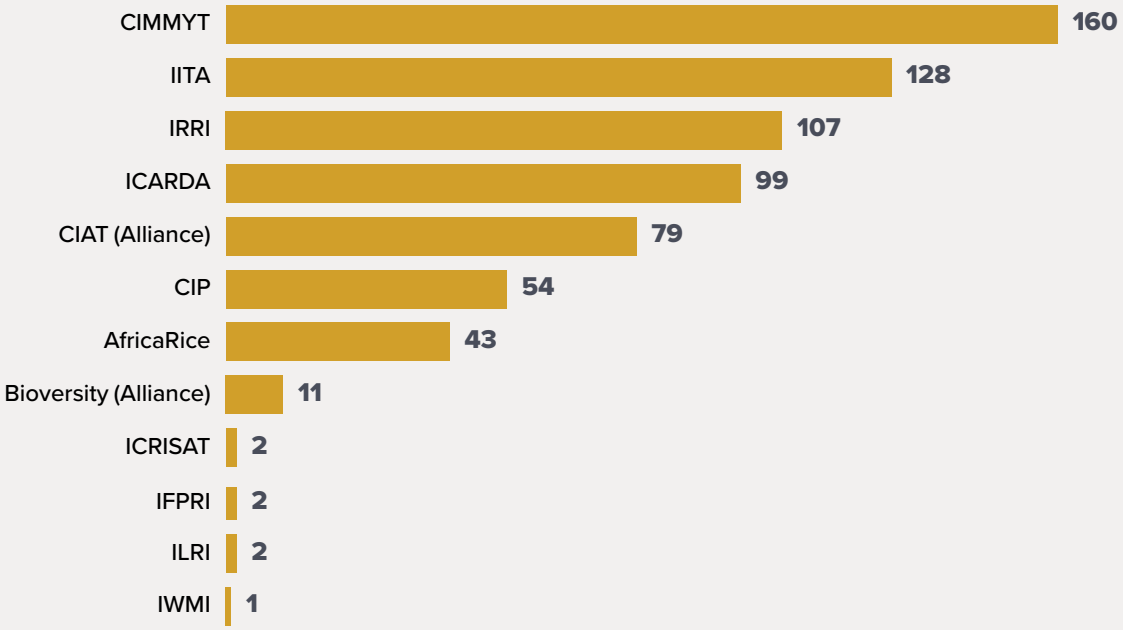
Section 4 Initiative key results

This section provides an overview of 2022 results reported by Accelerated Breeding. These results align with the CGIAR Results Framework and Accelerated Breeding's theory of change. Further information on these results is available through the CGIAR Results Dashboard.

