




CGIAR Research Initiative on **Breeding Resources**

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CGIAR Technical Reporting 2023

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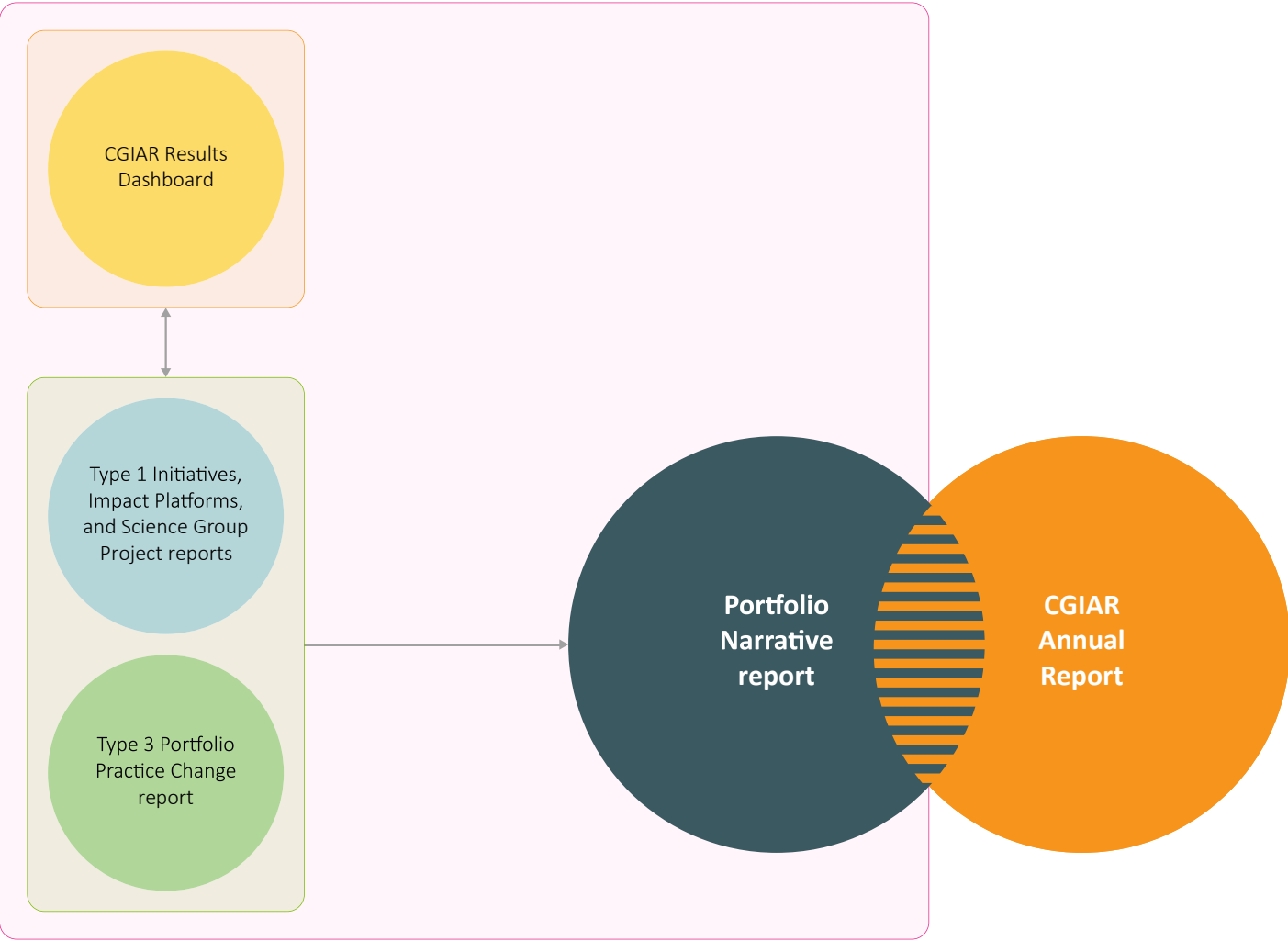
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CGIAR Technical Reporting has been developed in alignment with the [CGIAR Technical Reporting Arrangement](#). This Initiative report (“Type 1” report) constitutes part of the broader [CGIAR Technical Report](#). Each CGIAR Research Initiative submits 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, Impact Platform, and Science Group Project (SGP) reports, with quality assured results reported by Initiatives, Platforms and SGPs 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 Annual Report is a comprehensive overview of CGIAR’s collective achievements, impact and strategic outlook, which draws significantly from the Technical Report products above. For 2023, the Annual Report and Technical Report will be presented online as an integrated product.



Section 1: Fact sheet and budget

Initiative name	Breeding Resources
Initiative short name	Breeding Resources
Initiative Lead	Sharifah Syed Alwee (s.syedalwee@cgiar.org)
Initiative Co-lead	Eng Hwa Ng (N.Enghwa@cgiar.org)
Science Group	Genetic Innovation
Start – end date	01/01/2022 – 31/12/2024
Geographic scope	Global
OECD DAC Climate marker adaptation score ¹	Score 1: Principal 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 Climate marker mitigation score ¹	Score 0: Not targeted The activity does not target the climate mitigation, adaptation and climate policy objectives of CGIAR as put forward in its strategy.
OECD DAC Gender equity marker score ²	Score 0: Not targeted The initiative/project has not been found to target gender equality. However, as a minimum requirement for all initiatives/projects, (i) a gender analysis was conducted, (ii) its findings should be used to ensure at minimum that the initiative activities/interventions do no harm and does not reinforce gender inequalities, and (iii) data that is collected is gender disaggregated.
Website link	https://www.cgiar.org/initiative/breeding-resources/

¹ 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.

² 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.

EXECUTIVE SUMMARY

2023 has been pivotal in advancing our mission to provide CGIAR-NARES networks with first-class breeding services, practices, and technologies. One of our standout successes has been our meticulous process management work and its crucial role in supporting our day-to-day operations. To deliver high-quality germplasm and data, CGIAR-NARES networks need to establish common and streamlined processes at the [Genetic Innovation](#) Science Group level, ensuring compatibility in their ways-of-working. In 2023, the CGIAR Research Initiative on Breeding Resources launched four Process Teams: Product Development (led by the CGIAR Research Initiative on Accelerated Breeding), Trialing & Nursery, Lab Services, and Breeding Analytics. These Process Teams are made up of representatives from various crops and Centers, which identify, validate and set the course for continuous improvement in all aspects of breeding operations and activity. Across Centers and crops, the team works together to discover, develop and share best practices, document them, and identify capacity development needs.

A new Breeding Resources Service Request Portal was developed, launched and is currently available to both CGIAR users and external partners such as NARES to request and track a large range of CGIAR breeding support services offered by Breeding Resources. By digitizing service requests, this platform significantly reduces the daily administrative burden, improves the quality of service, accelerates submissions, reduces human errors and makes it possible to monitor and improve the quality of services provided.

Originally anticipated for release in 2024, Breeding Resources surpassed expectations by developing a breeding informatics strategy for CGIAR ahead of schedule, marking it a cornerstone achievement in 2023. The strategy delineates a CGIAR-wide approach for the effective management of breeding databases, pieces of software, and tools. It outlines the establishment of a centralized breeding data management system serving CGIAR-NARES networks. Meeting the expectations of funders, Breeding Resources released the full version of the software at the end of 2023. The tool currently manages breeding data for wheat, maize, and rice, and in 2023 witnessed the achievement of releases 6, 7, and 8, encompassing patches addressing major bugs. Structured as a “platform as a service” the Enterprise Breeding System (EBS) offers enhanced manageability over time at a reduced cost. The system is designed to bolster core breeding activities, including germplasm inventory management, trial design, field operations, phenotyping, sample tracking, genotyping, data analysis, and decision support.

Breeding Resources embraces innovative technology by implementing an advanced analytical pipeline in collaboration with the Accelerated Breeding Initiative — a powerful tool that harnesses big data to enhance decision-making in breeding processes. The analytical pipeline is a dynamic and modular project designed to extract data from various databases and perform analysis for better decision-making in breeding processes.

	2022	2023	2024
	▼	▼	▼
PROPOSAL BUDGET ▶	\$18.65M	\$21.50M	\$21.86M
APPROVED BUDGET ¹ ▶	\$6.96M	\$2.78M ²	\$5.40M ³

¹ The approved budget amounts correspond to the figures available for public access through the [Financing dashboard](#).

² This amount includes carry-over and commitments.

³ This amount is an estimation of the 2024 annual budget allocation, as of the end of March 2024.

