PRELIMINARY **CGIAR**
INITIATIVE OUTLINES

Accelerated Crop Improvement through Precision Genetic Technologies

Initiative Lead and Co-Lead	Primary CGIAR Action Area	Estimated 2022 - 2024 Budget
Inez Slamet-Loedin Marc Ghislain	Genetic Innovation	$30 - $40 M

Challenge

Feeding the world population of 8.5B by 2030 will require increasing crop yields, providing more nutritious and higher quality food while also making agriculture more resilient and sustainable. Currently, 15% of production is lost to pests and diseases with another 30% lost after harvest, while crop production is predicted to decline by 2-6%/decade due to climate change. Staple crops are generally poor in micronutrient content contributing to malnutrition estimated to cost $3.5 trillion per year.
Conventional crop breeding methods alone will not be sufficient to meet future demand. The modernisation of One CGIAR breeding aims to reduce the length of breeding pipelines. However, for many key target traits additional variation beyond the elite breeding and pre-breeding pools will be required. Even where beneficial alleles have been identified from crop relatives, the genetic linkage drag of poorly adapted alleles makes their incorporation into elite germplasm challenging. For other traits, useful alleles are simply not available in crop relatives but present in other crops or species. Certain intractable traits require fine-tuning of gene expression to obtain the desirable effect.
One CGIAR must keep up with this pace of change in order to ensure it makes available PGT benefits to small-scale farmers and low-income consumers where there is no attractive market for private investment. In addition, the costs, skills, complex IP landscape and variable public acceptance present a challenge across the crops and regions served by One CGIAR providing a clear case for co-ordinated investment. PGT development also requires coordinated implementation of best stewardship practices.

Objective

This initiative's main objective is to accelerate the development and delivery of value-added parental lines and the improvement of elite varieties with new traits unachievable or inefficiently attainable with conventional breeding approaches.
One CGIAR PGT products will aim to reduce crop losses by ~20 % and pesticide use by ~ 50%, and/or to improve micronutrient content (reaching 30-50% estimated-average-requirement/EAR) with a reduced environmental footprint and to deploy a novel hybrid production system. Prioritization on traits, crops, and countries target for 2022-2024 will be done by overlaying demand-driven TPP, aiming first for countries with PGT enabling regulatory environments, technology opportunities and impact level in consultation with One CGIAR market-intelligence, breeding and seed-initiatives. Trait lifecycles will be managed through a stage-gate process. Alleles conferring pest and disease resistance, yield improvement, better nutrition and quality, or adaptation and mitigation to climate change will be incorporated to parental breeding lines or elite varieties. Direct editing of alleles of complex or intractable traits in elite varieties can be achieved within 2-4 years compared to the 10-15 years needed by conventional breeding.
Three regional technical nodes of excellence with crop specialization will be designated from the six CGIAR centers working on biotechnology to efficiently deploy the latest technological innovations in PGT and enabling technologies. Local capacity development will make progress towards self-reliance.
A One CGIAR enabling platform to accelerate PGT product adoption will be developed to harmonize internal policies, regulatory stewardship, access to proprietary technology, and compliance. The platform will facilitate effective communication to support informed decision-making for PGT products and unified key messages in relevant international forums.

Theory of Change

Challenges of yield stagnation, malnutrition, climate change, and increasing population are putting severe pressure on agricultural and food systems, requiring accelerated deployment of more resilient varieties. This will not be achieved by conventional breeding alone. Adoption of innovative precision genetic technologies (PGT: defined as gene-editing, genetic-engineering and enabling tools), will expedite the development of more nutritious and climate-smart crops as they are able to overcome genetic linkage-drag, compatibility barriers and low allelic diversity for traits that are intractable to conventional breeding.
One CGIAR will access and pursue PGT with freedom to operate in target countries from public and private sectors. Translational research will be conducted in partnership with national partners to deliver two types of products : (1) parental-breeding lines with edited alleles conferring desirable traits for breeding; (2) improvement of existing elite varieties with alleles and/or gene insertions with value-added traits. Priority traits and deployment will be determined based on demand-driven target product profiles (TPP) that address the needs of farmers, supply-chains, consumers, with One CGIAR market-intelligence, breeding, and farmer-preferred-seed initiatives utilizing gene-bank-initiative' diverse 'omics' knowledge.
Regional nodes-of-excellence will be strengthened to enhance One CGIAR and local core competencies on PGT and its enabling technologies for effective development of new products, employing best stewardship practices.
Successful pathways to impact will be realized by adhering to product-lifecycle management, regulatory requirements, effective partnerships in communications with relevant stakeholders, and developing local capacities throughout the product development phases. Our strategic innovations will reduce the time and cost of developing improved varieties that will contribute to all five-impact areas.