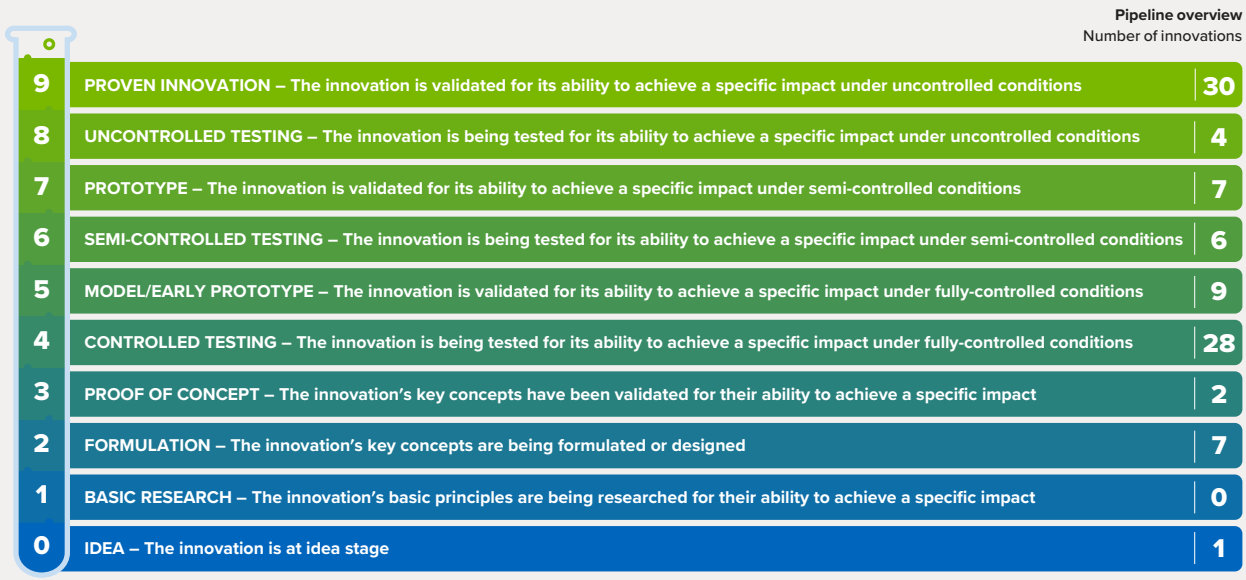
Results by country



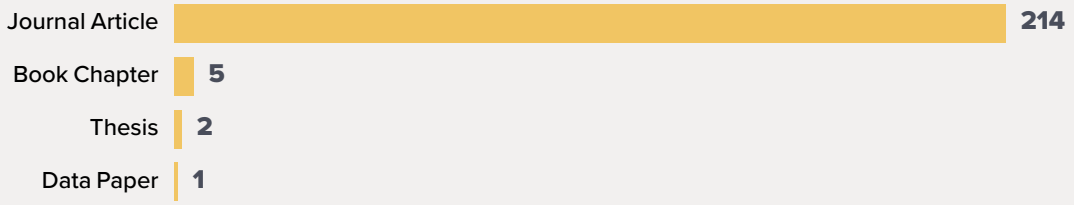
Contributing CGIAR Centers



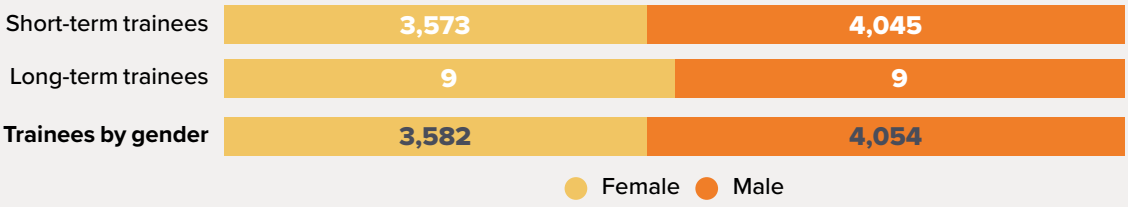
Innovations by readiness level



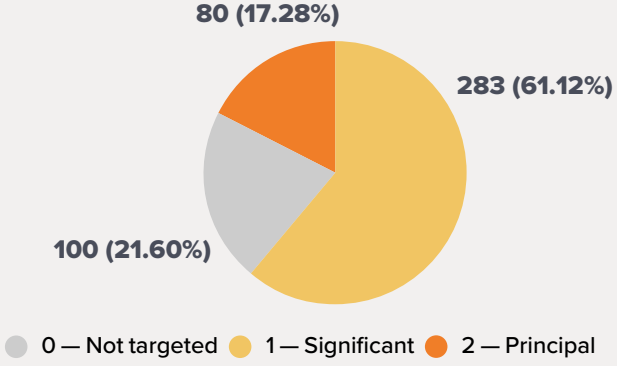
Knowledge product by category



Capacity development trainees by term



Results by climate change tag

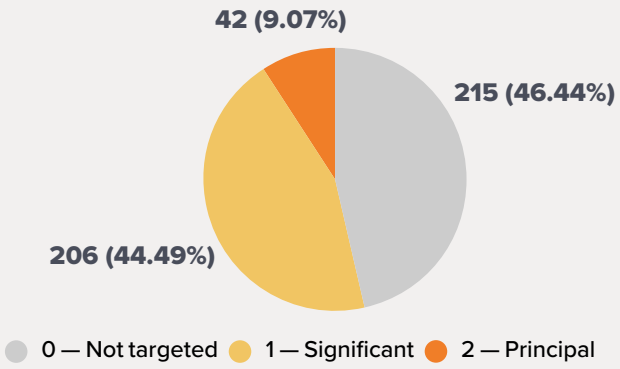


0 = Not targeted: The activity does not target climate mitigation, adaptation, and climate policy goals of the CGIAR as put forward in its strategy.

1 = Significant: The activity contributes in significant ways to either one of the three CGIAR climate-related strategy objectives — namely, climate