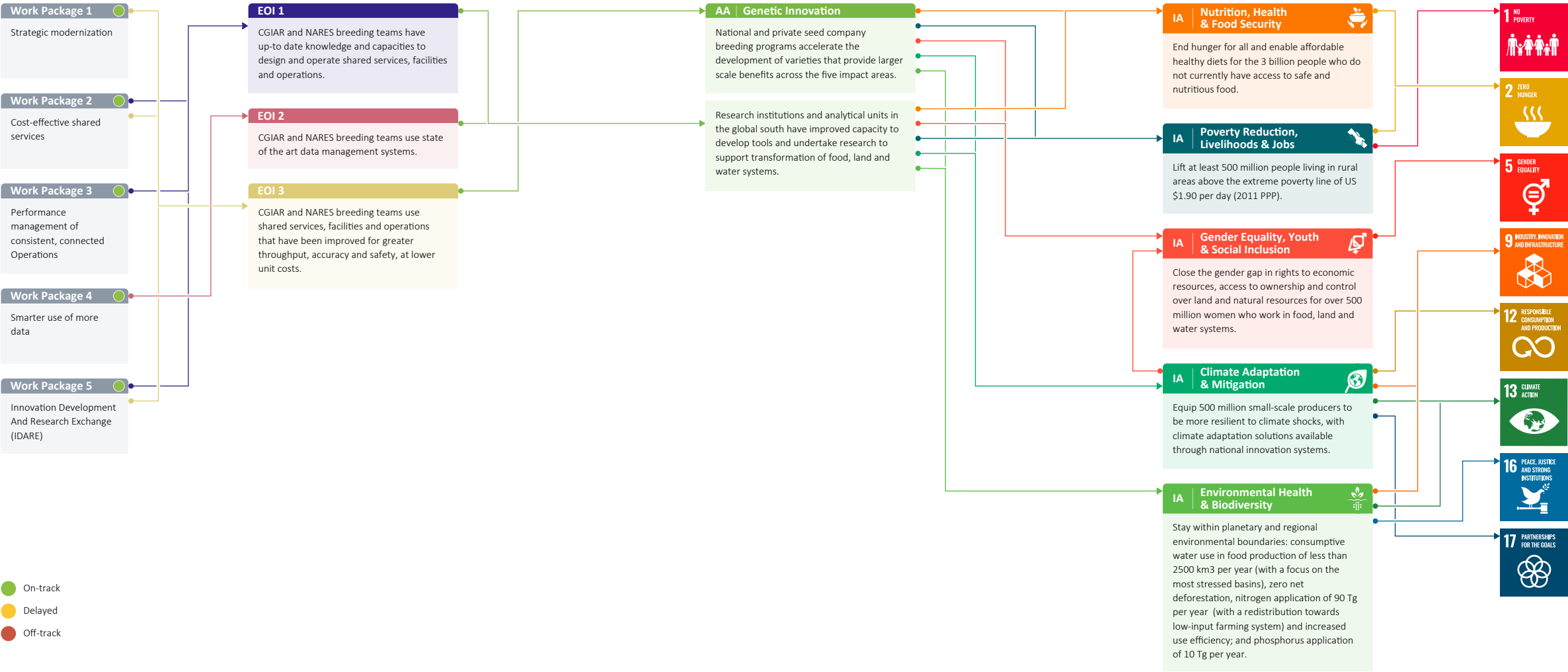


Technicians working on cassava at Kenya Plant Health Inspectorate Service (KEPHIS) Plant Quarantine and Biosecurity Station in Nairobi, Kenya.
Credit: Ngugi/Breeding Resources, 2024

Section 2: Progress on science and towards End of Initiative outcomes

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

Note: A summary of Work Package progress ratings is provided in Section 3.



Irrigation facility inauguration at Kiboko research station, Kenya.
Credit: Vinicius Rocha / Breeding Resources.

Summary of progress against the theory of change

In 2023, we rolled out all our services – genotyping, sequencing, elemental analysis, irrigation and engineering support (**Work Packages 2 and 5**). Establishment of shared services provides CGIAR with much greater bargaining power in purchasing or contracting equipment, services, and tools. This enables the generation of cost-efficient and high-quality data, consistent across the breeding network. Significant strides were made in improving genotyping lab services (**Work Package 2**), including new service offerings to support partners with low density single nucleotide polymorphism (SNP) genotyping (the Kompetitive Allele Specific PCR [KASP] platform, suitable for applications requiring less than 50 markers) and mid-density targeted sequencing (1-4K markers, suitable for genomic selection and fingerprinting). These services are now accessible via the [Service Request Portal](#), described below.

A reference genome service providing “one-stop” fully assembled platinum reference genomes with competitive pricing and turnaround time, and a whole genome resequencing service, will also be available in the portal soon. Partners are now able to access expanded biochemical testing for nutritional traits and quality, such as iron (Fe) and zinc (Zn) testing for breeding selection objectives. This is made possible through collaboration with organizations such as HarvestPlus and external vendors to establish a network of service labs with competitive pricing and standardized services to cater to CGIAR and NARES breeding needs.

CGIAR Centers and national programs routinely encounter challenges in accessing specialized engineering capacity, so the establishment of Trialing & Nursery (T&N) Support Services in 2023 is a pivotal advancement for CGIAR breeding networks (**Work Package 5**). Through the Service Request Portal, breeding teams can access agronomic practice support, engineering capacity and process improvement. For some Center programs, including the cassava, rice, and beans programs at [Alliance Bioversity International-CIAT](#), have already benefited from the expertise of an experienced agronomic practice consultant. The rice programs at [AfricaRice](#) have received engineering capacity support where consultancy is provided to assist breeding programs in designing new seed processing areas, irrigation infrastructure, and more.

Breeding Resources support also extends beyond breeding programs. A Breeding Resources partner engineering company aided the [CIMMYT](#) genebank in enhancing existing infrastructure. [International Institute for Tropical Agriculture \(IITA\)](#) also utilized the service for designing a new lab for [Kenya Plant Health Inspectorate Service \(KEPHIS\)](#) in Kenya. Our team of consultants, engineering companies and staff also offer tailored solutions to enhance operational processes (**Work Package 3 and 5**). This support ranges from selecting appropriate equipment to analyzing process efficiencies through structured methodologies. For example, prior to engaging an engineering company, CIMMYT received support from a Breeding Resources consultant who is an expert in Lean management, who, in collaboration with the team, identified numerous process improvement opportunities, forming the foundation for the subsequent engineering design.

Also in 2023, we launched the [Service Request Portal](#) (**Work Package 2**) making it possible for both CGIAR and external partners such as NARES to request and track a large range of CGIAR breeding support services including genotyping services, elemental laboratory analysis and trialing and nursery support. Through the portal, breeding programs can request engineering services, agronomic practice support for process improvement and so on. By accessing these customized services, breeding teams will be supported by consultants and companies specialized in multiple disciplines, such as seed processing, irrigation, soil management, pest and disease management, and others. In collaboration with [Scriptoria Sustainable Development Solutions’](#) Data Team, the portal provides users with access to a digital system that expedites submissions and minimizes errors. By digitizing service requests, this platform significantly reduces the daily administrative burden and makes it possible to monitor and improve the quality of services provided.

Originally anticipated for release in 2024, the Breeding Resources team surpassed expectations by developing a [breeding informatics strategy for CGIAR](#) ahead of schedule, marking it a cornerstone achievement in 2023 (**Work Package 4**). The strategy delineates a CGIAR-wide approach for the effective management of breeding databases, pieces of software, and tools. It outlines the

establishment of a centralized breeding data management system serving CGIAR-NARES networks. Key components of this system include creating a Digital Solution Unit tasked with managing, developing, and maintaining breeding data management tools, with the [Enterprise Breeding System](#) (EBS) as its foundational platform.

[Global User Support](#) (GUS) was established to facilitate the adoption and utilization of software tools supported by CGIAR through the Digital Solution Unit. [GUS](#) comprises a 24/7 support desk that handles user inquiries, connects them with specialists, registers issues and sets up demos. Users also have access to a wealth of resources, including user guides, release notes, e-learning materials, and video tutorials available in multiple languages. A roadmap to 2027 was also established indicating a timeline for the strategy’s successful implementation. It encompasses the transition of CGIAR Centers and NARES from their existing breeding information systems to EBS. It also provides a comprehensive overview of the landscape for both Digital Solutions and EBS. This includes a thorough examination of critical success factors, potential risks, and recommendations for guiding the next steps in the implementation process.

