Network 4 Enabling Tools, Technologies, and Shared Services (N4ETTSS)

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Proposal

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Introduction and context

This document provides a template for Proposals for CGIAR Initiatives, providing guidance on the elements and content anticipated. The purpose of the template is to provide CGIAR System Council funders and the Independent Science for Development Council with the information needed to inform their funding decisions around the Initiatives. The template is designed in light of the CGIAR 2030 Research and Innovation Strategy, reflecting the focus on partnerships, innovation systems and multiple SDG impacts from high-quality science, research and innovation. The template provides for assessment of CGIAR Initiatives against the features of CGIAR Initiatives laid out in the System Reference Group recommendations (Annex 1 of SC09.02), the ISDC Quality of Research for Development Criteria and the Eschborn Principles.

The Proposal template is based on that submitted to the System Council in 2020 (Document SC11.04a), and subsequently modified with the agreement of the CGIAR Executive Management Team and the Independent Science for Development Council, ensuring a fit to their needs. The template is current at the date of issue, taking into account all prior decisions of the System Council, System Board and CGIAR's Executive Management Team.

Proposal structure

Summary table

Initiative name	**Network 4 Enabling Tools, Technology and Shared Services**
Primary action area	**Genetic Innovation**
Geographic scope	**Global**
Budget	**US$ 62,000,000**

1. General information

- Initiative name: Network 4 Enabling Tools, Technology and Shared Services (N4ETTSS)
- Primary CGIAR Action Area: Genetic Innovation
- Proposal Lead: Young Wha Lee
- Proposal Deputy: Augusto Becerra Lopez-Lavalle

IDT members and affiliations

Name	Affiliation	Core advisory	Extended advisory	Writing	Coordinate consultations
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Bish Das	EiB		X	X	X
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Abbreviations

ABI	Accelerated Breeding Initiative
ARI	Advanced Research Institutions
BMS	Breeding Management System
BPAT	Breeding Performance Assessment Tool
CtEH	Crops to End Hunger
DMS	Data Management System
EBS	Enterprise Breeding System
EiB	Excellence in Breeding
EOI	End of Initiative
GI	Genetic Innovations Science Group
HH	Households
HTP	High Throughput Phenotyping
IBP	Integrated Breeding Platform
MIPP	Market Intelligence Initiative
N4ETTSS	Network for Enabling Tools, Technologies and Shared Services, this Initiative
BPIMS	Breeding Pipeline Improvement Monitoring System
SeEdQUAL	Seed Systems Initiative
SMART	Specific, Measurable, Achievable, Realistic, and Timely
SME	Small to Medium Enterprise
SOP	Standard Operating Protocol
TOC	Theory of change
TPE	Target Population of Environments
TTSS	Tools, Technologies, and Shared Services
WP	Work Package

2. Context

2.1 Challenge statement

Urgent action is needed to address the global challenges of poverty, nutrition, hunger, environmental degradation, and climate change. Improved crop varieties are a long-proven way to significantly impact these issues, with a broad reach that is less constrained by the spatial limits of extension networks[1]. Data driven, modernized breeding with tools and technologies such as genomic selection, quantitative genetics, high throughput phenotyping, bioinformatics, and environomic analysis, can accelerate and advance improvement in varieties[2] [3] [4] [5] (see Annex A).

Across the CGIAR-NARS network the independent operation of breeding programs, while giving regions autonomy, has meant that innovations are not shared to their full potential, costs associated with services such as bioinformatics are duplicated, data is fragmented and disparate as incompatible technologies are adopted, inconsistent standards are applied, and access to Tools, Technologies, and Shared Services (TTSS) varies.

Variable use of TTSS across CGIAR-NARS breeding programs means that while the results from past breeding programs have been impressive, breeding is not achieving its potential impact. Varieties that deliver improved nutrition, production, climate adaptation and other desired traits are taking longer than necessary to develop with foregone performance (genetic gain) of released varieties.

Excellence in Breeding (EiB) with Crops to End Hunger (CtEH) funders have established a baseline for breeding modernization across the CGIAR-National Agricultural Research System (NARS) network (i.e., Breeding Performance Assessment Tool (BPAT) results). Effective development and deployment of advanced varieties requires a coordinated networked effort across CGIAR and NARS, with NARS critical to location-specific development of varieties. It is now time to build on the proven methods of EiB and CtEH by extending efforts to include more NARS and expand assessments into a more holistic performance system aligned with CGIAR Impact Areas.

The Network 4 Enabling Tools, Technology and Shared Services (N4ETTSS) Initiative will use institutional innovation to form a collaborative, performance-oriented network that strategically uses modernized breeding to more efficiently deliver greater impacts (see Annex B). Innovations are “new ideas, products, services, and solutions capable of facilitating impact through innovation systems involving multiple partners and enablers”[6]. N4ETTSS will scale innovations for modernized breeding with activities that support the innovation system (“interlinked set of people, processes, assets, and social institutions”[7]) to mainstream TTSS adoption and maximize TTSS benefits. A corporate-style performance system with global standards of best practice breeding alongside metrics on social and environmental responsibilities, will monitor and motivate continuous improvement. N4ETTSS will establish shared services with a procurement team negotiating cheaper access to external vendors and service providers, TTSS functional teams will be formed from existing dispersed capacity through CGIAR institutional innovation and specialist technical support teams of experts will work with NARS to refine TTSS for local contexts. Modern TTSS generates significant data, and a common data sharing system underpinned by standardization and data governance, and local software support will bring that data together from across the CGIAR-NARS network to create larger, more powerful data sets. Data visualization tools will facilitate live use of data in time pressured breeding decisions.

As guided by innovation readiness and scaling, Modernization Facilitators (MF) will connect breeding programs with specialist teams to overcome local innovation application challenges and change management support will grow the ongoing breeding culture shift towards

multidisciplinary teams of internal and external experts, with mainstreamed TTSS through managed networks. The capacity of NARS will be raised to a level where all breeding programs are effective within the network. As guided by a Technical Advisory Committee (TAC) of public and private breeding experts and practitioners, an innovation ecosystem will be cultivated with partnerships brokered with advanced research institutions (ARIs), subject matter experts, private companies and others along the breeding to adoption pathway, ensuring ongoing technology prospecting and innovation development in breeding tools and technologies.

2.2 Measurable 3-year (end-of-Initiative) outcomes

The objective of N4ETTSS is to improve the genetic, economic, social and environmental performance of breeding programs across the CGIAR-NARS breeding network.

MELIA for N4ETTSS is challenged by contribution and time lags (see MELIA). Applied and specific indicators of breeding program impact at the outcome level requires multiple targets to capture reach and scale of expected improvements, as shown in the below figure. All targets are final year targets (2024).

2.3 Learning from prior evaluations and impact assessments (IA)

- N4ETTSS will deliver on the CAS recommendation to accelerate breeding modernization across the CGIAR-NARS network.[8]
- Relationships between ARIs and EiB has increased CGIAR breeding innovation[9]. These relationships will be fostered in Work Package (WP) 5's innovation ecosystem.

- EiB has used BPATs (https://plantbreedingassessment.org/) to improve CGIAR performance. This approach will be extended to NARS and expanded to more holistic performance assessment.
- Climate adaptation will need rapid cycle breeding with more intense selection supported by data driven decisions using high throughput phenotyping, breeding simulations and other TTSS[10]. N4ETTSS will increase use of TTSS, enabling breeding for climate adaptation.
- MELIA has not supported planning and improvement[11]. WP3 embeds MELIA into performance monitoring, with results used to adjust priorities and engagement methods in WP2, 4 and 5.
- Engagement of end users in research agenda setting increases relevance of solutions and technology uptake[12]. Regional consultation has informed this proposal and the ongoing BPAT and performance monitoring will ensure responsiveness to regional needs.
- Higher priority on nutrition, health, resilience, and environmental sustainability is needed in genetics research[13]. Holistic performance monitoring in WP3 will maintain SDG focus across the GI Initiatives.
- Gender needs to be integrated into all research steps[14]. It will be featured in Change Management and incorporated in Process Management and Modernization Facilitation.
- EiB capacity building activities are predominantly attended by men[15]. N4ETTSS will identify and apply mechanisms that encourage more women to participate.
- CtEH funders requested shared services, quantitatively optimized breeding, increased CGIAR-NARS capacity and incentives for increasing breeding performance[16]. N4ETTSS will deliver on these requests.

2.4 Priority-setting

N4ETTSS is designed to work seamlessly with the Accelerated Breeding Initiative (ABI). For this to occur, the priority systems, regions and crops determined by ABI have been adopted by N4ETTSS. N4ETTSS has instead focused its priority setting process on:

- Innovations with most potential to improve breeding efficiencies (see Annex A).
- Activities that are in-demand by stakeholders, partners, and service clients (including other CGIAR Initiatives).

Priority-setting consultation included (see Annex C):

1. Thematic analysis of Pre-concept feedback.
2. Informal discussions with industry leaders from Syngenta (Monica Menz), Bayer CropScience (Brian Gardunia), KWS (Viktor Korzun), and Corteva (Tabare Ibadie).
3. Discussions, information gathering and negotiations with all GI Initiatives, EiB and CtEH throughout the proposal development process.
4. Structured regional consultation with CGIAR, NARS, Borlaug Institute for South Asia (BISA), Universities and seed companies was done in three stages to identify priorities, develop widespread understanding and build support for N4ETTSS. The first round of six online workshops gathered over 735 lines of input, and an online survey was completed by 208 respondents and approximately 180 individuals participated in a second round of workshops.

Consultation results showed limited variability in TTSS priorities between CGIAR and NARS, with greater variability between regions. In response:

- The TTSS Strategic Plan will cascade global priorities to regional needs, taking into account differing capacity, infrastructure and TTSS gaps between regions.
- Change management plans will focus on the human experience and institutional enablers of modernization to increase change resilience.
- Modernization Facilitators will help breeding programs access relevant expertise to resolve regional specific technical barriers to TTSS adoption.

The final top TTSS priorities, along with brief rationales for prioritization, are summarized below.

Top priority TTSS and activities

Priority and Work Package (WP)		**Rationale (for supporting evidence see Annex D)**
Innovations	Abiotic and biotic stress phenotyping (WP2, 3, 5)	Top priority in regional consultation.
	Genotyping (WP2)	Top 5 priority in regional consultation.
	Grain quality & nutrient analysis (WP2)	Top 5 priority in regional consultation.
	Analytics (WP2)	Regional consultation identified as a priority, higher in Round 1 workshops than survey.
	High throughput phenotyping (WP2)	Top 5 priority in regional consultation.
	Data Management System (WP4)	Top 5 priority in regional consultation.
	Standardized operations (WP3)	Regional consultation identified as a common need. Top feature in Round 1 workshops. Strong support for using Standard Operating Protocols (SOPs) in survey results. Required to underpin DMS.
	Biometrics (WP2)	Regional consultation identified as a priority (higher priority in some regions). ABI have requested GBLUP, TPE analysis, Genetic gain analysis
	Bioinformatics (WP2)	Regional consultation identified as a priority
	Simulations (WP1)	Requested by ABI. Will also contribute to MELIA
	Digitization and automation (WP4)	Regional consultation identified as a priority
	Breeding Pipeline Improvement Monitoring System (WP3)	Regional consultation identified as a need. Also required for MELIA.
Activities	Change management plans (WP 5)	Regional consultation identified as a need. Role change identified in consultation. Highlighted as needed in industry support letters.
	Modernization Facilitators (WP5)	Regional consultation identified limitations in coordinated access to modernization services and expertise) as a major barrier to overcome.
	Regionalized capacity building strategies (WP5)	Regional consultation identified as a major barrier to overcome.
	Strategic prioritization (WP1)	Regional consultation identified as a priority. Modelling component will also inform TTSS prioritization and MELIA.
	Seed production and distribution support (WP3, 5)	Regional consultation identified as a priority in Round 1 workshops. Confirmed as high priority in Round 2 workshops.
	Mechanization/automation support (WP3, 4, 5)	Regional consultation identified as a priority in Round 1 workshops. Confirmed as high priority in Round 2 workshops.

