



Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops

Initiative Lead and Co-Lead

Michael Quinn
Clare Mukankusi

Primary CGIAR Action Area

Genetic Innovation

Estimated 2022 - 2024 Budget

\$90 - \$125 M

Challenge

Breeding programs targeting the developing world will need to urgently deliver higher genetic gains in farmer's fields to cope with current 21st century challenges: 50%-60% greater demand for food with increased nutritional value in the face of climate change, natural resource constraints and diet-related and food safety challenges. Climate change will reduce crop productivity by about 5% for every degree of warming above historical levels[1]. This alone will require breeders to speed up current efforts substantially[2], and more so to incorporate nutritional traits into modern varieties.

However, the pace of technological modernization in breeding programs targeting the developing world is inadequate. Farmers still grow obsolete varieties, partially because they derive inadequate benefits from recent breeding efforts. Breeding programs need to better address market demands. Breeding progress needs to be greater and more rigorously verified under farmers' own conditions -- and with consumers. Partial modernization of methods and approaches has begun to take place through the Excellence in Breeding Platform (EiB) and CtEH initiative. But organization and funding of CGIAR breeding are currently not conducive for joint priority setting, strategic use of human and financial resources, and mainstreaming of the best practices needed to consistently increase genetic gains across crops.

In addition, collaboration between the CGIAR and national breeding programs varies greatly in quality and effectiveness. Duplicate and inefficient efforts prevail.

Opportunities are missed for CGIAR and NARES jointly designing, owning and implementing common strategies to strengthen local breeding sectors, increase genetic gains and drive variety turnover on-farm as part of a collaborative breeding network.

[1] Challinor AJ, Watson J, Lobell DB, Howden SM, Smith DR, Chhetri N (2014) A meta-analysis of crop yield under climate change and adaptation. *Nat. Clim. Change* 4: 287-291. doi:10.1038/nclimate2153.

[2] Fischer RA, Byerlee D, Edmeades GO (2014) Crop yields and food security: will yield increases continue to feed the world? *ACIAR Monograph* (158, Canberra, 2014), available at http://www.regional.org.au/au/asa/2012/agriculture/7936_fischerra.htm.

Objective

The initiative will develop better performing, farmer-preferred crop varieties for crop-region combinations prioritized for their potential to increase incomes and reduce hunger in poverty-affected countries [3], and potentially new ones identified by MIPPI. Three objectives will set the base for achieving, by 2030, improvements of at least 1.5% p.a. genetic gain on-farm (for traits that are prioritized by distinct CGIAR impact goals), and reducing the area-weighted average age of varieties in farmers' fields to less than 15 years:

1. Climate-smart varieties addressing value chain demands: taking direction from MIPPI outputs to restructure and reorient breeding programs to develop varieties that demonstrate greater benefits (i) under farmers' actual and future growing conditions, (ii) for processors and consumers, and (iii) with more emphasis given to varieties that benefit women and marginalized groups.

2. Professionalize breeding: to systematically implement best-practice breeding and trialing approaches across breeding pipelines; replace multiple "in-house" solutions with high quality shared services established by ETTTSfGGI; and initiate organizational changes towards a single multi-crop breeding organization that pursues continuous improvement and achieves greater genetic gains.

3. Partnerships that deliver: to recast breeding networks and promote co-creation that empowers NARES and the local private sector, particularly small and medium sized enterprises (SMEs), to assume greater and clearer responsibility; and with the purpose of establishing ownership, enhancing effectiveness of individual and joint efforts, and driving variety adoption on-farm.

[3] Wiebe KD, Sulser TB, Dunston S, Rosegrant MW, Fuglie K, Willenbockel D, Nelson GC (2021) Modeling impacts of faster productivity growth to inform the CGIAR initiative on crops to end hunger. doi: 10.1371/journal.pone.0249994

Theory of Change

Breeding programs targeting the developing world urgently need to produce higher rates of genetic gain to address the increasing demands for affordable and nutritious food under changing climates, and create new opportunities for women, marginalized farmers and local processors. With the private breeding sector still targeting only a few crops and higher-income regions, modernizing CGIAR and National Agricultural Research and Extension System (NARES) breeding programs and partnerships are key to ensuring significant variety innovations will be forthcoming, now and in future.