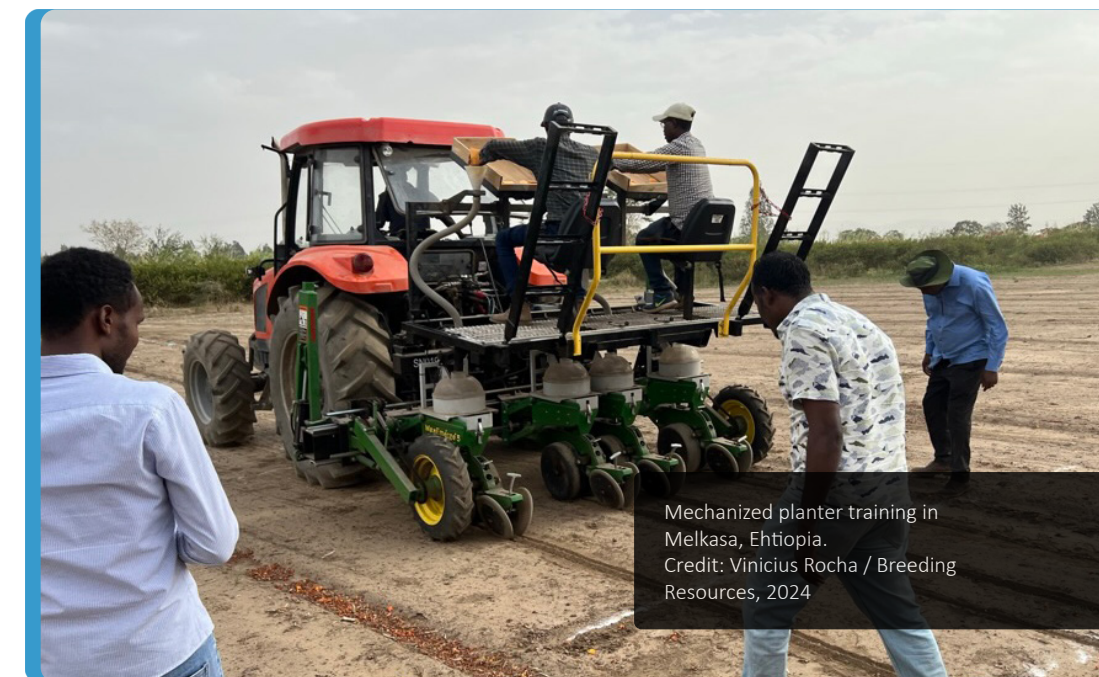
Meeting the expectations of funders, EBS development team released the full version of the software at the end of 2023 (**Work Package 4**). The tool currently manages breeding data for wheat, maize, and rice, and 2023 witnessed the achievement of releases 6, 7, and 8, encompassing patches including functionality improvements. EBS team embraces an iterative, continuous improvement approach, seeking user feedback to shape the software. Structured as a “Platform-as-a-Service” (PaaS) system, EBS offers enhanced manageability over time at a reduced cost. The system is designed to bolster core breeding activities, including germplasm inventory management, trial design, field operations, phenotyping, sample tracking, genotyping, data analysis, and decision support. EBS as a breeding data management system has been deployed as a fully operational application for rice, maize, and wheat breeding programs at [International Rice Research Institute \(IRRI\)](#), AfricaRice, CIMMYT, and IITA. [International Center for Agricultural Research in the Dry Areas \(ICARDA\)](#) Wheat, IITA Legumes, other CGIAR Centers, and their NARES partners will follow shortly.

Breeding Resources embraces innovative technology by implementing an advanced analytical pipeline — a powerful tool that harnesses big data to enhance decision-making in breeding processes (**Work Package 4**). The [Breeding Analytics Pipeline](#) is a dynamic and modular project designed to extract data from various databases and perform analysis for better decision-making in breeding processes. The tool has successfully delivered a proof of concept, showcasing its technical capabilities. It is set to undergo testing within the Breeding Resources and Accelerated Breeding Initiatives in Q1 2024. The official release, anticipated for Q2 2024, will incorporate feedback from users on technical relevance and usability. The project is jointly funded by both Window 1 Breeding Resources and [Crops to End Hunger](#) funds.

At the heart of Breeding Resources’ operations is process management (**Work Package 3**). The objective of [process management](#) is to deliver high-quality germplasm and data through establishment of common and streamlined processes, ensuring compatibility in the ways-of-working across CGIAR-NARES networks. The three process teams that were set up in 2022 – Trialing &

Nursery, Lab Services, and Breeding Analytics are made up of representatives from various crops and Centers. Together they identify, validate and set the course for establishment of a quality management system and continuous improvement practices. They discover, develop, and share best practices, document them, and identify capacity development needs. In 2023, they started the establishment of Standard Operating Procedures (SOPs) for breeding operation processes which involve describing and formalizing procedures and methods of operation to harmonize them across the organization, crops, and Centers.

To establish a robust quality management system in key CGIAR-NARES breeding stations, Breeding Resources evaluates them to identify areas for improvement, adoption of state-of-the-art equipment for their breeding activity (through projects like Crops to End Hunger) and refines processes to align with those established



Mechanized planter training in Melkasa, Ethiopia.
Credit: Vinicius Rocha / Breeding Resources, 2024

by the process management team (**Work Package 3 and 5**). A dynamic [dashboard](#) disseminates the findings of this work and offers users visibility into the capacity of these stations, highlighting their strengths and weaknesses, while also providing funders and Center managers with visibility into areas requiring improvement. Ultimately, this guarantees the application of top industry standards within the breeding stations, delivering high-quality data and results.

Breeding Resources is actively engaged in clearly defining its service offerings by adopting a business-model approach (**Work Package 1**). A business model is indispensable for informed decision-making and streamlined business operations. It identifies the sources of revenue, target customers, products and financing details. Formalizing the services offered by each Breeding Resources component will enhance clarity for staff and clearly communicate the expected services to clients. Breeding Resources business model aims to foster transparency and efficiency universally, ensuring a shared understanding of services among staff, leadership, and clients. Through consensus-building, the business model will enable Breeding Resources to distinguish between non-critical and critical services, allowing for a strategic focus on critical, albeit more labor-intensive, services. This, in turn, will aid in prioritization, resource allocation, and managing client expectations. Ultimately, the business model is positioned to be a guiding framework for Breeding Resources, facilitating informed decision-making and strategic resource management.

Progress by End of Initiative Outcome

- EOIO 1: CGIAR and NARES breeding teams use shared services, facilities and operations that have been improved for greater throughput, accuracy and safety, at lower unit costs.**
- EOIO 2: CGIAR and NARES breeding teams have up-to date knowledge and capacities to design and operate shared services, facilities and operations.**

In 2023, we rolled out all our services – genotyping, sequencing, elemental analysis, irrigation and engineering support.

Greater bargaining power in purchasing or contracting equipment, services and tools with establishment of a global shared services. This enables cost efficiency and generation of high-quality data consistently across the breeding network.

New service offerings with low density SNP genotyping, the KASP platform, and mid-density targeted sequencing.

Expanded biochemical testing for nutritional traits and quality, such as iron (Fe) and zinc (Zn) testing are now available to all partners and CGIAR breeding teams.

A service request portal was launched to allow easy access to all services including genotyping, sequencing, elemental analysis and a range of breeding operation support.

Process management team identifies, validates and sets the course for establishment of quality management system and continuous improvement practices within the Genetic Innovation Science Group.

Cross Center and crop process management team discover, develop, and share best practices, document them, and identify capacity development needs.

Establishment of SOPs for breeding operation processes have begun which involves describing and formalizing procedures and methods of operation to harmonize them across the organization, crops, and Centers.

Evaluation of key CGIAR-NARES breeding stations to identify areas for improvement, adoption of state-of-the-art equipment for their breeding activity (through projects like Crops to End Hunger) and refines processes to align with those established by the process management team

Establishment of a dynamic dashboard to disseminate the findings of this work and offer users visibility into the capacity of key CGIAR-NARES breeding stations, highlighting their strengths and weaknesses, while also providing funders and Center managers with visibility into areas requiring improvement.

Adoption of a business model approach to clearly define the service offering.

All services in Breeding Resources apply top industry standards within the breeding stations, delivering high-quality data and results.

EOIO 3: CGIAR and NARES breeding teams use state of the art data management systems.

A breeding informatics strategy was developed for CGIAR ahead of schedule outlining the establishment of a centralized breeding data management system serving CGIAR-NARES networks.

A Digital Solution Unit was created within Breeding Resources to manage, develop, and maintain breeding data management tools, with EBS as its foundational platform.

GUS was established to facilitate the adoption and utilization of software tools supported by CGIAR through the Digital Solution Unit.

A roadmap to 2027 was also established indicating a timeline for the strategy’s successful implementation. It encompasses the transition of CGIAR Centers and NARES from their existing breeding information systems to EBS.

EBS as a breeding data management system has been deployed as a fully operational application for rice, maize, and wheat breeding programs at IRRI, AfricaRice, CIMMYT, and IITA. ICARDA Wheat, IITA Legumes, other CGIAR Centers, and their NARES partners will follow shortly.