Other TTSS and activities required, as identified by only some regions as needed, are the following:

- Innovations - experimental design (WP2), specialized technical support (WP2, 4, 5).
- Activities - operations support (WP3, 5), agronomic support (WP3, 5).

In addition to the TTSS priorities, the consultation highlighted quality priorities for service provision by N4ETTSS e.g., reliable, timely, accountable, affordability.

2.5 Comparative advantage

Investment in agricultural R&D through CGIAR has generated more benefits than almost any other government investment, with a 10:1 benefit ratio. CGIAR's comparative advantages are founded in this experience and success.

CGIAR has a presence in and knowledge of the many countries where it works and has institutional links, combined with a solid scientific reputation, allowing it to leverage R&D capacity in higher-income countries for the benefit of low-income countries. These trusted relationships will encourage NARS to adopt TTSS.

The combined size and capacity of the CGIAR-NARS breeding network gives it collective purchasing power, access to expertise within the diverse group and connections within the network can facilitate internal transfer of learning to capitalize on existing capacity.

CGIAR can work across scales, from globally coordinated Initiatives to regional, national and local research programs. CGIAR can operate as regionally located but connected hubs with greater potential to achieve impact than isolated efforts. CGIAR is in a unique position to connect data and technology on a global scale.

Donors can maximize impact by leveraging the CGIAR's comparative advantages above, i.e., by maintaining scientific expertise in core areas while fostering collaboration with organizations that have strong capacity for scaling. The package of Genetic Innovation (GI) Initiatives proposed span the breeding pipeline and seed value chain in a holistic pathway from research to impact, leveraging within GI to compound the benefits achieved.

In support letters, it was commonly expressed that adoption of TTSS in modernized breeding is needed for CGIAR to maintain its role in public breeding. See Annex E.

2.6 Participatory design process

A participatory design process was structured to gather input from stakeholders, partners and clients on N4ETTSS priorities. See Priority Setting and Annex C for details on the consultation methods used and stakeholders consulted. Throughout, comments have been positive, encouraging and supportive. The full consultation results are in Annex D.

A sample of external representatives (NARS, private industry, ARI) were asked to review a draft proposal and invited to provide letters of support. Several responses confirmed the importance and benefits of modernization, as quoted below. The full letters received are provided in Annex E.

> 'Enabling Tool, Technology and Shared Services is critical to increase rates of genetic gains and reduce breeding cycles, thereby bring[ing] forward the benefits of improved genetics to small-holder farmers. We are pleased to note that the vision of N4ETTSS aligns with NARO's research agenda on modernized breeding programs for delivering farmer and market-oriented technologies contributing to improved livelihoods.'

"The proposal identifies the right set of technologies to be administered and deployed for the modernization of breeding across crops and geographies and proposes an organizational model that seems very adequate. Path forward, I think the proposal needs to have strong support from the CGIAR leadership and funders and needs to be equipped with a strong technical team with a vocation to carry it through despite the challenges they will sure[ly] encounter. In this next stage, continuity of the technical team is essential for success."

"It is encouraging to see such ambitious and impactful proposals for changes in [the] way the breeding programs operate in the new One CGIAR network."

"One of the aspects of this proposal that I think makes it stand apart from other proposals I have read is the ambition in scope of the Work Packages. With the five Work Packages, the proposal would modernize breeding program methods and structure, centralize resources for genotyping and analytics, improve safety and quality management, build [a] long-term data management system, and focus on innovation and change management. I think these changes are necessary to be able to reach the impact needs of the new One CGIAR organization as well as improving the many collaborating national programs."

"This [modernization] has been a challenge to implement at times but has allowed our breeding programs to continue to grow and to increase the rate of genetic gain and market share across crops.

If we had not made these changes—including investments in IT, data management and systems, centralization of services, and predictive analytics, we would have struggled to continue to develop innovative solutions for our customers and is a requirement for modern precision breeding programs to be competitive. This has been especially important for deploying new technologies to multiple crops and global regions that before this change were at very different levels of readiness for modern breeding program improvements."

"Overall, it is a very complete proposal with a realistic and pragmatic plan that was long overdue. At my own organization we constantly look for efficiencies in all process of R&D activities establishing similar changes: creating shared platforms and services in regional hubs that use standardized procedures, and its impact on the effectiveness of overall breeding operations and product development has been beyond expectations, clearly facilitating faster deployment of state-of-the-art technology, reducing risk and overall cost."

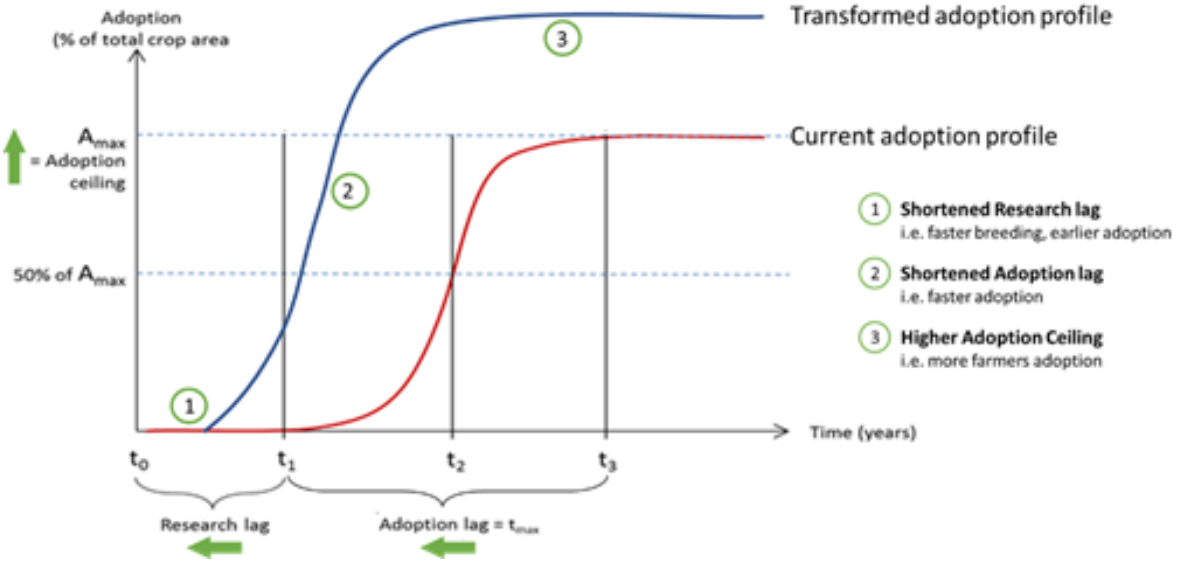
2.7 Projection of benefits

The projections below transparently estimate reasonable orders of magnitude for impacts which could arise as a result of the impact pathways set out in the Initiative's theories of change. Initiatives contribute to these impact pathways, along with other partners and stakeholders.

For each Impact Area, projections consider breadth (numbers reached), depth (expected intensity of effect per unit) and probability (a qualitative judgement reflecting the overall degree of certainty or uncertainty that the impact pathway will lead to the projected order of magnitude of impact).

Projections will be updated during delivery to help inform iterative, evidence-driven, dynamic management by Initiatives as they maximize their potential contribution to impact. Projected benefits are not delivery targets, as impact lies beyond CGIAR's sphere of control or influence.

Impacts of genetic innovations materialize when improved varieties are adopted by smallholder farmers, including women. All Initiatives in the GI Action Area jointly contribute to more efficient and faster development, release, dissemination, and adoption of improved, in-demand varieties through common impact pathways. Besides producing and delivering better quality seed to target beneficiaries in priority market segments, the proposed work aims at modernizing and transforming the genetic innovation system.



Market intelligence (MIPP) shortens the adoption lag and increases adoption levels as new varieties are targeted to specific market segments. This leads to faster and more complete replacement of existing varieties and accelerated varietal turnover. Investment in Genebanks reduces the research lag by making germplasm available to breeding programs, reducing the search time and cost for traits. In addition, potentially game-changing traits are preserved and made accessible, thus elevating future impact-levels. Development of improved varieties with producer/consumer-demanded traits improves livelihoods and food security. Modernized strategies and approaches accelerate breeding (ABI and N4ETTSS), thus reducing the research lag, and generating multiplier effects on the benefits from breeding and seed systems[17]. Improved tools and services enable breeders to create more complex, multi-trait products that match desired product profiles. Modernizing enabling tools and services (N4ETTSS) increases the speed of breeding, thus shortening the research lag and accelerating variety release. Efficient seed delivery (SeEdQUAL) 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 are realized in farmers' fields to benefit households (HH).

Selected examples across all five Impact Areas show the aggregated projected benefits of all GI Initiatives working in collaboration and contributing at different stages along the impact pathways (see Annex F for additional details).

Breadth		Depth	Probability
Impact Area: Nutrition, health & food security **Impact Indicator: # people benefiting from relevant CGIAR innovations**			
Higher yielding Vit A rich cassava: *Orange-flesh sweet potato*:	19.5 million people (3.9 million HH) 14.8 million people (3.1 million HH)	**Significant**: 10% permanent impact on income; some DALYs saved.	**High certainty**: 50 – 80% expectation of achieving these impacts by 2030, at this point
TOTAL: > 23.1 million people (> 4.7 million HH)			
Impact Area: Poverty reduction, livelihoods & jobs **Impact Indicator: # poor people benefiting from relevant CGIAR innovations**			
Higher yielding rice: *Stress tolerant maize*: *Higher yielding wheat*:	12.3 million poor people (2.8 million poor HH) 24.5 million poor people (5.2 million poor HH) 10.0 million poor people (1.9 million poor HH)	**Significant** 10% permanent impact on income	**High certainty**: 50 – 80% expectation of achieving these impacts by 2030, at this point
TOTAL: > 42.6 million poor people (> **9.0 million poor HH)**			
Impact Area: Gender equality, youth & social inclusion **Impact Indicator: # women benefiting from relevant CGIAR innovations**			
High yielding fast cooking Beans: *Orange-flesh sweet potato*:	1.8 million women producers > 3.4 million women in adopting HH 1.5 million women producers	**Significant**: 10% permanent impact on income	**High certainty**: 50 – 80% expectation of achieving these impacts by 2030, at this point
TOTAL: > 2.5 million women producers **> 3.4 million women/girls in all adopting HH**			
Impact Area: Climate adaptation & mitigation **Impact Indicator:** # people benefiting from climate-adapted innovations			
Stress tolerant maize:	69.9 million people (14.7 million HH)	**Significant**: 10% permanent impact on income	**High certainty**: 50 – 80% expectation of achieving these impacts by 2030, at this point
Impact Area: Environmental health & biodiversity **Impact Indicator: # plant genetic accessions available and safely duplicated**			
Aggregate increase to 2030: 15% (70,000 additional accessions become available)		*Not required for this indicator*	**Very high certainty**: >80% expectation of achieving these impacts by 2030, at this point in the design process

- ***1. Nutrition, health, and food security***

 # People benefiting from relevant CGIAR innovations: Vitamin A deficiency is a major disease affecting 48% of children aged 6–59 months in SSA[18]. We project that the nutrition, health and food security status of about 23.1 million people (i.e., 4.7 million households) in 16 SSA countries will improve significantly through the adoption of yellow cassava varieties with high β-carotene (precursor of Vitamin A) content and high dry matter, and orange-flesh sweet potatoes with high β-carotene and improved productivity (see Annex F). Benefits for adopting households arise through increased production, consumption, and sale of crops with higher nutritional value that increase diet quality. The number of beneficiaries is projected using crop/country specific adoption profiles based on past evidence and expert estimates, secondary data on national crop production area (narrowed down to target domains), average household size, and crop area per HH. We did not include benefits arising for end-consumers when they buy biofortified crops. The combined total number of beneficiaries accounts for an estimated 80% overlap (HHs growing both cassava and sweet potatoes) in eight countries included in both projections. Projected impact is in the lower bound of high certainty, since dissemination and adoption of the varieties may be challenged by available seed systems and face market constraints in some countries.