Building on Crops to End Hunger (CtEH) and focusing on the CGIAR Impact Areas, this initiative transforms CGIAR-NARES breeding to increase the rate of genetic gain from below 1% to >1.5% annually while significantly improving the benefit of new varieties to farmers and consumers, women and marginalized groups. Linking with the other Genetic Innovation Initiatives and exploiting advantages of a unified organization, it will: (i) apply best practices and partnership models across teams and crops; (ii) refocus CGIAR-NARES-SME breeding networks on distinct market segments and product profiles; (iii) modernize breeding approaches to shorten breeding cycles, increase selection accuracy, and pursue value from genetic resources; and (iv) implement bold models for breeding that strengthen NARES role and capacity in variety development.

The Initiative will result in crop varieties that are more likely adopted by farmers and consumers, driving down the age of varieties in farmers' fields. It will transform the local breeding sector and result in more sustainable and greater impact on incomes, nutrition, gender equality, and climate adaptation.

Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops

Highlights

Modernized breeding: This initiative will redesign CGIAR breeding networks to increase genetic gain delivered to farmers, consumers, traders and processors through improved varieties. CGIAR will be world-leading in applying and evolving best practices, aligned with quantitative genetics principles and strategic use of proven technology while developing and attracting scientific talent.

One CGIAR - global multi-crop breeding organization: This Initiative will apply world-class breeding services and operations capacity from the Enabling Traits, Tools and Technology Services for Genetic Gains Initiative (ETTTsFGGI) across crops resulting in greater trial accuracy, staff safety, and cost savings. All CGIAR breeding pipelines will be optimized to deliver higher genetic gains, in the form of farmer-preferred varieties.

Transforming partnerships: This Initiative will strategically empower national partners to become active drivers in ongoing CGIAR-NARES-SME breeding networks. NARES and local private sector capacity will be developed in a customized manner to identify breeding objectives, collaboratively develop improved varieties, and drive variety adoption together with the SeEdQUAL initiative.

Demand-driven breeding: CGIAR breeding will be demand-led. Trait prioritisation will be guided by multidisciplinary research by the Market Intelligence and Product Profile Initiative (MIPPI). All breeding decisions will be made in context of client-focused product profiles broadly describing the products needed to replace obsolete varieties in farmers' fields and address One CGIAR's Impact Areas.

Focused and prioritised Breeding: Breeding pipelines will target specific market segments informed by MIPPI. Resources will be allocated according to each pipelines' potential to contribute to One CGIAR's Impact Areas. Resources will furthermore be optimally allocated within each pipeline to maximize the likelihood of variety adoption and utilisation.