An advanced analytical pipeline — a powerful tool that harnesses big data to enhance decision-making in breeding processes – has been rolled out.

Section 3: Work Package progress

WP1: Strategic modernization On track



Work Package 1 progress against the theory of change

Breeding Resources adopted a business model approach to clearly define its service offerings. This approach allows for informed decision-making and streamlines business operations. It identifies the sources of revenue, target customers, products and financing details. Formalizing the services offered by each of Breeding Resources’ components will enhance clarity for staff and communicate the expected services to clients clearly. The Breeding Resources business model aims to foster transparency and efficiency universally, ensuring a shared understanding of services among staff, leadership, and clients. Through consensus-building, the business model will enable Breeding Resources to distinguish between non-critical and critical services, allowing for a strategic focus on critical, albeit more labor-intensive, services. This, in turn, will aid in prioritization, resource allocation, and managing client expectations. Ultimately, the business model is positioned to be a guiding framework for the Initiative, facilitating informed decision-making and strategic resource management.

WP2: Cost-effective shared services

On track



Work Package 2 progress against the theory of change

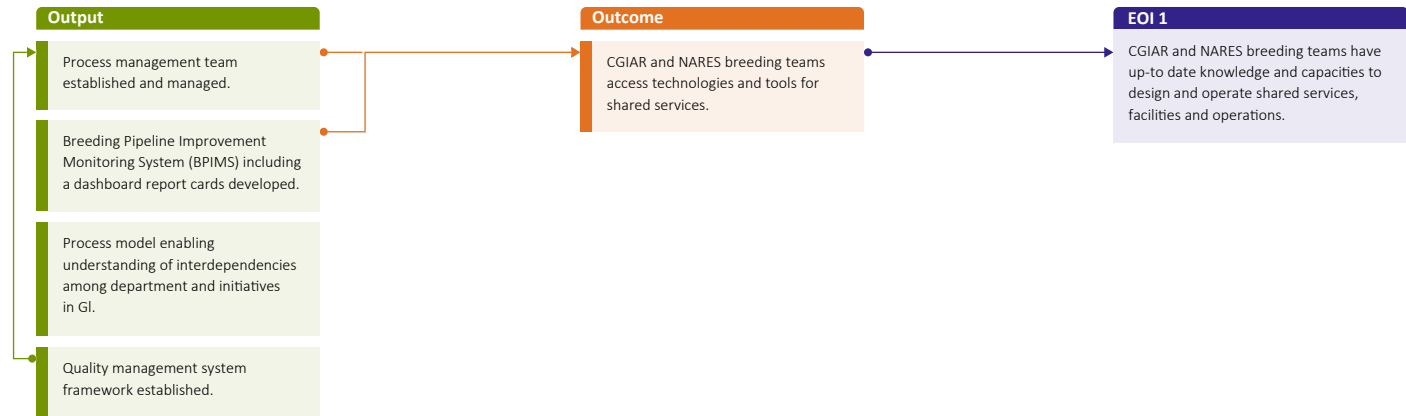
In 2023, global shared services were established, providing CGIAR with much greater bargaining power in purchasing or contracting equipment, services, and tools. This helps generate cost-effective, high-quality data consistently across the breeding network. New services were offered to support partners with low density SNP genotyping (the KASP platform, suitable for applications requiring less than 50 markers) and mid-density targeted sequencing (1-4K markers, suitable for genomic selection and fingerprinting). A reference genome service is also offered to provide “one-stop” fully assembled platinum reference genomes with competitive pricing and turnaround time. Partners are also now able to access expanded biochemical testing for nutritional traits and quality, such as iron (Fe) and zinc (Zn) testing for breeding selection objectives. This is made possible through collaboration with organizations such as

HarvestPlus and external vendors, to establish a network of service labs with competitive pricing and standardized services to cater to CGIAR and NARES breeding needs.

A Service Request Portal was launched, making it possible for both CGIAR and external partners such as NARES to request and track the deliveries of all shared services and breeding support services. In collaboration with Scriptoria Sustainable Development Solutions’ Data Team, the portal provides users with access to a digital system that expedites submissions and minimizes errors. By digitizing service requests, this platform significantly reduces the daily administrative burden and makes it possible to monitor and improve the quality of services provided.

WP3: Performance management of consistent, connected Operations

On track



Work Package 3 progress against the theory of change

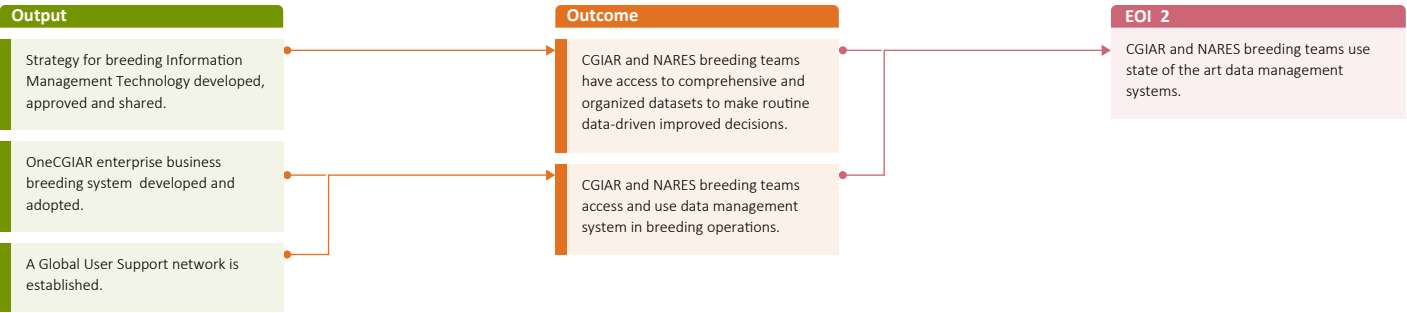
Work Package 3 functions as the heart of Breeding Resources’ service delivery which focuses on process management. The objective of process management is to deliver high-quality germplasm and data through the establishment of common and streamlined processes, ensuring compatibility in the ways-of-working across CGIAR-NARES networks. The three Process Teams that were set up in 2022 – Trialing & Nursery, Lab Services, and Breeding Analytics – are made up of representatives from various crops and Centers. Together they identify, validate and set the course for the establishment of a quality management system and continuous improvement practices within the Genetic Innovation Science Group. They discover, develop, and share best practices, document them, and identify capacity development needs. They have started the establishment of SOPs for breeding operation processes, which involves describing and formalizing procedures and methods of operation to harmonize

them across the organization, crops, and Centers.

As part of the Process Management work to establish a robust quality management system in key CGIAR-NARES breeding stations, Breeding Resources evaluates these stations to identify areas for improvement, adoption of state-of-the-art equipment for their breeding activity (through projects like Crops to End Hunger), and refines processes to align with those established by the Process Management Team. A dynamic [dashboard](#) disseminates the findings of this work and offers users visibility into the capacity of these stations, highlighting their strengths and weaknesses while also providing funders and Center managers with visibility into areas requiring improvement. Ultimately, this guarantees the application of top industry standards within the breeding stations, delivering high-quality data and results.

WP4: Smarter use of more data

On track



Work Package 4 progress against the theory of change

Over the past 15 years, efforts have been made to enhance breeding programs through the implementation of formal data management software. However, the results have been mixed. One of the primary challenges hindering widespread adoption of this software among CGIAR and NARES partners is the complexity of integrating new technology into existing processes. This task demands significant resources and occurs within the dynamic planting and harvest cycles, making it particularly challenging. To enable ‘Smarter use of more data’, Work Package 4 continues to focus on offering breeding programs more data management tools and capabilities through the deployment and expansion of EBS.