mitigation, climate adaptation, and climate policy, even though it is not the principal focus of the activity.

2 = Principal: The activity is principally about meeting either one of the three CGIAR climate-related strategy objectives — namely, climate mitigation, climate adaptation, and climate policy, and would not have been undertaken without these objectives.

Results by gender tag

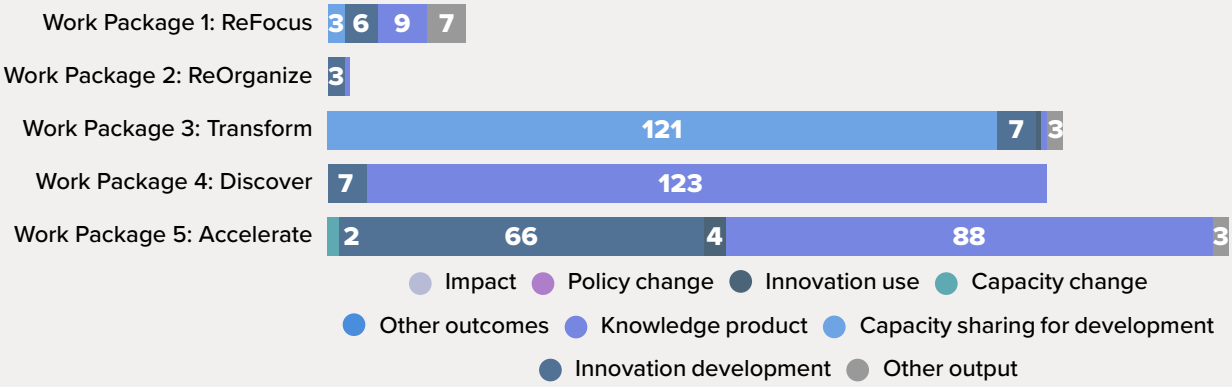


0 = Not targeted: The activity/result does not target gender equality.

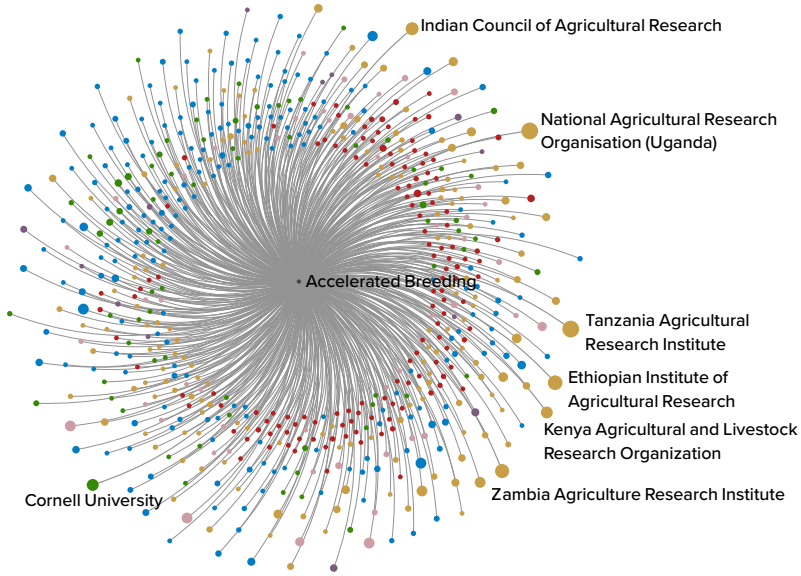
1 = Significant: The activity/result contributes in significant ways to gender equality, even though it is not the principal focus of the activity.