- ***2. Poverty reduction, livelihoods, and jobs***

 # Poor people benefiting from relevant CGIAR innovations: By enabling poor smallholder households to achieve higher yields and hence 'living income', adoption of improved varieties of rice, wheat and maize is expected to significantly benefit 42.6 million poor people (9 million poor HH) by 2030 (see Annex F). While the GI Initiatives have identified 12 priority crops for breeding, only three innovations (higher yielding rice in South and Southeast Asia[19]; high yielding wheat in South Asia[20] [21]; and stress-tolerant maize in Sub-Saharan Africa[22] [23]) are included in the projection. These varieties are at an advanced stage, almost ready to be released and benefits are expected to materialize soon and with high certainty. The number of poor people benefiting is estimated by multiplying the projected number of adopters by 2030 in each country with the poverty headcount ratio at national poverty lines (World Development Indicators, most recent year available). To avoid double-counting in the projected total number of beneficiaries, we accounted for the overlap, especially in the Indo-Gangetic Plain, where HHs frequently grow both rice and wheat[24], by reducing numbers accordingly.[25] [26].

- ***3. Gender equality, youth, and social inclusion***

 # Women benefiting from relevant CGIAR innovations: While approximately half of all beneficiaries of improved varieties are women, the GI Initiatives focus on crops/traits explicitly aiming at improving women's livelihoods. Two examples are bean varieties with increased yield and reduced cooking time[27] [28] and orange-flesh sweetpotatoes[29]. Women are benefiting from these varieties through different impact pathways:

1. increase of income if grown as "women's cash crops";
2. fast cooking (targeted 30% reduction) benefits women by freeing time, since collection of firewood and meal preparation are mostly conducted by women; and
3. health benefits for women and youth consumers.

For our benefit projection, we focus on 1 and 2 and follow the general steps outlined for indicators above, and then compute the share of women producers among all adopters (see Annex F). For the 'time saving' benefit, we assume one woman/girl benefits per adopting HH. Since most HH in SSA cultivate several crops, we use an 80% overlap for countries included in both crop projections. We project that at least 2.5 million women producers and 3.4 million women/girls in adoption HH will benefit significantly and with high certainty from these two crops in the included 17 countries alone.

- ***4. Climate adaptation and mitigation***

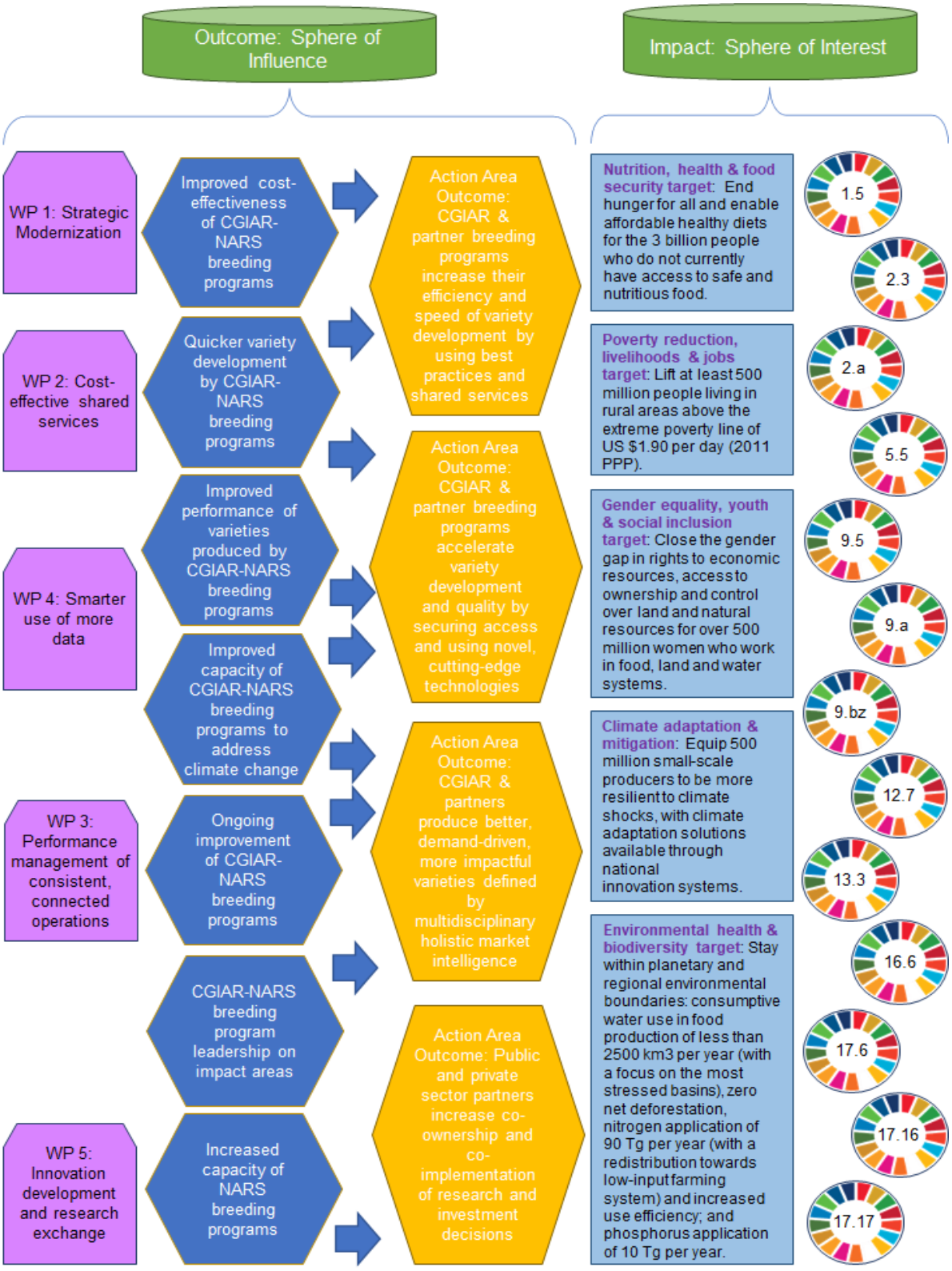
 # People benefiting from climate-adapted innovations: The projection of beneficiaries from climate-adapted innovations is derived from the number of farmers in Sub-Saharan Africa adopting maize varieties tolerant to abiotic stress (see Annex F). Droughts have become an almost regular occurrence in SSA, severely reducing yields of many crops[30]. Maize is an important staple crop in the region and the new drought and heat resistant varieties[31] [32] achieve 20% higher yields under drought conditions[33]. This effect is on the upper end of the "significant" depth criteria in terms of % permanent increase in income. We assume an s-shaped logistic adoption function and use country-level rates of current adoption of improved varieties as adoption ceilings[34], in some cases adjusted upward thanks to significant recent donor investment in the seed sector in target countries. With first adoption by farmers expected in 2022 and an estimated 10-year period to maximum adoption, we project that by 2030 about 14.7 million HH across the target domain will be adopting these improved varieties. This translates to at least 69.9 million persons benefiting from this climate-adapted innovation over the next 9 years.

- ***5. Environmental health and biodiversity***

 # Plant genetic accessions available and safely duplicated: CGIAR has an obligation to conserve, make available, and promote the use of crop collections under their management, according to the provisions of the Plant Treaty. Making accessions available for international distribution requires germplasm to have acceptable viability, are free of quarantinable diseases, with adequate stock, and legally available. In 2020, CGIAR genebanks were managing a total collection of 592,257 crop and forage accessions (not including ICRISAT and CIFOR-ICRAF) (with 79% available for international distribution). By 2030 CGIAR genebanks will achieve (and maintain) 90% availability (i.e., an additional 70,000 accessions becoming available). Progress is monitored through an online reporting tool (managed by the Global Crop Diversity Trust), and reported in the annual Genebank Platform reports: https://www.genebanks.org/resources/annual-reports/. The genebanks will process backlogs (e.g., health testing and cleaning, seed regeneration, verifying trueness-to-type, etc.) to reach this performance target[35]. Achieving and maintaining 90% availability enables genebanks to operate at a steady, efficient state, making them eligible for endowment funding, as well as ensuring users have access to germplasm. The effects of the pandemic and examples such as CGIAR's evacuation from Syria illustrate the importance of sustaining performance targets.[36]

3. Research plans and associated theories of change (TOC)

3.1 Full Initiative TOC



3.1.1 Full Initiative TOC narrative

Variety improvement is more than productivity gain. The varieties developed must deliver on the increasingly complex, multi-trait product profiles demanded by end-users if they are to be grown by small holders and impact SDGs. Climate adaptation brings additional requirements to product profiles to maintain production despite shifting pests and disease distributions and changing crop environments. Breeding for complex and multiple traits needs modern breeding methods. E.g., advanced scientific techniques such as genomic selection will allow multiple traits to be interrogated across diverse product profiles of climate adaptation, disease resistance, nutrition and others to be brought together in a timely fashion (Action Area Outcome, AAO).

Breeding for climate change will also require accelerated variety development with varieties developed in the most recently experienced climate[37], creating demand for targeted phenotyping for stress traits using efficient remote technologies. Automation and semi-automation of data entry will allow more data to be collected, quicker and cheaper for biometrics and bioinformatics supported selection decisions. These technologies will result in quicker breeding and increased ability to develop the required products.

N4ETTSS will improve breeding cost-effectiveness; that is the cost of breeding relative to the quality of the varieties produced, as judged by variety adoption (AAO). This assumes that varieties that deliver on in-demand, complex, multi-trait product profiles will be adopted by growers, and these varieties will deliver on the Impact Areas (supported by MIPP).

Performance monitoring will apply a corporate approach of taking responsibility for how products are produced (e.g., cost-effectiveness), and will complement the investor dashboard (MIPP WP4) which tracks the life cycle impacts of those products (i.e. real-world functioning). The approach assumes that transparent reporting will motivate ongoing improvements within breeding programs and track product delivery against the SDGs, including social, gender and environmental benefits of released varieties. This will further support N4ETTSS' contribution to impactful varieties.

The benefits of TTSS will be realized when there is mainstream adoption across the CGIAR-NARS breeding network (lead by ABI). Under the guidance of a Technical Advisory Committee (TAC), Modernization Facilitators (MF) will connect breeding programs with Specialized Technical Support (STS) teams to research and resolve TTSS technical barriers to adoption. Change management will facilitate the cultural shift and institutional reforms required for breeding programs to transform into dynamic multidisciplinary teams of experts.