Throughout 2023, three major versions of EBS were released. A new, more modern cloud infrastructure was deployed to host the EBS at CGIAR Centers which now allows the team behind EBS to deliver updates to the software more efficiently, while reducing the costs of its operation. New crops and Centers have started the adoption

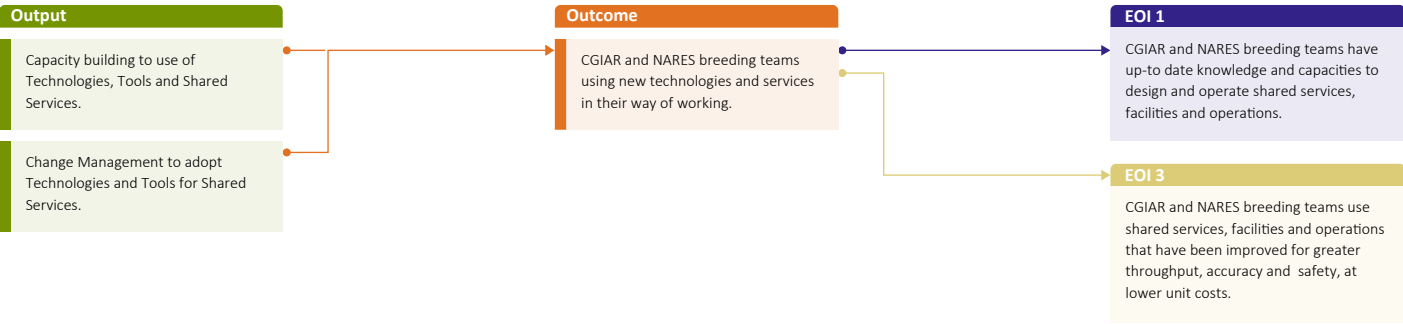
process of the system: ICARDA Wheat, and IITA Soybean and Cowpea. The first NARES partners have also kicked off the adoption of the EBS: PhilRice (Philippines) and BRR1 (Bangladesh).

A Breeding Information Management Technology (BIMT) Strategy was developed and fully endorsed by CGIAR’s Genetic Innovation Leadership, which led EBS team to transition into a BIMT unit, of which the GUS team is part, fulfilling another goal ahead of time; the establishment of the Data Management System (DMS) Support Network.

In 2023 the key performance indicator-driven approach for the adoption of the EBS continued to be used in decision-making by EBS Leadership Team, which allowed a complete turnaround for two of CIMMYT’s major crops, wheat, and maize, who finished the year at an unprecedented level of usage of one single breeding system as their main resource for daily breeding operations and decisions.

WP5: IDARE

On track



Work Package 5 progress against the theory of change

At the end of 2022, Work Package 5’s (WP5’s) scope underwent a significant reduction. To mitigate the impact of this reduction, and to continue addressing institutional changes, in 2023 the focus of WP5 was to ensure smooth implementation of process management teams in the scope of WP3, and to support the development and deployment of services in the scope of WP2.

Supporting the implementation of process management teams, WP5 focused its activities on organizing trainings and providing change management support to Process Stewards – approximately 60 CGIAR staff, from IRRI, CIAT, CIMMYT, IITA, AfricaRice and ICARDA, who are now equipped with proper tools and skills to implement the process management activities in their respective Centers and breeding

programs. With the knowledge acquired, the process stewards will be able in 2024 to lead the implementation of Quality Management System (QMS) at their respective Centers.

In the scope of shared services development, while WP2 focused its activities on strengthening the lab services package, by structuring the Service Request Portal, establishing partnerships for elemental analysis and improving the genotyping services, WP5 focused its activities on developing the Trialing & Nursery support services. In 2023, consulting support in engineering, agronomic practice, irrigation management and process improvement was developed and is now consolidated and available for breeding teams to access in the Service Request Portal (WP2).

Work Package progress rating summary

WORK PACKAGE	PROGRESS RATING & RATIONALE
1	<div><div></div><div>Progress rating A business-model approach has been taken to define the services offered by Breeding Resources. It identifies the sources of revenue, target customers, products and financing details.</div></div>
2	<div><div></div><div>Progress rating All shared services have been rolled out, namely: genotyping, sequencing, and elemental analysis. New service offerings were also made to support partners with low density SNP genotyping (the KASP platform, suitable for applications requiring less than 50 markers) and mid-density targeted sequencing (1-4K markers, suitable for genomic selection and fingerprinting). These services are now accessible via the Service Request Portal. Our reference genome service provides “one-stop” fully assembled platinum reference genomes with competitive pricing and turnaround time. Partners are now able to access expanded biochemical testing for nutritional traits and quality, such as Fe and Zn testing for breeding selection objectives.</div></div>
3	<div><div></div><div>Progress rating All process management components are in place. Harmonized SOPs are being developed across Centers and crops. This is the prerequisite for the establishment of a Quality Management System, which will happen in 2024.</div></div>
4	<div><div></div><div>Progress rating With the EBS being selected as the breeding data management system of choice for CGIAR and their NARES partners, the path for long-term data management within the Genetic Innovation Science Group has been defined.</div></div>
5	<div><div></div><div>Progress rating The main activity under the scope of WP5 was to establish a change management team. In 2022, the Change Leaders team was established, in coordination with WP3. In 2023, we agreed to simplify and empower the Process Stewards. Process Stewards received all respective training, including change management support to implement the expected activities.</div></div>