2 = Principal: Gender equality is the main objective of the activity/result and is fundamental in its design and expected results.

Results by Work Package



Section 5 Impact pathway integration – External partners



Partners typology	# of partners	% of partners
Research organizations and universities (NARS)	211	32.0%
Research O&U (NARS)	163	24.7%
Private company (other than financial)	136	20.6%
Government (National)	49	7.4%
Research O&U Intl. (General)	13	2.0%
All other categories	74	11.2%

Top five institution types

All other categories · Government (National) · Not applicable · Private company (other than financial) · Research O&U Intl. (General) · Research O&U (NARS) · Research O&U (National) (Universities)

Note: CGIAR Centres are excluded from the analysis. Partners and edges are sized by the number of results. Labels are shown for the partners involved in 13 or more results.

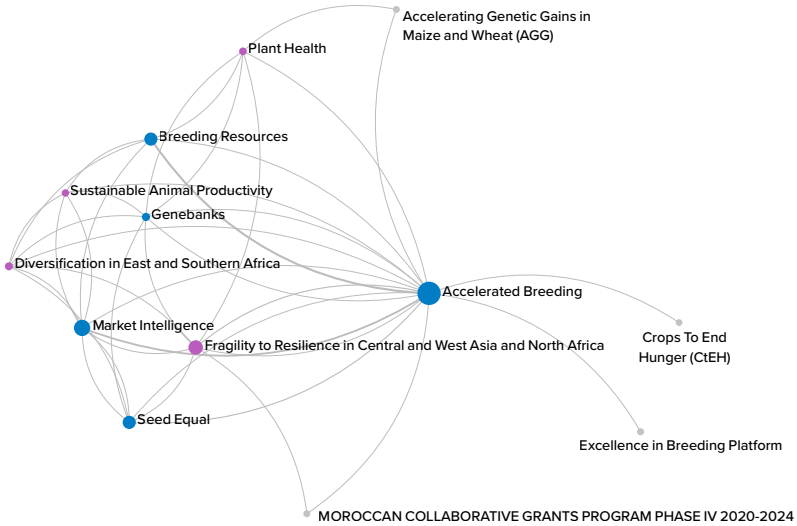
Partnerships and Accelerated Breeding's impact pathways

Research partnerships with ReFOCUS, DISCOVER, and ACCELERATE are exemplified by the co-authorship of knowledge products with approximately 500 research organizations globally. They (and not the Initiative's activities alone) inform vanguard CGIAR breeding approaches that are implemented (to the extent pooled and non-pooled funding permit) through the Dashboard-evidenced partnership networks that included only the most regular research-for-deployment partnerships of the total captured in 2022. These networks — further described by Dashboard Results 17, 28, 30–49, 53–62, and 305 — are also the main entry points toward impact. In addition, ReFOCUS, ReORGANIZE, DISCOVER, and ACCELERATE approaches are informed by adapting industry-type approaches to the public sector/not-for-profit context, which is a less formal but important version of research partnerships.

TRANSFORM's objective is to improve local partnership approaches. TRANSFORM is co-creating these at two levels: high/strategic level, in collaboration with representatives from subregional organizations and countries selected after a high-level meeting (Dashboard Result 1015); and at the operational level, by ensuring that partners co-create breeding priorities (e.g., market segments and TPPs) and have full participation and ownership of key decisions (e.g., variety advancement). In 2022, TRANSFORM developed various templates and processes to support breeding networks to identify partners, align with partner goals and ambitions, assess partner strengths, and define partners' roles.