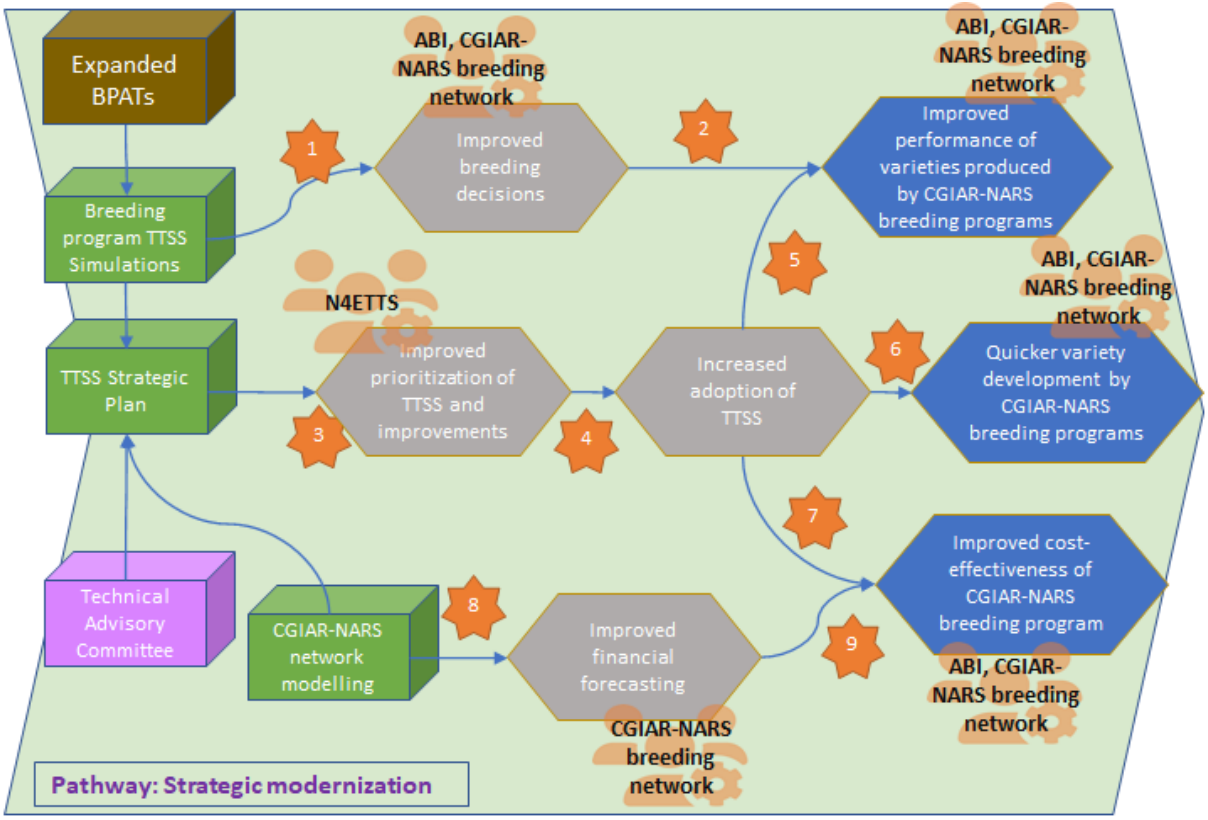
Breeding modernization is not a static end point. The TAC will contribute to ongoing prospecting for future TTSS and play an active role in fostering an advanced innovation ecosystem of public and private breeders, researchers and stakeholders (AAO). The innovation ecosystem will participate in breeding process research to ensure that best practice breeding continues to evolve, pushing forward the whole TTSS adoption curve while capacity building within the CGIAR-NARS breeding network will condense the adoption curve.

N4ETTSS assumes that breeding work, without modernization, would continue at the same pace and with the same level of impact as achieved over the last 20 years. Adoption of TTSS 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.

3.2 Work Package TOCs

3.2.1 Work Package TOC Diagrams

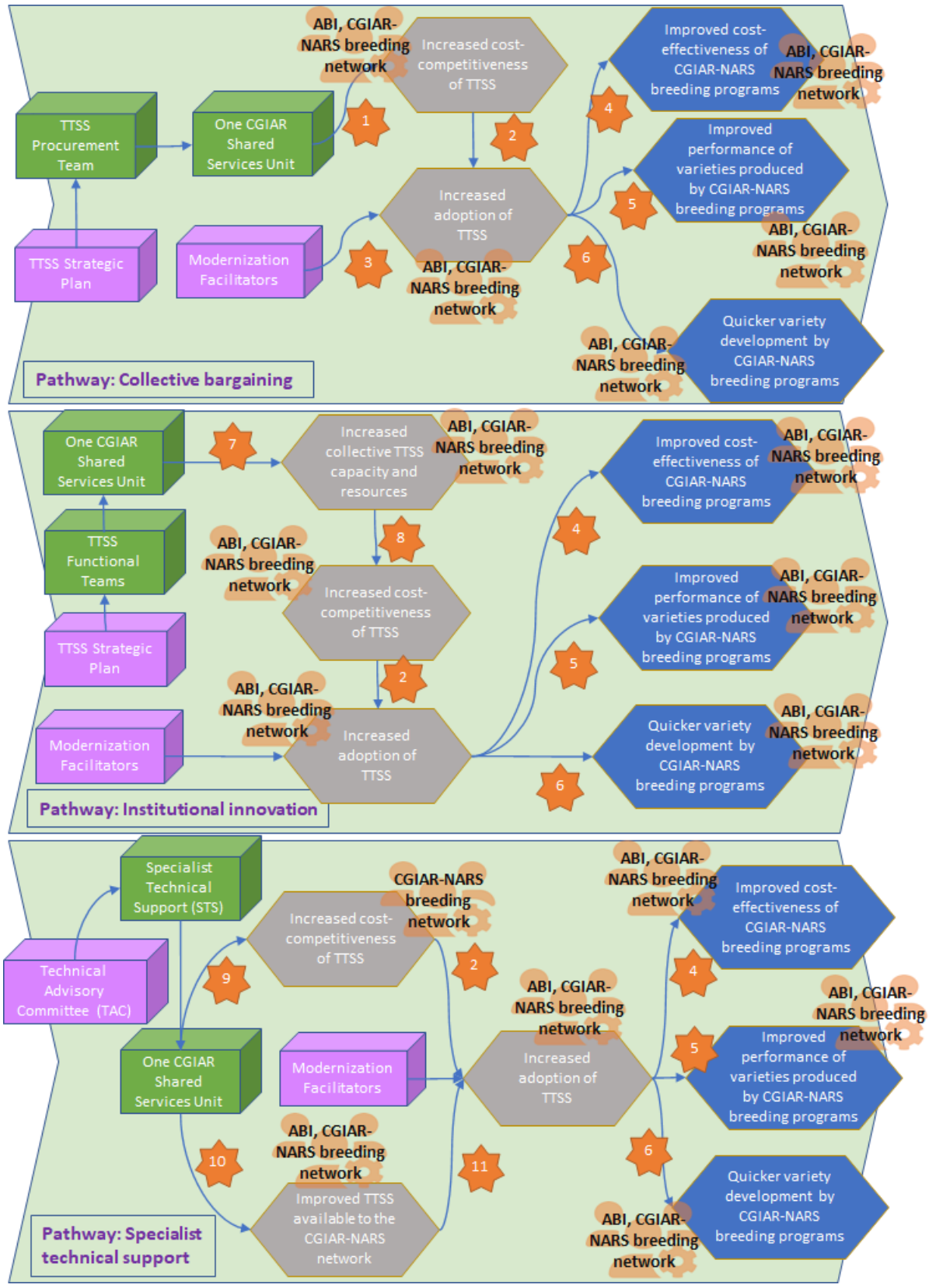
WORK PACKAGE 1: STRATEGIC MODERNISATION



Assumptions

1. Breeders will apply the results from simulations, simulations correctly identify optimal crosses.
2. Optimal crosses/improved breeding will mean better quality varieties are produced.
3. Strategic planning that takes into account existing TTSS use, resources and capacity along with regional variation can improve the prioritization of TTSS to be delivered/supported by N4ETTSS.
4. TTSS prioritization will direct efforts to TTSS that are more in demand and more likely to be adopted.
5. TTSS will increase the quality of varieties. This includes varieties that have multiple and complex trait combinations to meet diverse climate, end user and stakeholder needs.
6. Use of TTSS will increase the speed of breeding. Cycle times can be reduced.
7. Use of TTSS will reduce the cost of breeding relative to the quality of the varieties produced. Note, in some cases the cost of breeding may increase with TTSS adoption, but this is warranted by greater adoption of the resulting varieties.
8. It is possible to model TTSS adoption at a whole-of-network scale. The model can also be used to improve financial forecasting of individual breeding programs.
9. Financial acumen resulting from improved knowledge of forecast costs, empowers breeding programs to make decisions. Breeding programs are able to reduce costs or increase efficiencies, and when combined with the increased quality of varieties produced using TTSS, cost-effectiveness is increased.

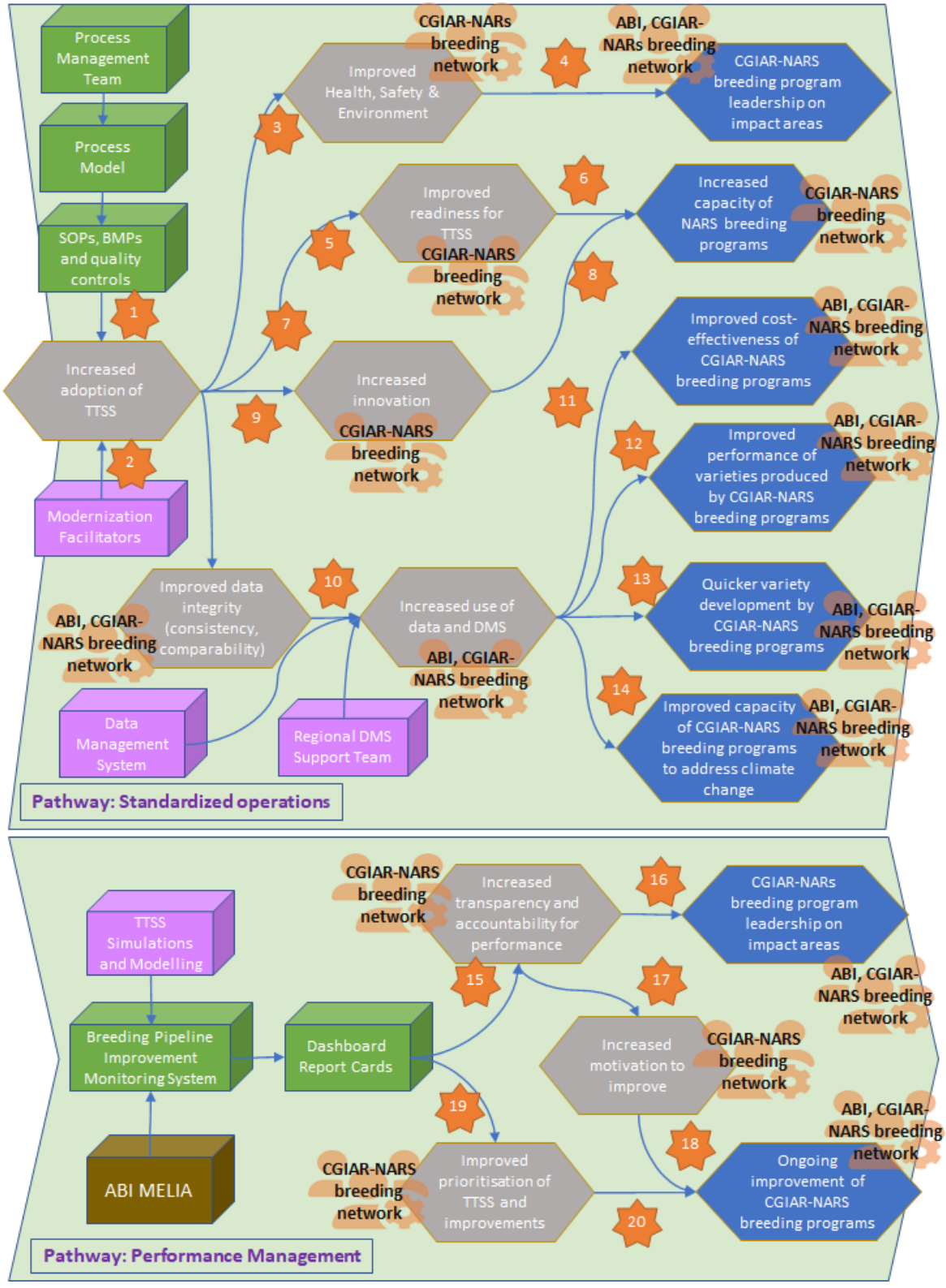
WORK PACKAGE 2: COST-EFFECTIVE SHARED SERVICES