Definitions

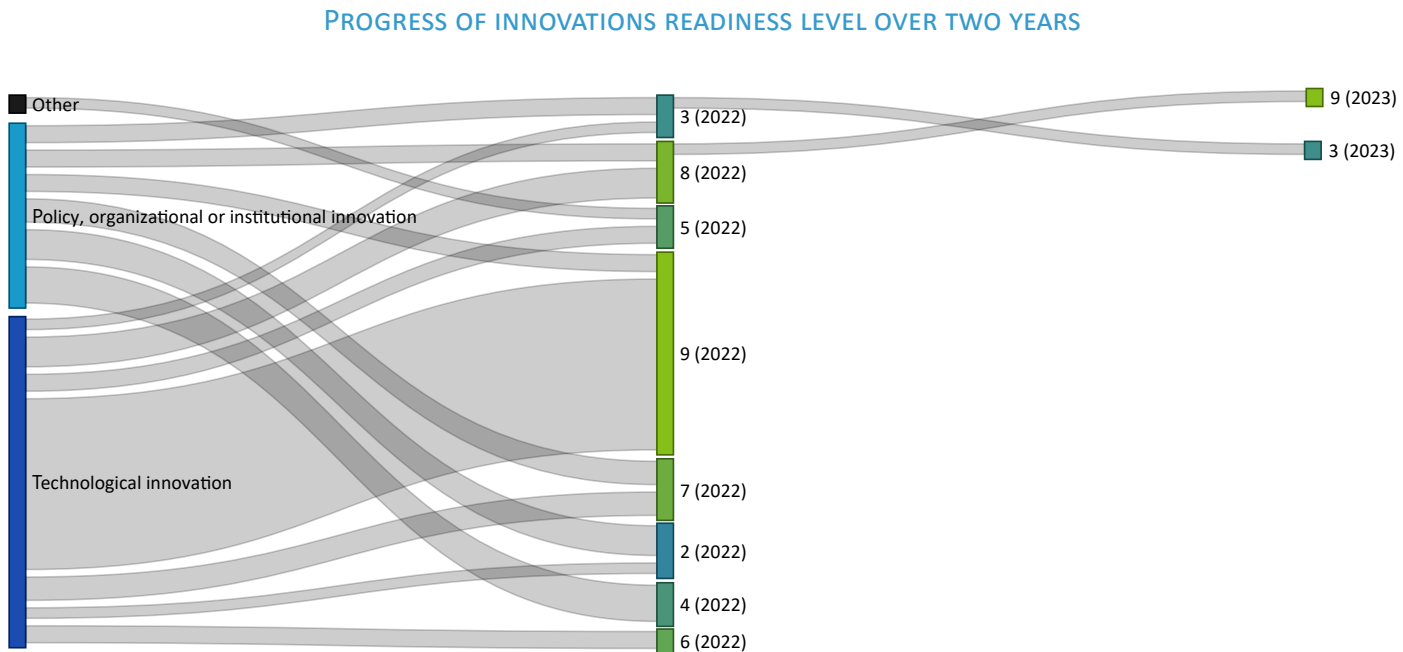
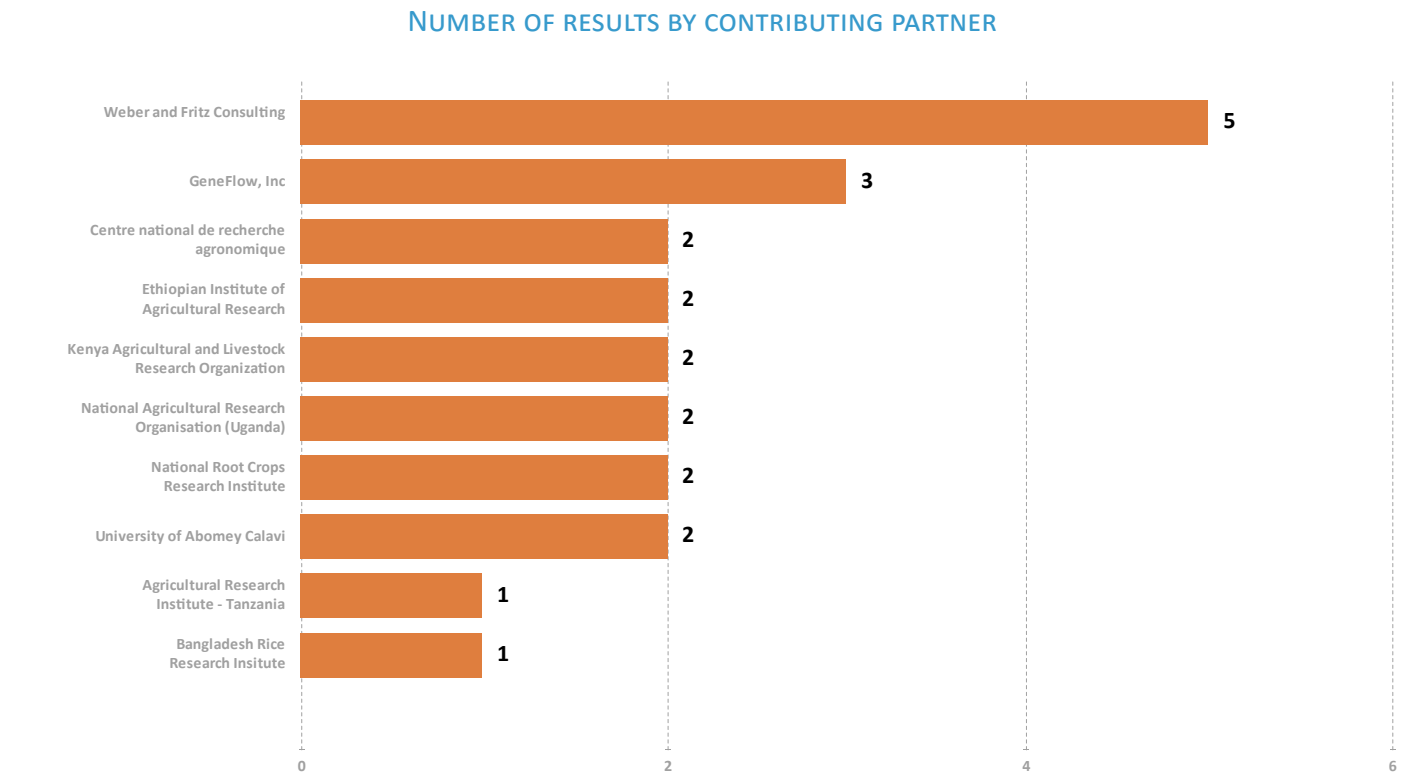
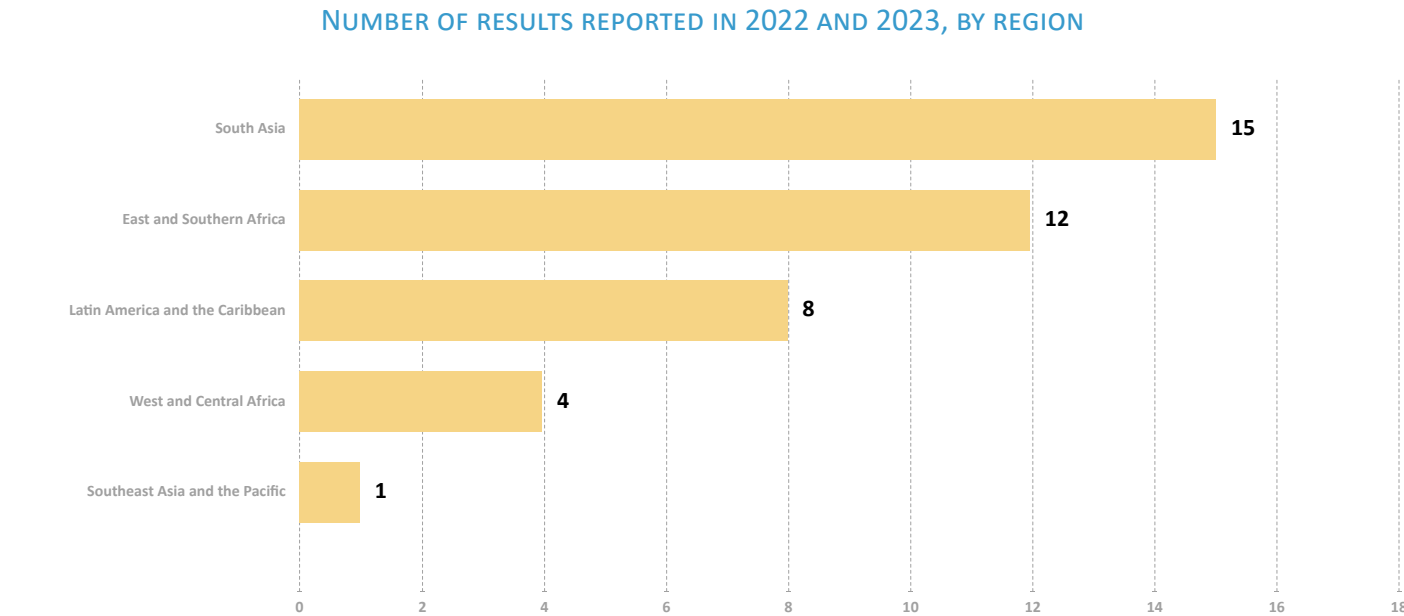
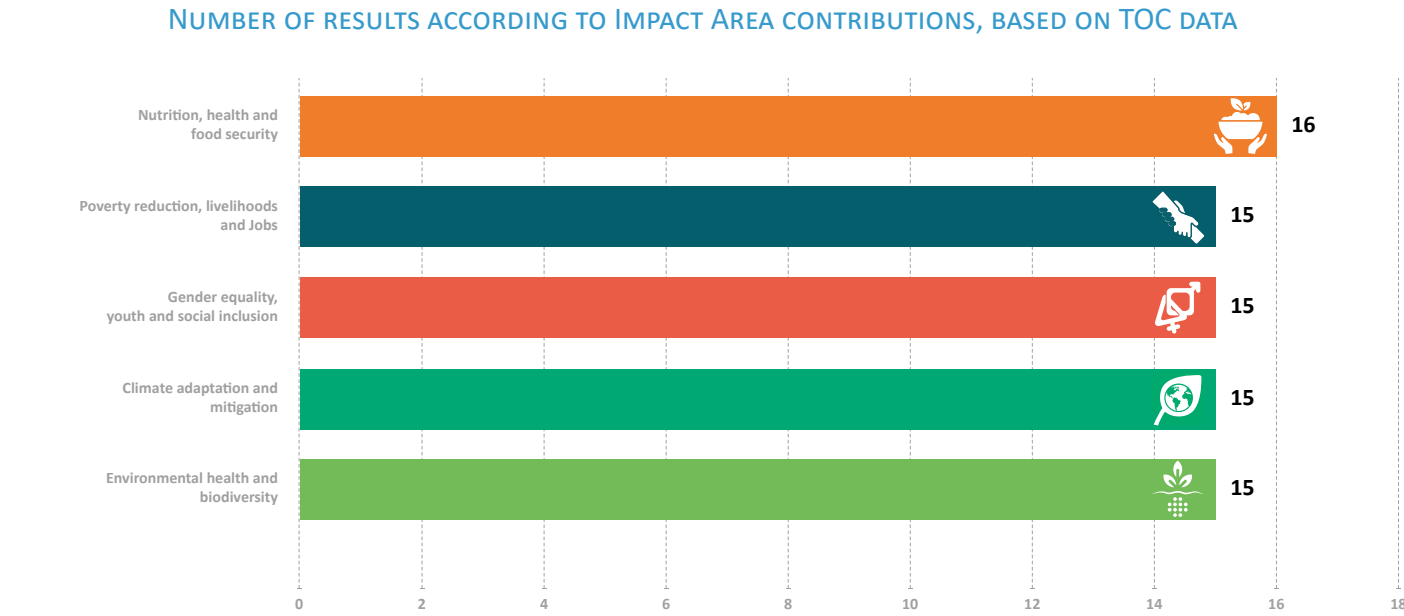
<div><div></div><div>On track</div></div>	<div><div></div><div>Delayed</div></div>	<div><div></div><div>Off track</div></div>
<div><div>✓</div><div>Annual progress largely aligns with Plan of Results and Budget and Work Package theory of change.</div></div> <div><div>✓</div><div>Can include small deviations/issues/delays/risks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



Mechanization workshop in Njoro, Kenya.
Credit: vinicius Rocha / Breeding Resources, 2024

Section 4: Key results

This section provides an overview of results reported by the CGIAR Research Initiative on Breeding Resources in 2023. These results align with the CGIAR Results Framework and Breeding Resources’ theory of change. Source: *Data extracted from the [CGIAR Results Dashboard](#) on 29 March 2024.*



Data here represents a trend overview of reported innovations progress (by type) from 2022 and 2023.