Accelerated Crop Improvement through Precision Genetic Technologies

Highlights

Streamlining of CGIAR biotechnology facilities and expertise through the designation of three regional nodes-of-excellence for precision genetics (LAC, Africa, Asia) from existing facilities with state-of-the-art technical capacities and crop specialization using best stewardship and data management practices. Phenotyping will continue to be done at relevant One CGIAR and target-country facilities.

Co-development of parental breeding lines through gene-editing using knowledge and/or allele-mining activities harnessed by Genetic-Innovation (GI) initiatives and private and public sector partners. Trait/crop prioritization and target countries will be decided based on demand-driven-TPP, considering gene editing technical feasibility, regulatory environments, consumer acceptance, forecast impact level.

Accelerated development and regulatory approval of existing elite varieties improved with value-added traits (e.g., pest and disease resistance and nutrition) obtained by genetic engineering but also gene editing. Deployment will be done in cooperation with breeding and seed-initiatives partnering with public/private sectors, and national-partners in stage-gated pipelines.

A One CGIAR platform for policy, biosafety, regulatory, coordinated communication, and legal expertise to obtain freedom to operate for PGT in target countries for specific traits and to apply best stewardship practices, and policy with the highest research ethics standards. This platform will be the voice of the One CGIAR in international forums.

New models of co-development that enhance local capacities in the technical, regulatory-stewardship, and communication aspects of our PGT innovations, considering downstream market/consumer demand including women and youth preferences, will be developed to ensure buy-in and foster wider local adoption to maximise impact.

Work Packages

	Scope of Work	3-year Outcomes
One CGIAR nodes of excellence for utilization of state-of-the-art precision genetics	Gain access and develop state-of-the-art precision genetic technologies and associated enabling technologies such as allele replacement, DNA-free editing, double haploid; establish three nodes of excellence (LAC, Africa, Asia) with One CGIAR focus crop specialization and linked phenotyping facilities in relevant locations.	One CGIAR and national scientists working at nodes-of-excellence, equipped with state-of-the-art enabling tools and best practice protocols, develop efficiently novel products with impactful PGT traits for focus crops in target geographies.
Improved edited parental breeding lines for use in demand-driven TPP breeding	Use gene editing technologies to introgress novel alleles of complex or intractable traits into selected breeding lines. Allele mining will be conducted with other Genetic innovation based on Genebank "omics" knowledge. Edited parental breeding lines will be delivered to breeding pipelines.	Breeders use PGT improved parental breeding lines in their elite breeding germplasm for developing mainstream traits and, in the future release of novel varieties. One CGIAR and national scientists use feedback on trait performance in the elite breeding germplasm to develop next generation products.
Expedite improvement of existing elite varieties with market-driven TPP traits or previously intractable traits	Advance and develop PGT innovations (gene-editing and genetic-engineering) along the product development pipeline; using existing elite varieties improved for disease resistance (e.g., Xanthomonas-wilt resistant banana, late-blight resistant potato, bacterial blight resistant rice), yield, nutrition (healthier banana and rice), quality, food safety, and climate resiliency; regulatory studies and dossiers.	Agronomists, breeders and seed system partners use PGT improved elite varieties for at least 2-3 CGIAR crops for seed production in a minimum of 4 countries (e.g., One CGIAR and national scientists co-develop 5 new candidate products meeting the decision criteria of demand-driven TPP and the trait lifecycle process.
Unified One CGIAR framework for precision genetics enabling environment	Obtain freedom to operate on proprietary technologies for all One CGIAR PGT; develop licensing schemes, crop-specific stewardship principles; promote the development of functional regulatory systems within partner governments; and develop the socio-economic analysis of the PGT products.	Freedom to operate in intellectual property agreements on the One CGIAR potential products is obtained and used to develop products in target geographies. Coherent best practices of biosafety, stewardship and compliance are applied across One CGIAR locations.
One CGIAR effective communication, stakeholder engagement, outreach, and capacity development for PGT products	Develop an effective coordinated One CGIAR communication strategy on PGT products that is inclusive of partners, value chain actors, and other stakeholders; establish new models of co-development with national partners on technical and communication capacities across the product development pipeline, informed by gender and youth considerations.	One CGIAR science leaders use common principles, policies, ethics on PGT. Decision makers, farmer leaders, women and youths, and value-chain stakeholders have increased awareness on the potential of PGT technology thereby making more informed decisions. In-country ambassadors are informed and empowered with efficient key messages on One CGIAR PGT products.