Assumptions

1. Commercial providers are willing to negotiate cheaper prices for CGIAR and NARS use of available services.
2. Cheaper prices overcome the barrier to TTSS adoption and breeding programs make use of shared services.
3. Breeding programs will need technical support to adopt TTSS, and this can be difficult to access. Modernization facilitators can overcome the technical barriers to adoption.
4. Use of TTSS will reduce the cost of breeding relative to the quality of the varieties
5. TTSS will increase the quality of varieties. This includes varieties that have multiple and complex trait combinations to meet diverse climate, end user and stakeholder needs.
6. Use of TTSS will increase the speed of breeding. Cycle times can be reduced.
7. Bringing technical human resources together into one team will increase their collective capacity to service the CGIAR-NARS breeding network.
8. A team of technical human resources is able to be more efficient than disconnected individuals, enabling services to be provided at a reduced cost.
9. Innovations can be further refined and improved by expert specialist technical support teams, and this includes cost saving and increased efficiencies of TTSS use.
10. Innovations need to be further refined for regional contexts and expert specialist technical support teams are able to identify these TTSS adaptations.
11. TTSS that are more suitable for regional contexts are easier to adopt by breeding programs

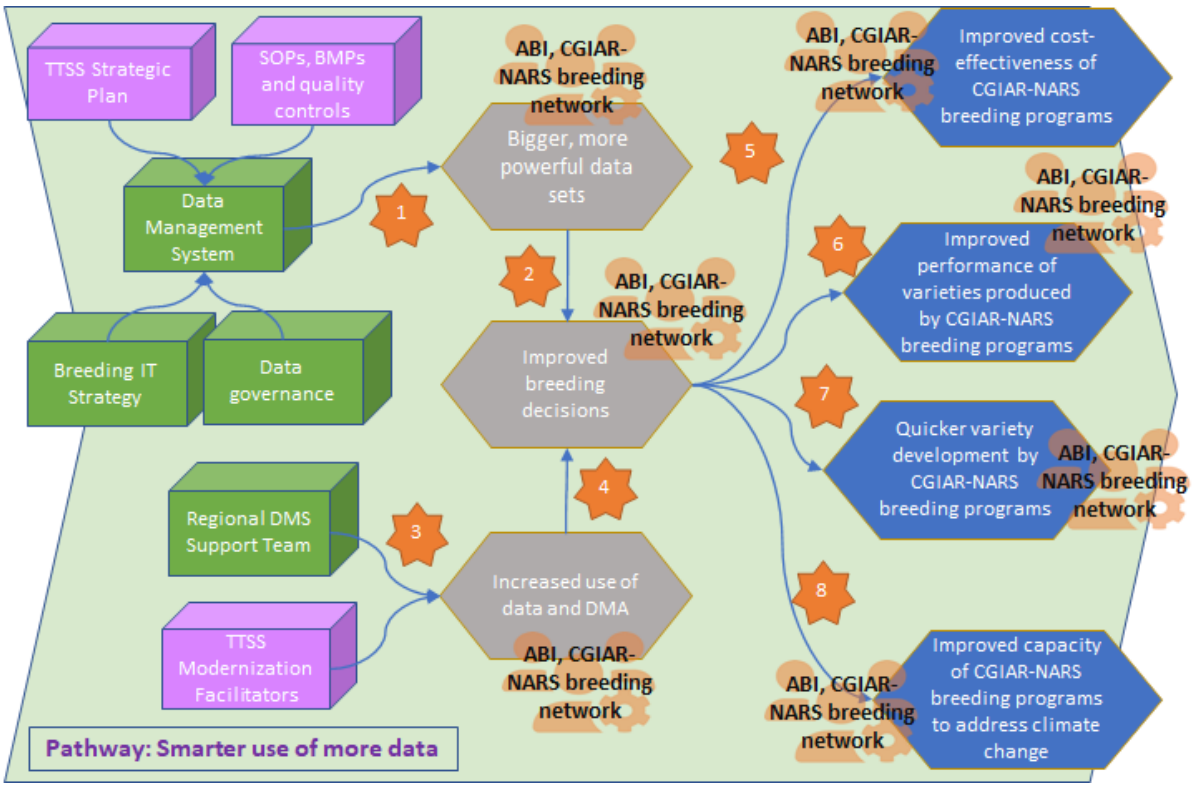
WORK PACKAGE 3: PERFORMANCE MANAGEMENT OF CONSISTENT, CONNECTED OPERATIONS



Assumptions

1. Breeding programs are ready to adopt SOPs, BMPs and quality controls.
2. Modernization facilitators are needed to assist breeding programs understand and apply standardization and connecting breeding programs to technical support to overcome technical barriers to standardization.
3. SOPs, BMPs and quality controls will include minimum standards for Health, Safety and Environment and adoption will result in improvements.
4. Breeding programs will demonstrate minimum standards for Health, Safety and Environment when trial sites are used in local extension, providing an example for growers to follow.
5. Standardization is a preliminary requirement for breeding program modernization and adoption of SOPs, BMPs and quality controls will increase the readiness of breeding programs for later TTSS adoption.
6. Increased readiness TTSS, through standardization, will create further opportunities to improve capacity of NARS breeding programs.
7. Increased standardization will increase innovations across the CGIAR-NARS breeding network through increased connectivity, scaling of standardization tools, practices and innovations and proofing standardization and associated innovations.
8. Increased innovation by breeding programs will increase capacity of NARS breeding programs, as a result of learning, experience and the innovations themselves.
9. Standardization will improve the consistency and comparability of data generated across breeding programs. Breeding programs can have greater confidence in the quality of data gathered by other breeding programs.
10. Improved data integrity across breeding programs will allow breeders to use data across locations and time, increasing the use of data-driven breeding.
11. Data driven breeding is more cost-effective, with less wasted crosses etc. and more targeted breeding decisions.
12. Data driven breeding brings together more types of data and more data, enabling breeders to make better decisions that result in increased genetic gain.
13. Data driven breeding reduces the number of breeding cycles required to achieve desired variety product profiles.
14. Data driven breeding allows breeders to bring together genomic, phenomic and environmental data, to analyze performance of multiple traits in multiple environments, enabling timely breeding for climate change.
15. Publication of breeding program performance will increase knowledge and transparency of breeding program performance, and this will make breeding program's accountable for their performance.
16. Increased transparency and accountability for breeding program performance on Impact Areas will create opportunities for breeding programs to demonstrate leadership.
17. Increased transparency of breeding program performance, and clearer identification of areas that can be improved, will motivate breeding programs to make improvements and improve their reputation and credibility among peers.
18. Breeding programs can and will act on their motivation and make ongoing improvements to their operations.
19. The dashboards will help breeding programs identify areas that can be improved, helping to prioritize TTSS adoption.
20. Improved prioritization of TTSS and improvements, will help breeding programs make changes that can influence their dashboard results, driving ongoing improvements.

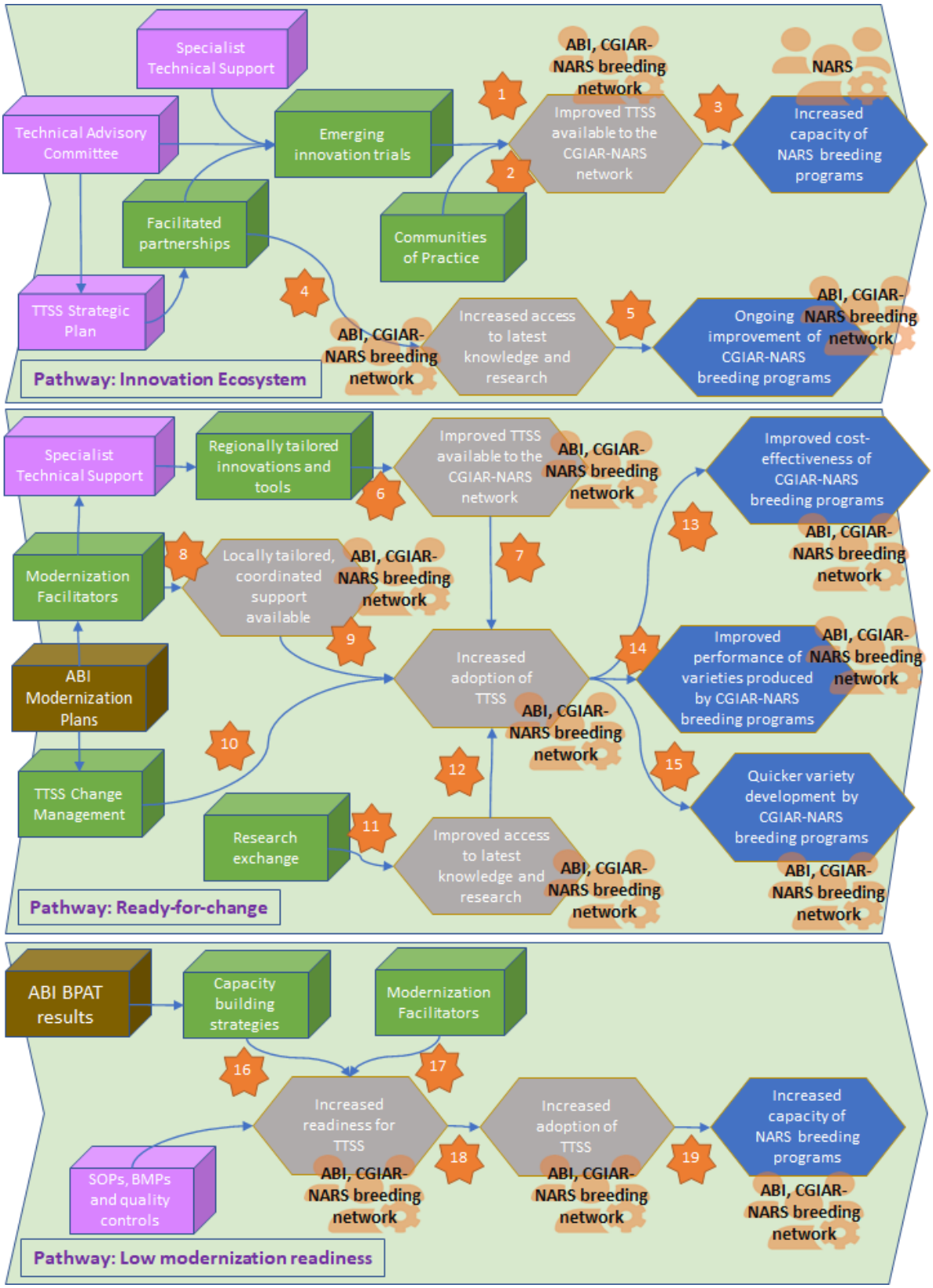
WORK PACKAGE 4: SMARTER USE OF MORE DATA



Assumptions

1. The DMS will provide a platform for bringing large volumes of different types of data together.
2. Increased availability of data, such as multi-environment performance data, will increase data use by breeding programs with high readiness.
3. There are skill and other capacity restraints to using the DMS that can be overcome by regional DMS support teams.
4. Increased use of data and DMS will enable data driven breeding with increased prediction ability and minimized breeding guesswork.
5. Data driven breeding is more cost-effective, with less wasted crosses etc. and more targeted breeding decisions.
6. Data driven breeding brings together more types of data and more data, enabling breeders to make better decisions that result in increased genetic gain.
7. Data driven breeding reduces the number of breeding cycles required to achieve desired variety product profiles.
8. Data driven breeding allows breeders to bring together genomic, phenomic and environmental data, to analyze performance of multiple traits in multiple environments, enabling timely breeding for climate change.