- Innovation typology**
- **Technological innovation:** Innovations of technical/ material nature, including varieties/ breeds; crop and livestock management practices; machines; processing technologies; big data and information systems.
 - **Policy, organizational or institutional innovation:** Innovations that create enabling conditions, including policy, legal and regulatory frameworks; business models; finance mechanisms; partnership models; public/ private delivery strategies.
 - **Other:** Unknown or the type does not work for the innovation.

Innovation type	Discontinued	Increased	Same	Total
Technological innovation	38	1		39
Policy, organizational or institutional innovation	16	1	1	18
Other	1			1
Total	55	2	1	58

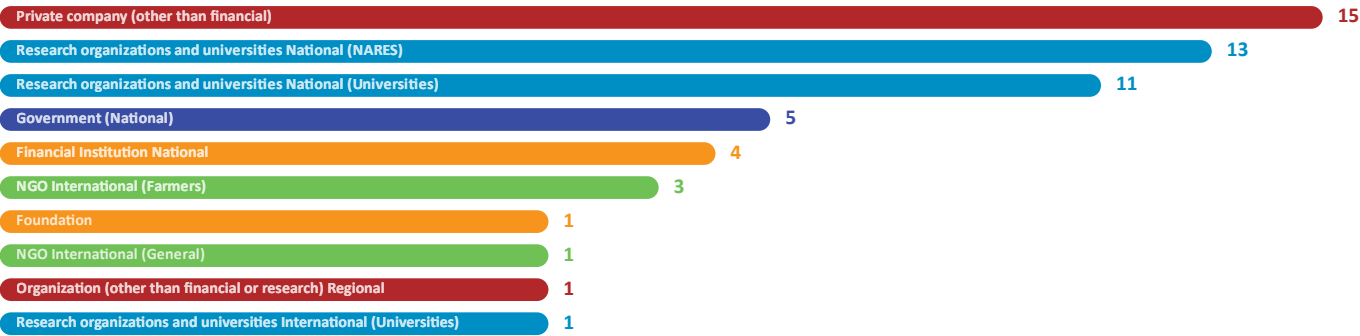
Section 5: Partnerships

Partnerships and Breeding Resources’ impact pathways

Two main partners for Breeding Resources are private companies, and research organizations and universities (including NARES partners). As our Initiative develops and provides services and support to breeding programs, we partner with private companies to access the best-in-class technology for use in the CGIAR-NARES breeding network. Through these partnerships, Breeding Resources gains greater bargaining power in purchasing or contracting equipment, services, and tools. This enables the generation of cost-efficient and high-quality data, consistent across the breeding network. Breeding Resources partners with private companies to learn and adopt a corporate approach to establish our ways of working, including establishing process management, continuous improvement and a quality management system. These tools and the management system adopted by many private companies proved to be effective in ensuring sustainability in all our operations.

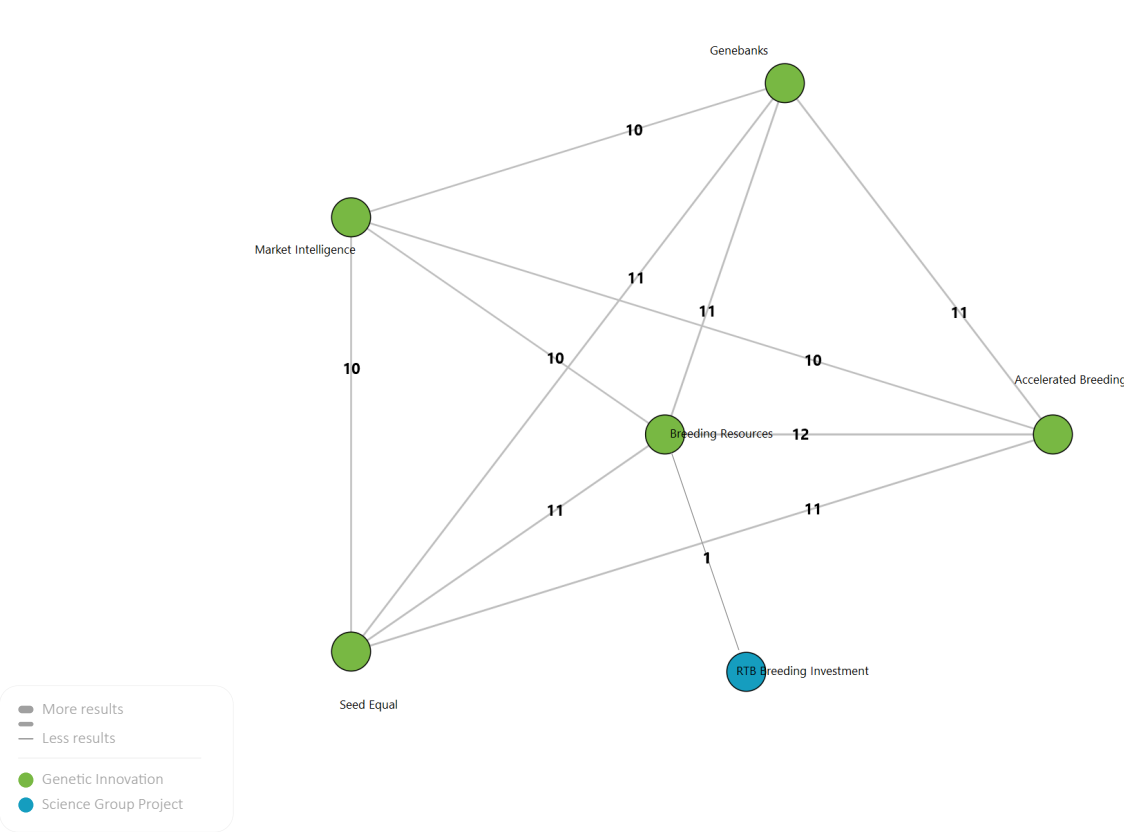
The benefits of the services and support provided by Breeding Resources are realized through their adoption across the CGIAR-NARES breeding network. Breeding Resources partnerships with research organizations and universities, which include our NARES partners, connect their breeding programs with global shared services and support. Through change management, we facilitate the cultural shift and institutional reforms required for breeding programs to transform into dynamic multidisciplinary teams of experts. Adoption of modern breeding tools such as genotyping will increase the speed of breeding and enable breeding to meet demands, bringing forward benefits and increasing the impacts compared to traditional breeding. Furthermore, it is unlikely that the more complex requirements posed by climate change or natural resources-limited environments could be met by traditional breeding in a relevant timeframe.

PARTNER TYPOLOGIES THAT CONTRIBUTED TO DELIVERING RESULTS



Section 6: CGIAR Portfolio linkages

BREEDING RESOURCES’ INTERNAL PORTFOLIO NETWORK



Connections are sized by the number of reported results.

Portfolio linkages and Breeding Resources’ impact pathways

Genetic Innovation Initiatives were designed to complement one another, making cumulative impact as one. All Initiatives in the Genetic Innovation Science Group jointly contribute to more efficient and faster development, release, dissemination, and adoption of improved, in-demand varieties, through common impact pathways. High performing breeding programs require genetic resources (the [CGIAR Research Initiative on Genebanks](#)), targeted demand-driven breeding for specific market segments ([the CGIAR Research Initiative on Market Intelligence](#)), modernized breeding to deliver complex multi-trait varieties (Breeding Resources), partnerships between CGIAR, NARES and private sector that link upstream and downstream breeding ([the CGIAR Research Initiative on Accelerated Breeding](#)), and delivering the genetic gains through seed systems to expand product reach ([the CGIAR Research Initiative on Seed Equal](#)). The Portfolio linkage diagram above shows exactly this.

Breeding Resources is designed to work seamlessly with the Accelerated Breeding Initiative. For this to occur, the priority systems,

regions and crops determined by the Accelerated Breeding Initiative have been adopted by Breeding Resources. Development and provision of shared services and support have been catered to meet the demands of stakeholders, partners, and service clients including other CGIAR Initiatives. Modernized strategies and approaches of both the Accelerated Breeding Initiative and Breeding Resources generate multiplier effects on the benefits from breeding and seed systems. Improved tools and services enable breeders to create more complex, multi-trait products that match desired product profiles. Modernizing enabling tools and services increases the speed of breeding, thus shortening the research lag and accelerating variety release. Efficient seed delivery (the Seed Equal Initiative) accelerates and increases adoption as targeted products reach even disadvantaged farmers faster. Moreover, enabling access to high-quality, clean seed and planting material ensures the potential of genetic innovations is harnessed in farmers’ fields for the benefit of households.