Work Packages

	Scope of Work	3-year Outcomes
Re-Focused Products	Based on current insights and forthcoming MIPPI input, restructure breeding pipelines to target most relevant market segments, moving away from more generic breeding approaches. Use product profiles to drive breeding decisions from crossing to variety selection. Iteratively adapt and evolve product profiles based on on-farm testing and partner consultations.	Product profiles are informed by updated social science insights, NARES, farmers and consumers input, generating varieties aligned with drivers of adoption and stakeholders' requirements. Investment cases linked to breeding pipelines will give decision makers greater confidence to make resource allocations aligned with development goals.
Re-Focused organization	Gradually establish specialized teams to focus on trait discovery, trait deployment, population improvement, and variety validation, in some instances across crops. Define and implement stage gates and handover criteria between teams to consistently pursue the prioritized product profiles, and hand-over to SeEDQUAL. Assess and learn from efficiency gains through reorganization.	Structuring and stage-gating breeding pipelines allows to systematize a culture of continuous improvement, learning and innovation where specialized yet integrated teams identify, fine-tune and streamline cutting-edge approaches. Beyond creating a modern, more efficient and responsive breeding engine, this approach more effectively attracts and develops talent and external partnerships.
Transforming NARES and SMEs	Collaboratively review CGIAR-NARES-SME crop breeding networks, define and implement approaches for NARES and SMEs to guide decision-making and assume more responsibilities in the implementation of collaborative breeding approaches, aligned with their evolving strength and mandate. Provide partners with crucial skills, tools and resources to execute their roles and responsibilities.	Local partners are motivated to engage in CGIAR-NARES-SME networks and more successful in ensuring a continuous flow of high-performing varieties, adapted to local needs, are moving towards commercialization or other forms of dissemination. Capacity development becomes an integral component, improving the network's and individual partners' performance.
Trait discovery and deployment	Identify novel sources for highly valuable and demanded traits, guided by the product profiles (e.g. climate resilience, nutrition and processing traits, new biotic threats), from CGIAR and other genetic resources. Develop and implement molecular and phenotypic selection methods and tools to support accelerated introgression into elite parents and varieties.	Coupling elite population improvement with access to valuable genetic diversity for current and emerging needs increases both the rates of genetic gain and enables a fast response to new threats (pests or diseases) or new MIPPI insights (e.g. gender relevant traits).
Population improvement and variety validation	Optimize breeding pipelines (for use of tools, traits, environments, and safety), accelerate breeding cycles, and implement best-practice phenotyping, molecular and data management approaches throughout CGIAR-NARES-SME population improvement and variety validation network, leveraging tools and services developed by Bismi. Shift trialing to better reproduce farmers' environments and management practices.	Rates of genetic gains will increase due to greater trial data accuracy, selection precision, and throughput. Expanding on-farm trialing and systematizing gender-informed user feedback will identify desirable varieties more accurately. Operations will be more efficient, quality-managed and safer.

Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops

Impact Area Contributions

Nutrition, health & food security	Increased genetic gains and variety replacement will increase the quantity of food, thereby lowering food prices and enabling poor consumers to diversify their diets. Developing biofortified varieties, with elevated zinc, iron, vitamin A content, and modified processing traits to address the higher need of adolescent girls and women for micronutrients.
Poverty reduction, livelihoods & jobs	Farmer-and market oriented value-chain planning will result in varieties better suited to local growing conditions, anticipated climate changes, sale at local and urban markets, and processing. Adopting farmers' food security and income will increase and local jobs created along the value chain. More nutritious food improves health and livelihoods.
Gender equality, youth & social inclusion	This initiative will work with the MIPPI to better understand how product profile choices can empower women, youth and socially marginalized people. On-farm trialing will use gender-sensitive indicators and use insights to adjust product profiles. Capacity development, choice of collaborators, and staff will follow targets to pursue gender equity.
Climate adaptation & greenhouse gas reduction	Varieties, parents and trait discovery will pursue adaptation to forecasted climate change impacts for specific crop-region combinations, such as drought, heat, flooding propensity, or changing disease and pest profiles, and achieve targets faster[4]. The MIPPI will provide input to local, desirable coping strategies in response to climate change. [4] Atlin GN, Cairns JE, Das B (2017) Rapid breeding and varietal replacement are critical to adaptation of cropping systems in the developing world to climate change. Global food security; volume 12: 31-37
Environmental health & biodiversity	Breeding-driven production gains reduce pressure on deforestation for production gain. This allows more land to remain in its natural state. This will be considered in the pipeline investment cases developed by the MIPPI. Traits supporting sustainable farming (e.g. direct seeded rice) will be weighted and targeted by selection.