WORK PACKAGE 5: INNOVATION DEVELOPMENT AND RESEARCH EXCHANGE (Idare)



Assumptions

1. CGIAR-NARS participation in trials of emerging innovations will increase the network's access to emerging TTSS.
2. Bringing together users of current TTSS to share experiences, challenges and lessons learnt will assist others to make refinements and improve TTSS.
3. Improved TTSS available to the network will increase the capacity of NARS, through access to TTSS and developed skills and experience with TTSS.
4. Strategically (guided by Technical Advisory Group to target promising emerging TTSS) facilitated partnerships of multidisciplinary and multi-context (public, private, NGO) stakeholders in a dynamic innovation ecosystem will increase the networks access to latest knowledge and research.
5. Knowledge that is brought into the network can then be more readily shared within the network and improve CGIAR-NARS breeding programs.
6. Innovations (TTSS) will need to be refined for use in different regional contexts (capacity available including infrastructure, funding and people).
7. Refined TTSS will address technical barriers, enabling mainstream adoption.
8. Modernization Facilitators (MF)will help breeding programs logistically plan and prepare for TTSS adoption and connect breeding programs to the support required to overcome implementation challenges. The support required will vary for each breeding program. Role of MFs will vary in accordance with the capacity of the breeding programs—for some MFs will take a leading project management role while for others MFs will support a breeding program TTSS implementation team or project manager.
9. Locally tailored support will be able to overcome the barriers to TTSS adoption, and increase the number of breeding programs using TTSS.
10. Leadership and cultural changes are needed within breeding programs as the adoption of TTSS transforms the role of the breeder into a leader of multidisciplinary blended internal and external teams of experts with greater use of business management of roles and deliverables.
11. Experiential learning of those seeking to adopt TTSS from those already using TTSS will improve knowledge and create relationships that can support TTSS adoption.
12. Access to the latest knowledge, including refinements of TTSS, will increase adoption of TTSS as breeding programs are able to apply knowledge to resolving implementation challenges.
13. Use of TTSS will reduce the cost of breeding relative to the quality of the varieties
14. Use of TTSS will increase the speed of breeding. Cycle times can be reduced.
15. TTSS will increase the quality of varieties. This includes varieties that have multiple and complex trait combinations to meet diverse climate, end user and stakeholder needs.
16. Breeding programs may have low readiness for TTSS adoption for a range of reasons (funding, infrastructure, skills). Increasing readiness will require an approach that is specific to the context of the breeding program.
17. Modernization Facilitators can work with breeding programs to identify the most appropriate pathway to modernization and make progress along that pathway.
18. Increased readiness for TTSS, either directly or in partnership with other breeding programs, will position breeding programs for later adoption of TTSS.
19. Increased adoption of TTSS is a reflection of increased capacity.

3.2.2 Work Package research plans and TOCs

- ***WORK PACKAGE 1: STRATEGIC MODERNIZATION***

Work Package title	**STRATEGIC MODERNIZATION**
Work Package main focus and prioritization	To guide informed decisions in CGIAR-NARS modernization investments ● Oversight of TTSS Strategic Plan by TAC. ● Breeding simulations for optimized breeding pipeline design according to quantitative genetic principles. ● Modelling of TTSS adoption and benefits across the CGIAR-NARS breeding network. ● Budget forecasting for management of the breeding product portfolio and for operational improvements.
Work Package geographic scope (Global/Region/Country)	Global

The Science

Research question or problem	**Scientific method/s or activities**	**Outputs**	**Key output/s**
How can we generate optimized breeding program designs for each crop prioritized by ABI that operates at the limits of biological and logistical constraints?	Breeding simulations guided by quantitative genetic principles	Formation of a dedicated team that conducts breeding simulations guided by quantitative genetic principles	Breeding simulation results
What are the top priorities (TTSS with maximized impacts) for breeding modernization across the CGIAR-NARS network and for each region?	Breeding program simulations Regional surveys and consultations on operation support networks (see WP5)	Simulation results Meta-analysis of simulations to identify CGIAR scale priorities Assessment of demand for services by region/type of organization	TTSS Strategic Plan
What are the opportunities and constraints to evolving shared services into a full cost recovery model?	Assess current and potential market demand (internal and external), competitiveness of services, willingness and ability to pay and the resources and structures required.	TTSS Business Planning	TTSS Strategic Plan
What is the forecasted budget needed for developing a variety to fulfil product profile X by breeding program Y? (collaboration with MIPP WP4)	Development of a validated cost structure for operational activities for each crop. Breeding program costing	Global cost structure by crop and region Financial forecasts for breeding program	Cost structure database Costing and forecasting tool
Can the application of TTSS be modelled across the CGIAR-NARS network to identify priorities and expected results?	Modelling of TTSS adoption	CGIAR-NARS model of TTSS (note: this will contribute to MELIA and updated projection of benefits)	CGIAR-NARS modelling results

The theory of change

There are several options for modernizing breeding with competing technologies and tools available. Significant resources are invested in generating data across the CGIAR-NARS breeding network, however, growing misalignment between technologies and tools as programs individually modernize is fragmenting the network, threatening data compatibility and limiting research outcomes. A coordinated breeding network that can share knowledge across regions, needs compatible data for cross and meta-analyses. The need for such global and long-term data sets has never been so pressing. Climate change will require varieties to be assessed under forecast conditions to prioritize parents accordingly and historical and cross-regional breeding results can provide valuable, time saving insights, if the data is available and compatible.

Strategic Modernization aims to guide informed investment in CGIAR-NARS modernization. A TTSS Strategic Plan will be developed under the guidance of a multi-stakeholder Technical Advisory Committee (TAC) (see WP5 for further details) and be informed by meta-analysis of ABI WP3 BPAT results and extensive regional input to create commitment and ownership. Broad support for the plan will reduce disparate investments in conflicting TTSS and align efforts to maximize the utility and legacy of all breeding research. The TTSS Strategic Plan is a major stage gate and will prompt refinement to all N4ETTSS WPs. The plan will deliver on the Eschborn principles of big lifts, rigorous priority setting, financial realism, transparency and embed principles such as defined success metrics in a shared agenda with stage-gating to further ensure improvements in breeding programs are maximized.

Crucially, the plan will focus breeding program investments to a common set of TTSS and encourage adoption of TTSS, bringing forth the benefits of breeding modernization. These outcomes will assist ABI, as the main primary beneficiary of N4ETTSS, to maximize its impact on global challenges.

A model of TTSS investment across the CGIAR-NARS network will inform the TTSS Strategic Plan by identifying the most appropriate package of TTSS for a unified, integrated CGIAR-NARS breeding network that connects with small to medium enterprises. The model will also inform more detailed projection of benefits and MELIA.

Modelling of TTSS in the CGIAR-NARS network will also develop consistent financial forecasting capability for breeding programs. N4ETTSS will harmonize the cost structure of operations across the CGIAR-NARS network. This will support global forecasting, program and portfolio scales of planning with responsiveness to changing demands (e.g., new product profiles) and informed capacity design by CGIAR management. Improved financial acumen will further enable management decisions that improve cost effectiveness of breeding and increase transparency in the value generated by funder investments.

ABI WP3, ABI WP5, EiB's BPAT results, and this proposal's regional consultation findings are important inputs to this WP. As ABI expands BPAT-like assessments and modernization plans to NARS, this WP will provide breeding simulations for individual breeding programs (see Annex A for examples). The simulations will inform breeding program decisions, increasing variety performance gains. The value of simulation has been validated at a smaller scale by the EiB Platform, which has piloted such support to champion programs within each crop. A team of quantitative geneticists and biometricians will engage with breeding teams to identify areas that can be improved and be translated into greater genetic and economic performance. The results will validate the benefits of simulations and further encourage TTSS adoption.

A diagrammatic summary of the Strategic Modernization WP is provided in Annex B.

- ***WORK PACKAGE 2: COST-EFFECTIVE SHARED SERVICES***

Work Package title	**COST-EFFECTIVE SHARED SERVICES**
Work Package main focus and prioritization	To reduce the cost of TTSS, making modernized breeding more accessible with shared services across the global CGIAR-NARS network. This WP objective applies CGIAR-NARS combined purchasing power, enables the generation of quality and consistent data across the breeding network and coordinates analytics expertise to maximize TTSS accessibility and impact to breeding programs. Shared services will be established for: ● Genotyping ● Sequencing ● High throughput phenotyping (HTP) ● Quality and biochemical testing (nutritional traits, soil analyses) ● Biometrics ● Bioinformatics
Work Package geographic scope (Global/Region/Country)	Global

The Science

Research question or problem	**Pathway**	**Scientific method/s or activities**	**Outputs**	**Key output/s**
How can commercially available TTSS be accessed more cheaply?	Collective bargaining	The scientific methods and outputs vary in response to current market failure and comparative advantage(see Annex B). Shared Services will draw on the combined market strength of the CGIAR-NARS network to facilitate cheaper access to external suppliers, increasing the cost-competitiveness of TTSS. For example: ● EiB has negotiated favorable pricing for low and mid density genotyping through Intertek and DaRT. ● Similarly, genome sequencing for all of CGIAR is currently sourced through Corteva.	TTSS Procurement Team	One CGIAR Shared Services Unit
How can existing capacity and resources be more cost-competitive and effective?	Institutional innovation	This will require research to further develop TTSS for regional applications (by Specialist Technical Support Teams) along with organization of existing capacity into Functional Teams. For example: ● Breeding analytics function with biometricians to provide best in class statistical support both in season and in improvement efforts. ● Bioinformatics that specializes in development and updating of marker panels, removing genotyping and marker usage as a modernization barrier.	TTSS Functional Teams	
What TTSS adaptations are needed to mainstream NARS use of TTSS?	Specialist Technical	Dedicated Specialist Technical Support (STS) will address technical barriers to TTSS adoption through	Specialist Technical	

	Support (STS)	innovation scaling projects identified by the TAC and Modernization Facilitators in WP5. These research projects will promote adoption by: ● improving the cost-effectiveness of current CGIAR-NARS TTSS ● tailoring and refining innovations where possible, further reducing the costs of TTSS The STS team will actively improve the readiness of less developed Innovation Packages.	Support (STS)	

The theory of change

Cost is a significant barrier to adoption of breeding modernization, particularly in NARS. Poor adoption of TTSS prevents timely development of higher yielding, more nutritious and climate ready varieties and perpetuates poverty, hunger and inequalities. This WP will reduce the cost of TTSS, making modernized breeding more accessible.

The two main assumptions underpinning this WP are that cost is limiting widespread uptake of TTSS (validated during consultation); and that as access to TTSS is improved, technical support will be needed to overcome practical, operational challenges to TTSS adoption (supported by consultation findings).

Regional consultation has identified in-demand TTSS and EiB has identified TTSS with the greatest potential to improve effectiveness (higher performing varieties) and efficiency (cost to develop varieties) of breeding programs. Once the priority TTSS are confirmed by the TTSS Strategic Plan, The One CGIAR Shared Services Unit will apply a decision flow chart to identify the most appropriate pathway to reduce cost of each TTSS, and oversee the Procurement Team, Functional Teams and Specialist Technical Support Team.

Costs can be reduced through collective bargaining, drawing on the comparative advantage of the CGIAR-NARS network to negotiate with suppliers. The TTSS Procurement Team will reduce costs of commercially available TTSS to encourage adoption, while WP3 and 5 will work to overcome other barriers to adoption. Increased TTSS adoption will deliver modernization benefits; improved performance of varieties, quicker variety development and improved cost-effectiveness.

Where existing capacity and resources within CGIAR are not distributed or available across the CGIAR-NARS network, institutional innovation will coordinate and prioritize resource allocation. This will address the System Reference Group Recommendation 3 Institutional Integration, part b - One CGIAR Policies and Services. Harmonization of internal business systems will involve organizational changes to HR structures, financial arrangements, and site operations. The resulting Functional Teams will improve TTSS accessibility, enabling adoption. It will also equitably provide all CGIAR breeding programs with support on three key analytics capabilities that have been prioritized by ABI: realized genetic gain estimation, genomic breeding value estimation, and target profile environment analyses.

In some cases, a TTSS may be predicted to have significant benefits, but capacity to service the CGIAR-NARS network is not available. Functional Teams for newly targeted TTSS will be established to increase collective capacity and resources available to the CGIAR-NARS network and increase access. WP5's Modernization Facilitators will further assist breeding

programs to access technical support and overcome implementation challenges, leading to increased adoption of TTSS.