Aligned with CGIAR's pro bono/philanthropic mandate and sources of funding, this technical support and aligned collaborative breeding investments are mostly oriented toward 20 crop networks and 26 countries in Africa and South Asia, where CGIAR-derived benefits to low-income farmers are assessed to be the greatest (based on current evidence available). Wider benefits can be created if other CGIAR regions and countries increase their investment in an aligned agenda, as is increasingly emerging through consortia-type breeding approaches.

Section 6 Impact pathway integration – CGIAR portfolio linkages



Name	Action Area	Total connections	Total results
Accelerated Breeding	GI	151	478
Market Intelligence	GI	10	145
Seed Equal	GI	11	114
Fragility to Resilience in Cent. & W. Asia and N. Africa	RAFS	7	109
Breeding Resources	GI	7	100

Action Area

Genetic Innovation Non-pooled Resilient AgriFood Systems

Note: Initiatives, non-pooled projects, and the connections are sized by the number of results. The table is sorted by Total Results. The network and summary table include all connections to Accelerated Breeding (INIT-01), as well as the connections between INIT-01's connections (i.e. the ego network)

Portfolio linkages and Accelerated Breeding's impact pathways

ReFOCUS has worked closely with **Market Intelligence** to arrive at the current set of market segments and TPPs. **Market Intelligence** will provide new market intelligence insights, methods for assessing gender relevance of TPPs, and methods and data for pipeline investment case estimation for improved across- and within-crop priority setting. **Seed Equal** will provide greater understanding of seed producer demands for new varieties and requirements for seed production. With **Plant Health**, Accelerated Breeding is using sentinel breeding sites to monitor the evolution of new pathogen strains or insect-pest biotypes, and appropriately modify the strategies for breeding improved germplasm with resistance to key diseases/insect-pests.

ReORGANIZE is working with **Market Intelligence**, **Seed Equal**, and **Genebanks** to document stage gates at interfaces with **Accelerated Breeding**. It leads breeding process definition, articulation, and documentation, and breeding KPI development in alignment with joint KPI system definition with **Breeding Resources**.

TRANSFORM works with **Market Intelligence** to support breeding networks in establishing and reviewing market segments and TPPs, including for gender relevance, and within-crop priority setting. **TRANSFORM** seeks to align capacity development with NARES-defined improvement plans for: use of, and access to, shared services and tools provided by **Breeding Resources**; and breeding scheme optimization provided by the **ACCELERATE** team.

DISCOVER collaborates with **Market Intelligence** on evolving the methodology for ROI assessment. It discusses and defines scope, opportunities, and interactions with **Genebanks** Work Package 3. It works with **ReORGANIZE** to align KPI definition and approaches.

ACCELERATE: Strong linkages have been developed with **Breeding Resources** to contribute to design and then utilize their tools and services. **ACCELERATE** seeks to align with **Seed Equal** on candidate variety deployment to seed system actors supported by **Seed Equal**, and with **Crops to End Hunger** to align on high-impact investments to increase breeding effectiveness and efficiency with Centers and NARES.