CIP technician at KEPHIS tissue culture lab in Kenya. Credit: CIP

Section 7: Adaptive management

RECOMMENDATION	SUPPORTING RATIONALE
Accelerated Breeding and Breeding Resources will collaborate to prioritize network support for potato (ESA variety), cowpea (WCA variety), and maize (ESA variety).	Both Breeding Resources and the Accelerated Breeding Initiative support the networks in different capacities. However, as both Initiatives evolve and mature, a closer collaboration would provide both teams with better focus which can result in resource use efficiency. Pilot programs can be established to achieve this while also potentially leading to cost savings, increased productivity, and improved outcomes.
Linking breeding IT with breeding portal and analytical pipelines.	The development of breeding IT, a breeding portal and analytical pipelines happens at separate times throughout the Initiative timeline. Now that all three are operational, linking them would improve efficiency through streamlining data collection, analysis, and decision-making within the breeding program. It would enable breeders to share information and resources more effectively. Data-driven decisions can be made to provide breeders with deeper insights from breeding data and to make informed breeding choices.
More frequent updates; develop a governance team with key stakeholders for breeding IT (EBS, BMS and Breedbase).	Currently, activities relating to breeding IT strategies, including updates on integration of the EBS-BMS-Breedbase, are not being reported sufficiently. Enhanced communication is also necessary to facilitate clear understanding between developers, domain experts, and end-users, ensuring all needs are met. Establishment of a governance team would improve decision-making where assessment of user needs, prioritization of updates, and allocation of resources can be made effectively. A defined team structure can foster clear ownership and responsibility for the breeding IT systems.
Breeding Resources to ramp up regional and local T&N support personnel.	There is a gap in Trialing & Nursery support for areas outside the designated 15 Crops to End Hunger (CtEH) stations. This lack of resources could hinder the ability to effectively deliver on Breeding Resources' agenda to support breeding programs in those locations.

Section 8: Key result story

Maize breeding in Kenya: Helping millions across Sub-Saharan Africa

World-class breeding facilities at Kiboko, Kenya, enable impactful genetic innovations, helping millions of smallholder maize farmers in Sub-Saharan Africa.



Aerial view of the KALRO Kiboko Research Station in Kenya. Credit: CIMMYT

The CGIAR Research Initiative on Breeding Resources (Breeding Resources) is fostering progress in crop breeding, exemplified by its support to maize breeding programs of CGIAR and partners in Kenya. From streamlining selection processes to enhancing operational efficiency and fostering gender inclusivity, the Initiative’s multifaceted interventions are driving maize breeding innovations that are impactful across Sub-Saharan Africa.

Crop breeding is critical in addressing global challenges but is also a complex science that relies on numerous services to consistently generate quality data, including genotyping, trialing and nursery management, mechanization, etc.

For CGIAR breeders and partners to accelerate genetic gains and develop climate-resilient crop varieties with farmer-preferred traits, access to top-tier breeding services is crucial. This is where Breeding Resources steps in, offering indispensable support to crop breeding programs worldwide, as evidenced by maize breeding in Kenya.

CGIAR’s maize breeding work has been ongoing for three decades in Kenya, where the crop is the primary source of sustenance for millions of smallholder farmers. Breeding Resources is supporting CIMMYT and partners in their collaborative maize breeding efforts, including improvements on operational efficiency, infrastructure development, and capacity building.

At Kenya Agricultural and Livestock Research Organization’s (KALRO) Kiboko research station, CIMMYT established a maize Double Haploid (DH) facility in 2013, to accelerate breeding cycle time. DH technology significantly shortens the development time of homozygous maize lines, from three to four years to one year.

However, prior Breeding Resources intervention, seedling mortality during the DH process was a major issue, especially after chromosome doubling treatment of the haploids. Through the establishment of Standard Operating Procedures (SOPs) optimizing processes, and continuous improvement activities guided by the Initiative, survival rates of the treated seedlings surged to an impressive 90 percent, dramatically reducing DH production costs and enhancing efficiency.

Breeding Resources investments in cutting-edge equipment, such as near-infrared spectroscopy-based color sorter, transformed the labor-intensive process of sorting haploid seeds from the diploids. What once took 3-4 months, and a team of 20-30 people, can now be accomplished in just 3 weeks by 2-3 individuals.

With these improvements, Kiboko produces elite DH lines at scale and at cost comparable to what multinationals achieve. Over the last five years, the DH facility in Kiboko developed and delivered over 200,000 DH lines benefiting CIMMYT, IITA, national partners, and SME seed companies across Sub-Saharan Africa.

Mechanization of breeding operations, with funding support from the Crops to End Hunger (CtEH) program, implemented by Breeding Resources, is enabling the use of planters and combines

for enhanced precision and productivity, while drastically reducing manual labor.

Drip irrigation systems for the managed drought stress blocks, and investments in more sustainable water and electricity supply are improving the station’s phenotyping capacities. Electronic data capture has been scaled up, facilitated by CtEH-provided tablets, accompanied by comprehensive training.

Medium-sized seed dryers are now accessible at the Kiboko station, facilitating the harvesting of breeding materials well before physiological maturity in the field. This allows for drying to the required moisture levels, enabling three-season nurseries and significantly shortening the breeding cycle time.

Breeding data management is facilitated by the Enterprise Breeding System (EBS), a software developed by Breeding Resources and slated for gradual deployment across all CGIAR breeding programs.

Breeding Resources is also providing genotyping services to maize breeders who need to study the genetic makeup of their newly developed lines and utilize the data in breeding programs. The Initiative leverages global requirements across crops and economy of scale for samples to be genotyped at lower cost.

Breeding Resources support extends beyond breeding, as seed processing and storage is being significantly strengthened through CtEH funding, ensuring integrity and quality of seeds while reducing the need for frequent seed multiplication.

Occupational health and safety protocols have been enhanced, ensuring compliance with industry standards and fostering a culture of well-being. At Kiboko station, women now hold key management roles and benefit from targeted training, challenging traditional gender norms and contributing to a more inclusive research environment.

The breeding hub at Kiboko is now transitioning from a recipient of support to a requester of services, via Breeding Resources’ Service Request Portal, a simplified platform where breeding teams can seamlessly request the Initiative’s support.

With expanding operations and the addition of new crops, Kiboko station has transformed into a multi-crop center of excellence. The upgrades underway benefit CGIAR Centers and national partners, extending to multiple Initiatives, notably Accelerated Breeding and Seed Equal.

This comprehensive upgrade exemplifies a scalable model that is implemented by Breeding Resources in other CGIAR research stations and Centers globally, illustrating the Initiative’s large mandate.

Breeding Resources goes beyond simple facilitation, highlighting the power of collaboration, and providing world-class breeding services leading to new germplasm and impactful breeding innovations that transcend international borders.

Primary Impact Area



All 5 Impact Areas are targeted equally

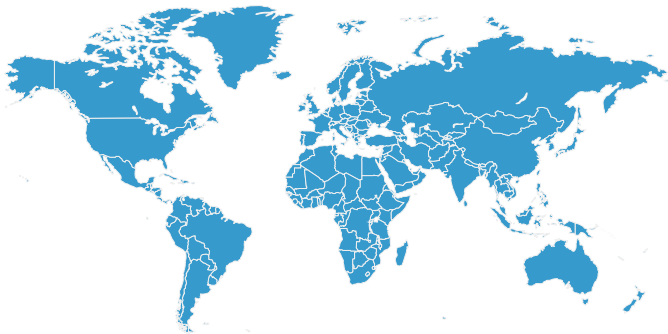
Contributing Centers

CIMMYT- International Maize and Wheat Improvement Center · Centro Internacional de Mejoramiento de Maíz y Trigo · AfricaRice- Africa Rice Center · CIAT (Alliance) Alliance of Bioversity and CIAT- Regional Hub (International Center for Tropical Agriculture / Centro Internacional de Agricultura Tropical) · IITA- International Institute of Tropical Agriculture · IRRI- International Rice Research Institute

Contributing external partner

Weber and Fritz Consulting (WFC)

Geographic scope



Global



The maize breeding hub at Kiboko, Kenya, illustrates the beauty of CGIAR-NARES partnership. The facilities established at this key research station, harnessing the expertise of world-class experts to deliver top-tier breeding services to partners, has led to impactful products, serving millions of maize farmers in Sub-Saharan Africa.

Prasanna Boddupalli, CGIAR Global Maize Breeding Lead & Director, Global Maize Program, CIMMYT



Front cover photo

Rosemary Gatimu, CIP, at the Tissue Culture Laboratory of KEPHIS Plant Quarantine and Biosecurity Station in Nairobi, Kenya.
Credit: Ngugi / Breeding Resources, 2024

Back cover photo

CIMMYT technicians collecting data at Kiboko research station with CteH-provided tablets.
Credit: CIMMYT



INITIATIVE ON
Breeding Resources