Accelerated Crop Improvement through Precision Genetic Technologies

Impact Area Contributions

Nutrition, health & food security	Application of precision genetics will accelerate the development and deployment of resilient varieties and contribute to meeting future demand for healthy foods. Improved varieties are expected to close the yield gap by 10-20%. Micronutrient content of a few staple crops will be improved to reach 30-50% of women/children EAR.
Poverty reduction, livelihoods & jobs	Increased agricultural production, reduction in input costs, and improved nutrition will increase the incomes of households and improve their livelihoods. A more deliberate focus on farmer- and market-informed product profiles will stimulate and diversify opportunities for the agri-food sector and its entrepreneurs and employees.
Gender equality, youth & social inclusion	Gender and youth participation in developing product profiles and prioritization to make decisions on target crop-traits will be emphasized, as well as the potential of enabling new income opportunities. Adoption of a gender intentional approach is essential for deployment of healthier crops. Cutting-edge technology product development attracts youth involvement in agriculture.
Climate adaptation & greenhouse gas reduction	Varieties better adapted to climate change will be developed by targeting traits such as heat tolerance, methane reduction, and/or nitrogen-use-efficiency. The reduction of inputs resulting from the cultivation of pest and disease resistant varieties will help reduce carbon emissions from producing, transporting, and spraying pesticides to control pathogens.
Environmental health & biodiversity	Cultivation of improved varieties with pest and disease resistance will help reduce chemical inputs currently needed to control them. Non-target organisms affected by chemicals will be restored in agricultural environments, thereby increasing soil and aboveground biodiversity.

Impact on SDGs

Regions

Global	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 Crop Improvement through Precision Genetic Technologies

Innovations

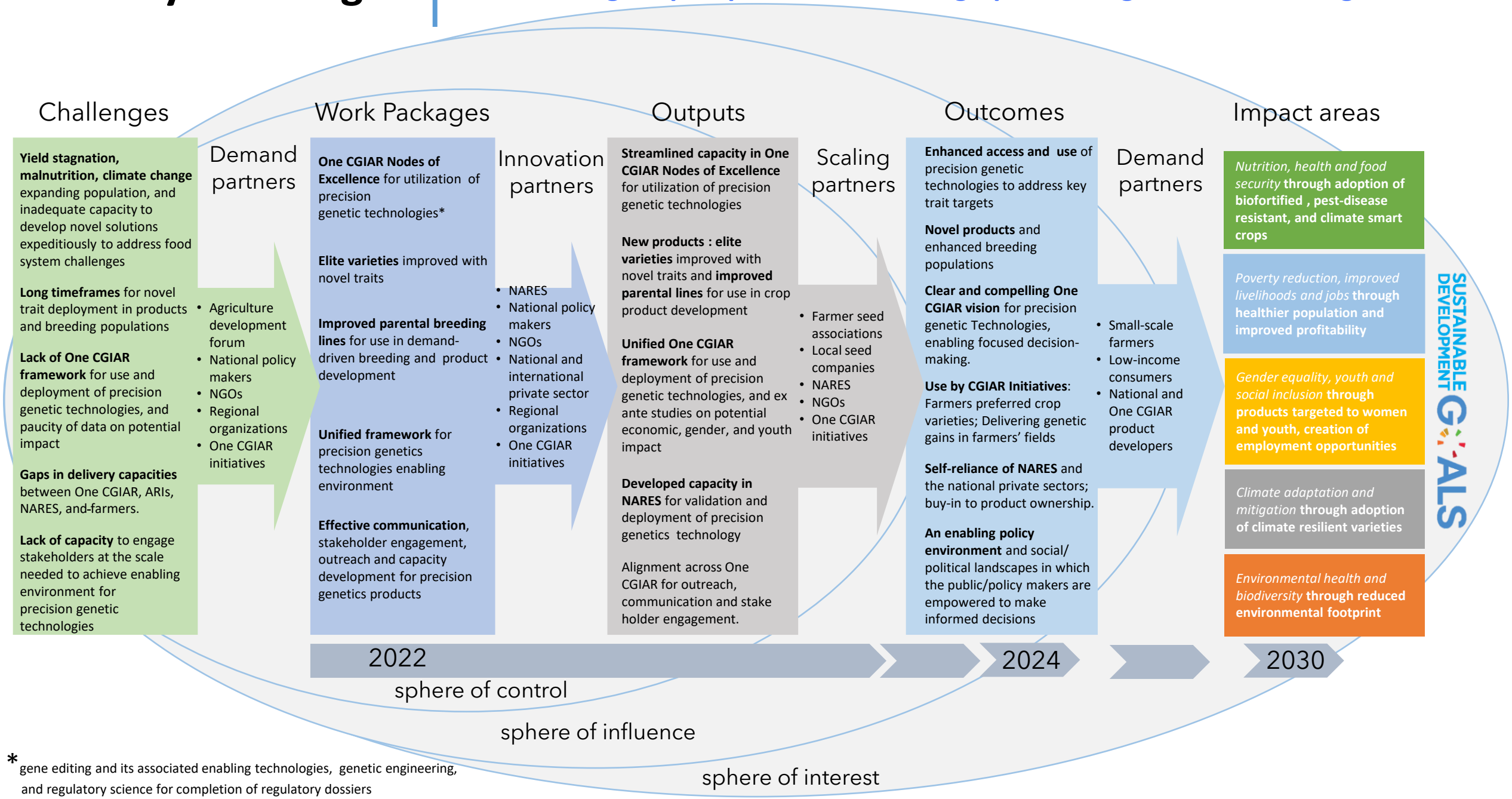
Advanced gene editing and associated enabling technologies (e.g., allele replacement, DNA-free editing, plant transformation, transfection, tissue culture, protoplasts, double haploidy) for One CGIAR focus crops.
PGT parental breeding lines of One CGIAR crops, prioritized by traits and countries, with enhanced quality, nutrition, safety, abiotic, biotic stresses and/or other intractable traits, for screening and use in breeding programs, leading to future release in Africa, Asia and LAC.
PGT improved existing elite varieties of banana, cassava, maize, potato, rice, and/or wheat with pest and disease resistance or enriched nutritional content either submitted for cultivation approval for genetically-engineered products or receiving non-GM regulatory status for gene-edited products in 1-3 target countries.
PGT to improve maize hybrid production for African and Asian Farmers and to produce improved breeding lines and seeds (e.g., double haploid, apomixis, etc.).
A unified One CGIAR strategy and platform for development of precision genetics technologies, deregulation, deployment, and awareness of PGT products, and an enabling environment for informed decision-making.