Section 7 Adaptive management

RECOMMENDATION	SUPPORTING RATIONALE
Accelerated Breeding will **strengthen implementation of genomic selection**, by facilitating cross-commodity learning, providing roadmaps for successful application, and strengthening quantitative genetics capacities.	Accelerated Breeding proposal reviewers highlighted the complexity of genomic selection and the role of systematic capacity development. At this stage, 35% of CGIAR breeding pipelines implement genomic selection. Insights were captured in 20 publications in 2022 alone. Crop-specific and crop-agnostic areas for further improvement have been identified and are being followed up (Dashboard Result 342). There is need to further strengthen quantitative genetics capacities.
Capitalizing on information developed by other Initiatives, Accelerated Breeding will seek to **make available relevant environmental information to crop breeding programs** for improved targeting and selection of varieties.	More detailed understanding of the environmental conditions targeted and the interaction with performance of varieties needs to be developed to support successful breeding approaches (Dashboard Result 344). The same environmental information can serve multiple crop breeding programs. Capacities exist across crop breeding programs that can support this objective while capitalizing on information developed by other Initiatives.
Given **the crucial and unique role of CGIAR breeding**, Accelerated Breeding suggests becoming **more specific on the type of collaboration and benefits extended to diverse partners and countries**.	Accelerated Breeding influences the agenda and derives value from a wider breeding community than where it invests. A systematic partner analysis allows to better express the value of collaboration and our focus: (i) **focal countries** receiving greatest technical support; (ii) countries that **share breeding objectives**, and engage in collaborative germplasm development and use; and (iii) countries that **regularly use** CGIAR breeding materials.
To identify a cross-Initiative team (or external capacities) that **analyzes national and subregional priorities in Africa relevant to Genetic Innovation**.	Subregional organizations and NARES in Africa, through an aide memoire (Dashboard Result 1015), requested better alignment with national and subregional priorities. Accelerated Breeding proposes a systematic analysis and understanding of those priorities that are relevant to, and can guide, Genetic Innovation interventions.
Accelerated Breeding proposes to more systematically use a two-dimensional theory of change to **further increase the relevance of the Results Framework, and foster alignment** across implementers and funding sources.	During 2022, Accelerated Breeding took stock of CGIAR breeding activities and partnerships. This established important baseline information for what needs to change. The theory of change was reviewed using a two-dimensional theory of change that distinguishes between outputs that drive the main impact pathway and scientific and institutional innovations that increase the capabilities of actors along the impact pathway. Both approaches help to implement a more focused and aligned agenda (across Centers, across projects).

RECOMMENDATION	SUPPORTING RATIONALE
To meet shortfalls in crop breeding programs by **adjusting funding allocations within the 2022–24 business cycle**, and improving priority-setting and financial models for the 2025–27 business cycle.	CGIAR's crop breeding programs were unable to achieve their workplans with the 2022 resources available. In coordination with the Genetic Innovation managing director, Accelerated Breeding reallocated a substantial amount of resources to crop breeding programs, at the expense of cross-cutting work. Genetic Innovation convened a cross-Centre task team to generate a more transparent budget allocation tool for 2023 that takes into account all funding sources. Accelerated Breeding supports Market Intelligence's efforts to arrive at increasingly reliable projection of benefits and likelihood of impact information, to inform the 2025–27 business cycle. Better financial models that take into account all sources of funding, and more accurate costing of breeding pipelines, will also be important.
Accelerated Breeding is on track with implementing **recommendations and learnings from an Independent Science for Development Council-sponsored EiB review**.	Accelerated Breeding is continuing with significant parts of the EiB agenda. EiB was extensively reviewed in 2021. Recommendations are relevant to Genetic Innovation as an entity, and several of its Initiatives. Accelerated Breeding is on track with implementing recommendations, as also evidenced by this report.

Harvesting rice at CIAT's headquarters in Colombia. Photo credit: Neil Palmer (CIAT)

Section 8 Key result story

Cultural transformation in CGIAR and national programs drives collaborative breeding networks to deliver towards national, CGIAR, and SDG 2030 goals

CGIAR has a unique global mandate for developing crucial crops as international public goods. Accelerated Breeding is driving cultural transformation within CGIAR collaborative breeding networks, enabling delivery of new in-demand varieties, faster and more collaboratively. Building on Excellence in Breeding achievements, programs now employ a breeding pipelines inventory, associated market segments, target product profiles, agreed stage gates, and joint genetic gain assessments. The pace to systematically strengthen capabilities and partnerships is accelerating to deliver toward national, CGIAR, and SDG goals.

Amidst growing food needs and shifting market demands, smallholder farmers in Africa, Asia, and Latin America face increasingly erratic weather, pests, soil degradation, and crop diseases. But too many farmers still use outdated varieties that cannot meet these challenges. Modern breeding approaches offer opportunities to better align research with the needs of farmers and consumers, and apply tools and technology to redesign breeding processes to increase rates of genetic gain.