The core innovations in WP2 are advanced with some already used by a few CGIAR-NARS breeding programs (high innovation readiness). Initially core innovations will be prioritized based on in-demand needs and greatest economic and effectiveness (genetic gain) benefits for the CGIAR-NARS network. The immediate innovation and scaling partners are ABI and breeding programs in the CGIAR-NARS network.

The systems and structures established will be designed for future expansion beyond the CGIAR-NARS network, post 2025. Full Innovation and Scaling Plan development is a top priority (first wave) for WP2 to identify unforeseen bottlenecks, develop a strategy for broader adoption of TTSS beyond the CGIAR-NARS network, and plan for service maintenance post 2025 (working towards cost recovery and potential for external clients).

Ultimately, success of WP2 will be the widespread adoption of the targeted TTSS across CGIAR-NARS and collective costs saved. WP5 will also make a significant contribution to this outcome. Data will be contributed from WP1 modelling, and WP3's Breeding Pipeline Improvement Monitoring System (BPIMS).

Modernization will mean earlier intervention with genetic solutions to global issues such as nutrition, hunger and climate change, reducing how long people are impacted by these issues. Modernization will also improve the cost-effectiveness of breeding programs, including those in ABI, enabling more to be achieved with the funding and resources available.

A diagrammatic summary of the WP is provided in Annex B.

- ***WORK PACKAGE 3: MONITORING OF CONSISTENT, CONNECTED OPERATIONS***

Work Package title	**MONITORING OF CONSISTENT, CONNECTED OPERATIONS**
Work Package main focus and prioritization	To motivate and guide continuous improvement of breeding programs. A dedicated Process Management team will support breeding programs and data management IT teams in describing, harmonizing, and adopting standard operating protocols, workflow charts, and quality controls across the breeding networks. These activities will result in: ● Standardized protocols shared in a common system ● Harmonized operations enabling consistent data generation ● Adoption of quality management systems within facilities ● Breeding Pipeline Improvement Monitoring System (BPIMS) established to track key indicators and outcomes of operational and breeding performance
Work Package geographic scope (Global/Region/Country)	Global

The Science

Research question or problem	**Pathway**	**Scientific method/s or activities**	**Key Outputs**
To what extent will standardized operations improve the performance of the CGIAR-NARS breeding network?	Standardized operations	A Process Model will structure the complexity of breeding processes across the organization and thus provide a resilient framework for continued improvements in organization, execution excellence and technology.	Breeding Process Model Dedicated Process Management Team

		A formal Process Management team will be established to manage this Process Model and support reliable delivery of breeding varieties through sustained and rigorous operations management. The team will support breeding programs in defining the process model for breeding operations that captures and structures complex relationships to enable transparent business analysis. The team will support standardization of breeding program operations and will harmonize and improve processes, unlocking the potential for further innovation through scaling, proving and coordinating (increased compatibility)[38] The team will foster transparent decisions on process changes and improvements based on data.	SOPs, workflows, quality controls, and change control process defined
How can the profile and materiality of MELIA be raised so it is actively used in decision-making and operations?	Improvement monitoring	A Breeding Pipeline Improvement Monitoring System (BPIMS) will define indicator results for each breeding program, with comparison to the average results from other programs, generating insights on the relative strengths and weaknesses of each breeding program, which can then be used to target ongoing improvements. The BPIMS will generate an annual dashboard to report on a range of informative metrics spanning the breeding pipeline with design input from ABI. It will complement the investor dashboard (MIPP WP4). Together the two dashboards will demonstrate leadership on the SDGs and apply a corporate social responsibility ethos of taking responsibility not just for the development and production of new varieties, but also the downstream impacts of new varieties. This whole-of-value chain approach to performance monitoring will require data from other Initiatives, including ABI, SeEdQUAL, MIPP and all WPs in N4ETTSS.	Breeding Pipeline Improvement Monitoring System & associated Dashboard Report Cards
To what extent can increased transparency on Impact Area contribution from breeding motivate improved performance on impacts?	Performance Management	A MELIA study will test the assumption that increased transparency of performance will motivate improvements. The Initiative scope targets prioritized breeding programs for support, and as such programs can be compared	MELIA study report

The theory of change

CGIAR MELIA was identified as inadequate in the CAS Evaluation and has been an ongoing challenge for CGIAR-NARS. There are innumerable metrics that can be measured at significant cost. However, informative performance monitoring requires reducing the complexity of breeding activities to the core metrics that are material for decision-making, as aligned to shared goals. Performance monitoring will track implementation of standardized processes and quality of operations along with modernization progress and the impacts of the resulting breeding products. The BPIMS will generate monitoring results that will inform

evaluation by the TAC and contribute to a Mid-term Review. This recognizes the distinction between gathering data (monitoring) and the thinking process of interpreting and applying judgement to data to generate findings and learning (evaluation). See MELIA for further information.

Standardization of processes goes hand-in-hand with monitoring and will increase innovation[39] and TTSS adoption. The N4TTSS industry consultation found that 89% of respondents would adopt a unified cross-CGIAR system to share standard operational procedures. A dedicated Process Management team will provide support to programs in standardizing protocols and harmonizing operations. Standard operating protocols (SOPs), workflow charts, and quality controls will be developed to guide adoption of best practice for a range of outcomes, including minimum standards for health, safety and environment. Improvements to staff wellbeing and minimized environmental impacts from breeding programs will demonstrate leadership on the Impact Areas, with breeding programs, including trial sites, showcasing responsible operations to farmers in their respective regions.

Standardization of operations across scales and regions will underpin use of TTSS in WP2 and adoption of the Data Management System (DMS) in WP4, ensuring consistent compatible data of high integrity can be brought together into a global resource for multi-environment analysis, speeding up development of climate-ready varieties and preparing for future pest and disease resilience. High data quality is foundational increased data use in modernized data driven breeding programs, that are cost-effective and can quickly develop high performing varieties. For some breeding programs, SOPs, best practices and quality controls will increase skills, in preparation for future adoption of TTSS, increasing innovation, readiness and NARS capacity.

WP3 will motivate and guide continuous improvement of breeding programs through a high-profile, corporate-like holistic Breeding Pipeline Improvement Monitoring system (BPIMS) with transparent monitoring across the CGIAR-NARS network. Performance will be reported at whole of network and breeding program scales, increasing accountability for results, motivating improvements and fostering a culture of continuous improvement for ongoing performance gains. The Process Management team will provide expert advice to the Modernization Facilitators and change management functions (WP5) to support breeding program management to shift towards common indicators. An example of the BPIMS dashboard report is provided in Annex B and further MELIA details in 6.2.

The BPIMS is a non-technical core innovation, founded on the assumption that increased awareness and knowledge on performance, with transparent benchmarking, will motivate improvements. The initial focus will be metrics associated with N4TTSS outcomes of improved cost-efficiency of breeding programs using input from WP1's modelling. As the BPIMS is further developed, it will need additional input from a range of different groups and supporting policy settings with the CGIAR-NARS breeding network. As such, Principle 5 of the Innovation and Scaling Readiness Plan is of special relevance and will guide detailed partner engagement strategies.

WP3 will provide monitoring results for the other WPs, and other GI Initiatives. The BPIMS results generated will enable informed stage-gating of N4ETTSS and reprioritization of activities through annual internal performance reviews with input from the TAC.

- ***WORK PACKAGE 4: SMARTER USE OF MORE DATA***

Work Package title	**SMARTER USE OF MORE DATA**
Work Package main focus and prioritization	To enable CGIAR-NARS to 1) share standardized data, creating larger more powerful data sets that can be 2) readily analyzed and interpreted for routine and strategic decision-making. WP 4 priorities are: ● A Data Management System (DMS) that enables collection, curation, and analysis of data; facilitates meta-analysis of the data generation process, and structure documentation for institutional memory. ● On the ground user support network for data management and DMS adoption
Work Package geographic scope (Global/Region/Country)	Global

The Science

Research question or problem	**Scientific method/s or activities**	**Key Outputs**
What DMS is needed for data capture and analytics to transform breeding?	Design and develop a slim cross-functional organizational structure that manages data governance rules Design, develop and establish the Enterprise Breeding System with the following features: ● centralized deployment and support ● local access and control ● advanced experimental design ● support for digitization tools ● automated data processing and analysis pipelines ● sample management ● genotype data management ● program management The DMS will be connected to a business intelligence tool with visualizations and interpretative tools to guide routine breeding decisions. It will enable joint development and interoperability between data management systems in use in the CGIAR-NARS network The DMS will need to connect the development and sustainable management of the Enterprise Breeding System (EBS), Breeding Management System (BMS) and Breedbase.	Data governance rules Data Management System(s) Dedicated Breeding IT team
How can improved data management be readily implemented and mainstreamed by the CGIAR-NARS breeding network?	With the existing Integrated Breeding Program network as a base, build a centrally managed but regionally implemented cross-crop service that will support DMS adoption and implementation, including: ● digitization of data collection workflows ● curation of data ● training ● timely and responsive in-season user support ● expertise on digitization equipment ● end-to-end data management	Regional DMS Support network with state-of-the-art data management strategies and practices

The theory of change

Modern breeding produces large volumes of genotype and phenotype data that must be processed, analyzed, interpreted, and applied to decision-making in short turnaround times. A reliable, responsive and future-looking Data Management System (DMS) is needed if the effectiveness gains from technological advances such as high-throughput genotyping, data digitization, and high-throughput phenotyping are to be realized. In the absence of sophisticated data processing that reduces manual entry, allows user-driven analytics and delivers interpretative visualizations, the full benefits and return on investment from modernization will not be harnessed.

N4ETTSS will transform CGIAR-NARS breeding into a data driven, highly targeted and efficient response to global challenges. This WP will enable CGIAR-NARS to contribute standardized data into larger more powerful data sets that can be readily analyzed and interpreted for routine and strategic decision-making. It assumes that harnessing the full potential from the vast quantities of data collected during breeding will require a robust DMS, underpinned by governance of data ownership, access and sharing rules and with regionalized data management support. The DMS will be situated within a unified Breeding Information Technology (BIT) Strategy for the public breeding sector, ensuring it is designed for current and future BIT needs as part of an integrated CGIAR BIT package.

Regionally based and globally connected support services will work with breeding programs during time pressured harvest and decision-making windows to assist with efficient data entry using digitization tools (semi- and full automation) and software support. Timeliness of support services will be critical to preventing users from reverting to inefficient manual data entry and rudimentary analysis in generic software. This user support function will build on the existing network of data managers, user specialists and trainers established by the Integrated Breeding Platform (IBP) and EiB. Support services, combined with WP5's Modernization Facilitators and change management, will increase capacity to use DMS and enable organization of breeding information into bigger, more powerful data sets. These data sets can be used for multi-environment analysis that breeders can apply to improve breeding decisions. Improved decision-making will increase the precision of breeding selections to minimize waste and improve breeding cost-effectiveness. It will also increase the speed and rate of breeding improvements. For example, analysis across time and climatic zones will speed up development of climate ready varieties and preparedness for related threats (pests, diseases).

The DMS connects several key elements of N4ETTSS. SOPs (WP3) will promote high quality, consistent data for interrogation as part of a larger, collective data set. Improved access and use of TTSS (WP2) will generate large volumes of data that will need interpretative analytics for data driven decision-making. WP5 will support NARS adoption of data management practices, with tailored Modernization Facilitators support. The primary beneficiary of the DMS and associated support will be ABI.

DMS performance will be monitored through background metrics on how it is used by breeding programs, including ABI and the results monitored through the WP3 Dashboard Reports.

A diagrammatic summary of the WP is provided in Annex B.