Impact on SDGs



Regions

Global Central and West Asia and North Africa (CWANA), East and Southern Africa (ESA), Latin America and the Caribbean (LAC), South Asia (SA), South East Asia and the Pacific (SEA), West and Central Africa (WCA)

Countries



Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops

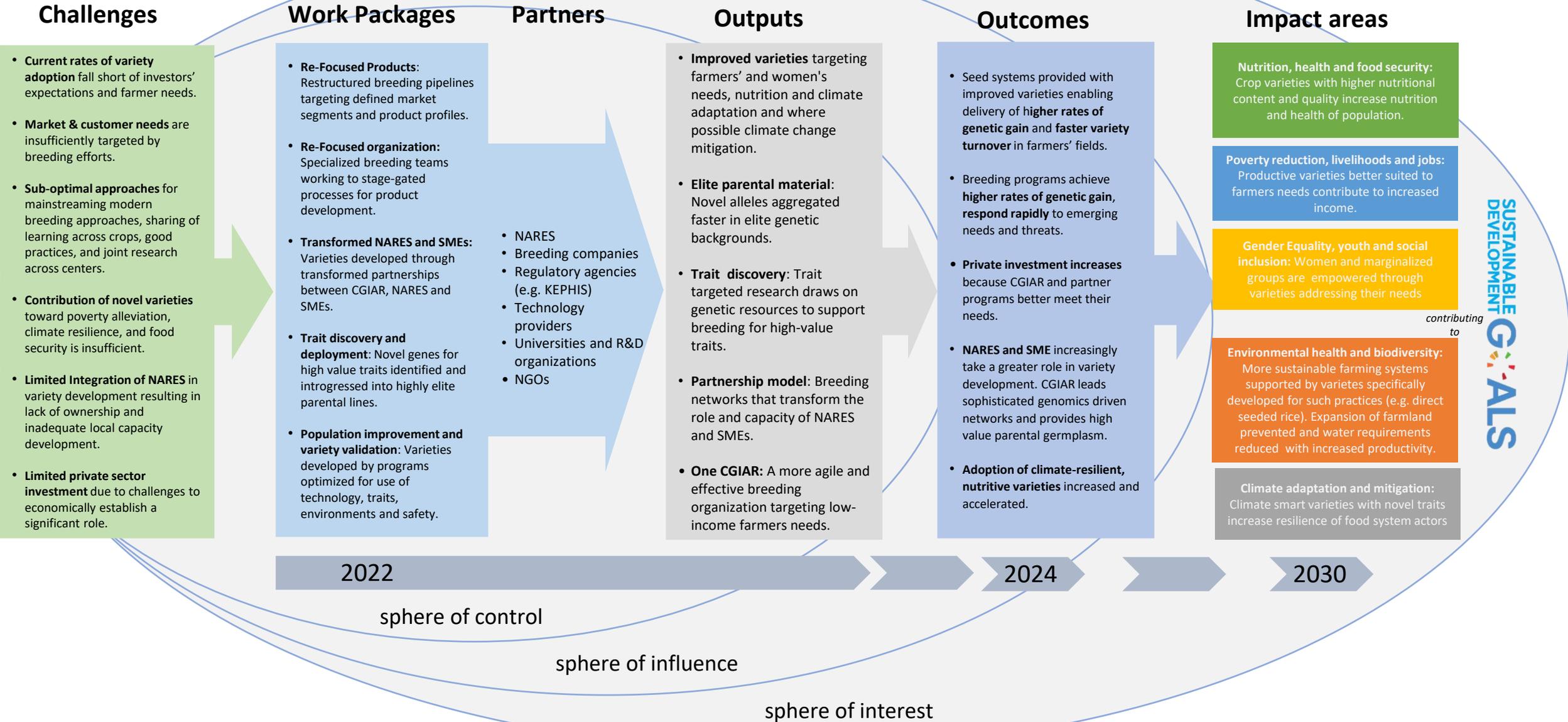
Innovations

- CGIAR-NARES-SME Partnership model. NARES and SME as active partners in formally-managed collaborative CGIAR-NARES-SME breeding networks, reducing inequities and strengthening local ownership and capabilities.
- Prioritisation framework. Well described CGIAR breeding portfolio that demonstrates the link between breeding pipelines, varieties developed, and the type and number of beneficiaries, allowing rationalization of public sector breeding investments.
- Novel genetic resources. Fully characterised novel sources of genetic variation for key traits on the product profile and other intractable traits, e.g. blast resistance in rice. Including traits needed today and in future climates and growing conditions.
- High value breeding parents. e.g. broadly adapted wheat lines with novel sources of genetic variance for intractable traits (e.g. climate adaptation) to be used as parents by NARES breeders and private sector reducing need for duplicated efforts by local breeding teams.
- Market preferred varieties. e.g. drought-tolerant and NUE maize varieties for East African highland farming systems to strengthen smallholders' capacity to cope with climate and weather variability and to produce despite nutrient depleted soils.

Key Partners

Demand	Academic, Training and Research	Academic Institutions in the developing countries: Universities such as the World Bank-supported centers of plant breeding excellence: African Centre for Crop Improvement (ACCI) - South Africa, West Africa Centre for Crop Improvement (WACCI) - Ghana, Makerere University Regional Centre for Crop Improvement (MaRCCI) - Uganda. Regional Agricultural Research Organizations focused on strengthening inter-regional research capacity and collaboration, e.g., West and Central African Council for Agricultural Research and Development (CORAF/WE CARD), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)
	Government	National Breeding Programs, e.g., National Agricultural Research Organization (NARO) of Uganda, Bangladesh Rice Research Institute (BRRI).