CGIAR breeding has a rich history of producing game-changing varieties, and a vast partnership network across 135 countries. Continuing the foundational work of CGIAR Excellence in Breeding (EiB), the Accelerated Breeding community is driving a cultural transformation within CGIAR breeding networks, enabling the development of new in-demand varieties, faster and more collaboratively.

This transformation begins with sharpening breeding's primary aim — the goal is now squarely on improving genetic gain for farmer- and market-demanded varieties, to replace outdated varieties. Programs are integrating market intelligence within breeding targets to better meet farmers' and consumers' needs in distinct target regions. Decisions are backed by the first-ever comprehensive mapping of breeding pipelines to target market segments, across the entire CGIAR breeding portfolio of 21 crops and forages. Breeders have begun to use product profiles to ensure the next generation of plants meets increasingly better described climate, nutritional, and food quality needs.

Countries' insights are crucial in right-sizing these targets and are intensely discussed through breeding networks. For example, the International Institute of Tropical Agriculture (IITA) improved product profiles for cowpea, cassava, maize, and yam across West and Central Africa. Centro Internacional de la Papa (CIP) did similar for potato and sweet potato in East and Southern Africa. TPPs will guide breeding decisions within networks, delivering varieties with much greater likelihood of both adoption and impact.

During 2021–22, breeders agreed on single approaches to stage-gating breeding pipelines and estimating genetic gain rates — across Centers, crops, and traits — to better assess and overcome bottlenecks to developing in-demand varieties faster. CGIAR teams are optimizing breeding schemes, with many reporting substantive changes ready to dramatically increase rates of genetic gain per dollar invested.

Accelerated Breeding supports this shift through simulation and breeding pipeline management tools built on quantitative genetics principles. For example, the International Rice Research Institute (IRRI) has optimized parental selection, crossing, and variety evaluation for all nine pipelines in the OneRice breeding strategy. Scientists are also becoming more experienced in implementing genomic selection — using genomic fingerprints of the entire breeding population to make selection decisions. For example, genomic selection is integral to the International Maize and Wheat Improvement Center (CIMMYT) developing multi-stress-tolerant maize in Africa and zinc-biofortified

wheats for Asia. These are only some of the changes; there is potential for much more.

And finally: collaboration and cohesion. Accelerated Breeding brings CGIAR breeding together, working across crops and Centers. Teams work closely with NARES to identify the most impactful targets and better capitalize on each other's strengths. Joint program assessments — so far executed with 38 national breeding programs — and joint capacity-sharing drive the process. At the high level, research leaders from over a dozen African countries worked with CGIAR leaders to map out collaboration principles on national program improvement and deliver new varieties faster to smallholders. The International Center for Agricultural Research in the Dry Areas (ICARDA) implemented a similar process in the Central and West Asia and North Africa region.

To combat poverty, malnutrition, and climate change, farmers need diverse and continually improving crop varieties. With 303 varieties released by partners in 2022 alone, CGIAR breeding networks are on their way to delivering the climate-resilient and gender-intentional varieties needed. And the new culture means breeders are asking, "How can we deliver even greater benefit to farmers and consumers?" With this culture of transformation, CGIAR-NARES programs are institutionalizing tangible changes to deliver real impact.

"We are witnessing a transformation in CGIAR crop breeding, with Centers and NARES working more closely through demand-driven product profiles and integrating novel tools to increase genetic gains more widely. Maize is developing much better varieties faster. Smallholder farmers will be the beneficiaries of these changes and greater synergies."

B.M. Prasanna, Director, Global Maize Program, CIMMYT & CGIAR OneMaize Breeding Program Lead.

References

1 *Definition of the portfolio of distinct, achievable TPPs, by all CGIAR breeding programs, provides the basis for collaboratively assessing and agreeing on the most impactful CGIAR breeding targets.* CGIAR Dashboard Result 348.