Key Partners

Demand	Government	National agriculture research and extension services and other agencies from Ministries of Agriculture, Health, Environment, Finances, Science and technologies in target countries. (https://bit.ly/3triuMl)
	National NGO	Non-governmental organizations focused on science, women, youth, agriculture, environment, farmers, etc.
	Other	CGIAR initiatives: Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops; SeEdQUAL: delivering genetic gains in farmers' fields
		Funders: BMGF, USAID, FCDO, 2BLADES, etc.
	Other Public Sector	AATF, ASARECA, CORAF, SEARCA, etc.
Innovation	Academic, Training and Research	Advanced research institutes (e.g., CSIRO, CIRAD, JIRCAS, IRD, DDPSC), universities (e.g., Michigan State University, Heinrich Heine University, University of Berkeley, University Cambridge and Oxford University) and national science and technology institutes. (https://bit.ly/3triuMl)
	International NGO	Helen Keller International; International Centre for Diarrheal Disease Research -Bangladesh:Cornell Alliance for Science; ISAAA; etc.
	National NGO	Biotechnology Coalition of the Philippines; Farming Future Bangladesh, Society of Indonesia for Agriculture Biotechnology (MASBIOPI); etc.
	Other	CGIAR initiatives: Conservation and use of genetic resources (Genebanks); Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops; Enabling Traits, Tools and Technology Services for Genetic Gains; Market Intelligence for More Equitable and Impactful Genetic Innovation; SeEdQUAL: delivering genetic gains in farmers' fields; HarvestPlus; South Asia Biosafety Program; African Biosafety Network of Expertise; etc.
	Private Sector	Corteva Agriscience, Latin American Fund for Irrigated Rice (FLAR); etc.
Scaling	Government	Farmer cooperative seed organizations and other seed organizations, and national extension services in target countries.
	Other	CGIAR initiatives: Accelerated Breeding: Meeting Farmers' Needs with Nutritious, Climate-Resilient Crops; SeEdQUAL: delivering genetic gains in farmers' fields.
	Private Sector in Aid Recipient Country	Local seed companies, Farmers cooperatives. (https://bit.ly/3triuMl)

Theory of change

Accelerating crop improvement through precision genetic technologies



* gene editing and its associated enabling technologies, genetic engineering, and regulatory science for completion of regulatory dossiers