	Private Sector	Local Seed Companies, e.g., Western Seed in Kenya, Nalweyo Seed Company (NASECO) in Uganda, Zamseed in Zambia etc. in addition to emerging start-ups focusing on root and tuber crops. Local and international processing companies, e.g., TrueFoods canning industry in Kenya.
Innovation	Academic, Training and Research	Academic Institutions in the developing countries: e.g. African Centre for Crop Improvement (ACCI) - South Africa, West Africa Centre for Crop Improvement (WACCI) - Ghana, Makerere University Regional Centre for Crop Improvement (MaRCCI) - Uganda National Breeding programs, e.g., Kenya Agricultural and Livestock Research Organization (KALRO), Indian Council for Agricultural Research (ICAR)
	Other Public Sector	USAID Innovation Labs and affiliated Universities (eg Cornell University))
	Private Sector	Leading private breeding companies, e.g., Bayer, Corteva.
	Private Sector in Aid Recipient Country	Downstream local and international processing, aggregating and offtaking companies, e.g., Nutreal in Uganda, Heinz in the USA
Scaling	Government	Government subsidy and farmer support programs [Farmer Input Subsidy Programs (FISP)] that are active in various countries in Sub-Saharan Africa (e.g.; Zambia, Tanzania, Rwanda, Malawi) National agricultural research and extension systems, e.g., Directorate of Agricultural Extension Services of the Ministry of Agriculture and Animal Industry (MAAIF) - Uganda, National Agricultural and Livestock Extension Program (NALEP-GoK) - Kenya, Agricultural Transformation Agency (ATA) - Ethiopia
	International NGO	International humanitarian organisations and social enterprises: e.g., One Acre Fund, Netherlands Development organization (SNV), World Vegetable Centre (WorldVeg), Catholic Relief Services (CRS), World Vision, Alliance for a Green Revolution in Africa (AGRA)
	National NGO	Community-based organizations such as Karagwe Development and Relief Services (KADERES) in Western Tanzania. Faith-based organizations (FBO's) such as the Inter Religious council of Uganda (IRCU)
	Private Sector in Aid Recipient Country	Local seed companies:, e.g. Beula in Tanzania, Dryland Seeds in Kenya, ZamSeed in Zambia, SeedCo in several African countries, Mukushi Seeds - Zimbabwe, Maslaha Seed - Nigeria, Heritage Seeds - Ghana, Sedab - Senegal

Theory of change – Accelerated Breeding



SUSTAINABLE DEVELOPMENT GOALS