2 *Signed Aide Memoire. High Level Sub-Saharan Africa NARES–CGIAR meeting on Genetic Innovation. Nairobi, Kenya. 28 June 2022. Demonstrating agreement on principles and improved collaboration.* https://excellenceinbreeding.org/sites/default/files/u1025/Aide%20Memoire%20NARES-CGIAR%2028%20June%202022%20signed_07_12.pdf

3 *A new approach aligns genetic gain assessments of CGIAR breeding pipelines across crops and traits, providing a tool for monitoring the impact of breeding pipeline optimization efforts.* CGIAR Dashboard Result 346.

4 *Covarrubias-Pazaran, et al. 2022. Breeding Schemes: What Are They, How to Formalize Them, and How to Improve Them? Frontiers in Plant Science.* https://doi.org/10.3389/fpls.2021.791859

5 *Covarrubias-Pazaran, et al. 2021. Strengthening Public Breeding Pipelines by Emphasizing Quantitative Genetics Principles and Open Source Data Management. Frontiers in Plant Science.* https://doi.org/10.3389/fpls.2021.681624

LINKS TO IMPACT AREAS

Primary Impact Area:

Other relevant Impact Area(s):


Which collective global targets for the relevant Impact Area(s) from the CGIAR 2030 Research and Innovation Strategy does the key result contribute to?

- End hunger for all and enable affordable healthy diets for the 3 billion people who do not currently have access to safe and nutritious food.
- Lift at least 500 million people living in rural areas above the extreme poverty line of US$1.90 per day (2011 PPP).
- Turn agriculture and forest systems into a net sink for carbon by 2050, with emissions from agriculture decreasing by 1 Gt per year by 2030 and reaching a floor of 5 Gt per year by 2050.
- Equip 500 million small-scale producers to be more resilient to climate shocks, with climate adaptation solutions available through national innovation systems.

GEOGRAPHIC SCOPE

Region: West and Central Africa; East and Southern Africa; Central and West Asia and North Africa; South Asia; Southeast Asia and the Pacific; Latin America and the Caribbean

LINK TO CGIAR RESEARCH PROGRAMS

None

CONTRIBUTORS TO THE KEY RESULTS STORY

Contributing Initiative(s): Accelerated Breeding
Contributing Center(s): AfricaRice; Alliance of Bioversity International and CIAT — Headquarters (Bioversity International); Alliance of Bioversity International and CIAT — CIAT Regional Hub; CIP; ICARDA; IITA; IRRI. Primary: CIMMYT.
Contributing external partner(s): ACIAR — Australian Center for International Agricultural Research; ARC — Agricultural Research Corporation; ASARECA — Association for Strengthening Agricultural Research in Eastern and Central Africa; BARI — Bangladesh Agricultural Research Institute; BMGF — Bill & Melinda Gates Foundation; BMZ — Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung / Federal Ministry of Economic Cooperation and Development (Germany); CCARDESA — Centre for Coordination of Agricultural Research and Development for Southern Africa; CORAF/WECARD — West and Central African Council for Agricultural Research and Development; CSIR — Council for Scientific and Industrial Research (Ghana); DARS — Department of Agricultural Research Services; DR&SS — Department of Research and Specialist Services (Zimbabwe); EIAR — Ethiopian Institute of Agricultural Research; FCDO — Foreign, Commonwealth & Development Office (formerly DFID)(United Kingdom); IAR — Institute of Agricultural Research (Nigeria); ICAR — Indian Council of Agricultural Research; IER — Institut d'Economie Rurale (Mali); IGKVV — Indira Gandhi Krishi Vishwavidyalaya University; IIAM — Instituto de Investigacao Agraria de Mozambique; ISRA — Institut Senegalais de Recherche Agricole; KALRO — Kenya Agricultural and Livestock Research Organization; NARO — National Agricultural Research Organisation (Uganda); TARI — Tanzania Agricultural Research Institute; USAID — U.S. Agency for International Development; ZARI — Zambia Agriculture Research Institute.

We would like to thank all funders who supported this research through their contributions to the CGIAR Trust Fund.

COVER PHOTO: IITA Youth Agripreneurs demonstration plot for youth agribusiness training. Photo credit: IITA