- ***WORK PACKAGE 5: INNOVATION DEVELOPMENT AND RESEARCH EXCHANGE (Idare)***

Work Package title	**INNOVATION DEVELOPMENT AND RESEARCH EXCHANGE (Idare)**
Work Package main focus and prioritization	To increase global adoption of modernized breeding TTSS across the CGIAR-NARS network ● Change management plans

	● Regionalized capacity building ● Modernization facilitation for integration of regional capacity building investments into operations
Work Package geographic scope (Global/Region/Country)	Global

The Science

Research question or problem	Pathway	Scientific method/s or activities	Key Outputs
How can the barriers to adoption of TTSS be most effectively overcome?	All	Regional consultation with breeding programs to identify the technical process for implementing TTSS (Modernization Facilitation) and the barriers to TTSS adoption (change management support).	TTSS Change Management Support (Plans and advisors) Trained Modernization Facilitators
How can innovations from developed countries be brought into developing country contexts?	Innovation ecosystems (technology users)	Organization of the state-of-the-art TTSS from WP 1-4 into regionally tailored innovation ecosystems. Examples of new and emerging technologies in the innovation ecosystem include: ● Molecular markers ● HTP phenotyping (including automation and remote sensing technologies) ● Data management systems ● Business Process Management methods and principles	Facilitated global partnerships with private industry, vendors, and advanced research institutions Emerging innovation trials Facilitated Communities of Practice
What are the emerging innovations that can continue breeding program improvement?	Innovation ecosystems (technology users)	Technical Advisory Committee (TAC) will provide technical governance and leadership on emerging technologies. Includes annual technology prospecting consultation with GI Initiatives, TAC, private breeders, ARI and breeding programs to identify potential emerging TTSS	Technical Advisory Committee TTSS Strategic Plan BPIMS Dashboard Reports - TAC to critically review and look to problem solve gaps/shortfalls Annual technology prospecting report
How can adoption of TTSS be mainstreamed within the CGIAR-NARS breeding network? (i.e., adoption of ABI WP3 Breeding Program Modernization Plans)	Ready-for-change breeding programs	All TTSS identified in WP1, 2, 3, 4 Facilitate collaborations with STS teams (WP2) and Regional DMS Support (WP4) to regionally tailor innovations (Innovation scaling projects). Implementation of ABI WP3's breeding modernization plans that address multiple elements of TTSS in parallel with coordination of interdependencies for effectively staged improvements Regionalized capacity building	Dedicated Modernization Facilitators to guide breeding programs and assist with accessing technical support Innovation scaling projects Regional TTSS Change Management Plans Research exchange with innovation ecosystem
What capacity or resources are needed to increase	Low modernization readiness	Operations (both business operations, and field and	Regional Capacity Building Strategies

breeding program readiness?	breeding programs	breeding operations) support to prepare for future modernization Regionalized capacity building	

The theory of change

Adoption of modernized breeding is variable across the CGIAR-NARS breeding network, with the capacity and capital required to upgrade limiting widespread TTSS use with this slowing down variety development. Each additional year's delay in the delivery of improved varieties is another year of ongoing poverty, poor nutrition and other social impacts.

WP5 will increase global adoption of modernized breeding across the CGIAR-NARS network, through a dedicated Modernization Facilitators service for breeding modernization coupled with change management support.

- Modernization Facilitators will pragmatically support mainstreaming of the TTSS made available through WPs 2, 3 and 4 (the technical innovations); and
- Change management support will guide the ongoing cultural shift that is transforming the role of breeders into leaders of dynamic, expert-based multidisciplinary teams (the people).

WP5 applies the theories of technology diffusion and innovation ecosystems to create a strategic package of pathways, supported by the Modernization Facilitators and change management support teams. This assumes that:

- Readiness and capacity to adopt a specific TTSS will vary across breeding programs, with some being more advanced in one area of technology while lagging in another.
- Some breeding programs are able to invest and pilot innovations ahead of others (early adopters, technology users).
- Overtime as implementation challenges are overcome, TTSS is mainstreamed and adopted by more breeding programs (mid-term adopters or ready-for-change).
- The capacity of individual breeding programs can be increased through mainstreaming current innovations and building modernization readiness.
- Capacity of the network as a whole can be driven forward by developing new and emerging innovations with leading breeding programs, reducing the knowledge spillover lag.

The results of ABI's WP3 modernization readiness assessments will be used to group breeding programs into three broad technology adoption readiness levels (technology users, ready-for-change, and low readiness) for each TTSS. A tailored pathway will be used for each of these groups, empowering all breeding programs to improve relative to their current capacity and contribute to overall improved capacity of NARS and increased TTSS adoption in the CGIAR-NARS network.

1. **Technology users** will be engaged in a regionally tailored innovation ecosystem of skilled staff at breeding programs, STS teams (WP2), ARIs and private sector organizations. The innovation ecosystem will progress CGIAR-NARS knowledge and experience with emerging technologies, as identified by a Technical Advisory Committee (TAC) of private and public breeding pipeline experts and practitioners (including ABI). The TAC will
    - Lead annual technology prospecting, including review of discovery project ideas proposed by other GI Initiatives.

- Identify innovation discovery projects that will be coordinated by STS teams (WP2) and implemented as multi-partnered research in the innovation ecosystem.
- Identify opportunities for CGIAR-NARS collaboration or connection with external investments to leverage work done by universities, government research organizations in developed countries, vendors and private industry partners.
- Provide technical leadership input to WP1's TTSS Strategic Plan.
- Annually review WP3's BPIMS Dashboard.

This technical governance will maintain future looking innovation capabilities and continual improvement of N4ETTSS. Ongoing capacity development of technology users will be supported through increased opportunities for CGIAR-NARS input in ongoing TTSS advancements, connections and relationships that will improve access to breeding tools and other novel innovations and encouraged knowledge spillovers that are critical to leverage R&D investments in developed countries.[40]

2. **Ready-for-change breeding programs** (strong interest and existing capacity) have the most latent potential for improvement and impact. Individual Modernization Facilitators will provide locally tailored support to increase access to STS and solve TTSS implementation challenges, overcoming the barriers to TTSS adoption. The precise details of the Modernization Facilitators will be refined through an Innovation and Scaling Readiness Plan, with the six principles helping to identify potential bottlenecks and enabling conditions for mainstreaming TTSS. WP5 will lead Innovation Readiness and Scaling work for N4ETTSS.

   Capacity building activities, such as research exchange and mentoring, will connect ready-for-change breeding programs with advanced technology users, building relationships, increasing professional capacity, and improving access to technical specialists, further encouraging TTSS regionalized improvements.

3. **Breeding programs with low TTSS readiness** (due to a lack of resources, technical capacity, infrastructure, funding) will be individually supported to increase their readiness for future TTSS adoption. Regional-scale, holistic capacity building strategies will address the complex social and political underpinnings of lower capacity and identify sustainable, pragmatic pathways to modernization. This may include supporting NARS to gain access to external funding or redefining the role of these breeding programs within the CGIAR-NARS networks.

A diagrammatic summary of the WP is provided in Annex B.

4. Innovation Packages and Scaling Readiness Plan

4.1 Innovation Packages and Scaling Readiness Plan

For the purposes of Innovation and Scaling strategies the Innovation Packages to be developed fall into the following categories:

- Innovation Package 1: the TTSS to be delivered by N4ETTSS, including the DMS (WP1, 2, 4, 5).
- Innovation Package 2: TTSS Procurement Team and financial costing/forecasting capacity for breeding programs (WP1 and 2).
- Innovation Package 3: the BPIMS and standardization of outputs delivered by the Process Management Team (WP3).

These packages are at different stages of innovation and scaling readiness. For several, N4ETTSS builds on EiB and CtEH capacity and awareness. Mindsets have already shifted and there is demand for the Innovation Packages in WPs 1, 2, 3, 4. Several innovations (e.g., DMS, breeding simulation) have already been piloted by a subset of breeding programs (high innovation readiness). A few innovations will need further refinement for local, less resourced contexts to advance the innovations to uncontrolled conditions. The wave and track for Innovation and Scaling strategies has been informed by innovation readiness and innovation target audiences. The change management program described in WP5 takes a lead role in the development of Innovation Scaling and Readiness plans by examining Innovation Packages, tailoring packages to end-users, and supporting the other WPs to overcome bottlenecks.

First wave and standard track – Innovation Package 1 is end user focused so will benefit most from being in the first wave, standard track. This wave integrates with the Implementation phase of the Initiative. (see section 7.1).

First wave and light track – Innovation package 2 and breeding assessments in ABI will inform scaling readiness for the other Work Packages but is otherwise largely internally focused. This wave integrates with the Inception and Baseline phase of the Initiative. (see section 7.1).

Second wave and standard track – Innovation Package 3 will require additional time to design and establish the performance management system, and in the early phases of the Initiative will benefit most from Innovation Package design. It is a key legacy of the Initiative and provides a solid foundation for scaling beyond this Initiative. This wave integrates with the Legacy Preparation and Closure phase of the Initiative. (see section 7.1).

The Initiative aims to apply the Innovation Packages and Scaling Readiness approach to 76-100% of the total Initiative innovation portfolio by the end of 2024.

The Initiative allocated US$1,950,000 to implement the Innovation Packages and Scaling Readiness plan (2022: US$650,000; 2023: US$650,000; 2024: US$650,000). Dedicated activities, deliverables, indicators and line-items are included in the Management Plan, MELIA and Budget Sections.

5. Impact statements

5.1 Nutrition, health & food security

- ***Challenges and prioritization***

There are several components of nutrition, health and food security that can be addressed through improved varieties. The specifics of breeding interventions are informed by in-country contexts such as culture, prevalent health or nutritional issues and crops with greatest potential impact on the targeted beneficiaries. This strategic prioritization is best led by MIPPI and implemented by ABI.

Breeding improved varieties can have a significant effect on nutrition, health, and food security. E.g., Cassava breeders at CGIAR have successfully introgressed high carotenoid into elite cassava germplasm at a rate of 8.2% a year in genetic gain.

N4ETTSS will improve access to TTSS, enabling ABI and breeding programs to meet strategic nutrition, health and food security priorities and deliver impacts effectively and efficiently.

- ***Research questions***

To what extent can increased transparency on Impact Area contribution from breeding motivate improved performance on impacts?

- ***Components of Work Packages***

All WPs will be increasing adoption of TTSS across the CGIAR-NARS breeding network, with modernization increasing impacts of breeding programs either by bringing forward results or improving the results achieved.

WP 3 will take a leading role in monitoring the performance of breeding programs, including performance of the products released.

- ***Measuring performance and results***

Developing a new improved variety to release can take up to 10 years, with additional time for adoption (i.e., significant time lags and assumptions to measure performance). To overcome: the BPIMS will monitor progress across the breeding process for each EOI outcome and Impact Areas; and modelling of TTSS adoption to forecast expected results. The relevant SMART outcomes are:

- Cost-effectiveness is improved at 70% of ABI's targeted breeding programs by at least 25%
- Performance of varieties is improved with the average age of varieties in farmers' fields reduced for 50% of ABI's targeted crops to below 15 years
- Quicker variety development with breeding cycle to biological limits reduced at 70% of ABI's targeted breeding programs by at least 30%

- ***Partners***

ABI, CGIAR-NARS, other GI Initiatives

- ***Human resources and capacity development of Initiative team***

See Section 9.

5.2 Poverty reduction, livelihoods & jobs

- ***Challenges and prioritization***

There are several ways that breeding solutions can reduce poverty and improve livelihoods and jobs. Most commonly, contribution will occur through increased production. E.g., although the number of adopters of improved cassava varieties seem modest (6-15%) they could account for 30 to 50% of the overall crop production. In some cases, breeding can increase properties or improve traits for harvesting, processing, or manufacturing of products. Regionalized strategic prioritization is best led by MIPP and implemented by ABI, using TTSS made available through N4ETTSS. N4ETTSS will enable ABI and breeding programs to meet strategic poverty, livelihoods and jobs priorities and deliver impacts effectively and efficiently.

- ***Research questions***

To what extent can increased transparency on Impact Area contribution from breeding motivate improved performance on impacts?

- ***Components of Work Packages***

All WPs will be increasing the adoption of TTSS across the CGIAR-NARS breeding network, with modernization increasing the impacts of breeding programs either by bringing forward results or improving the results achieved.

WP 3 will take a leading role in monitoring the performance of breeding programs, including performance of the products released.

WP 5 will make a direct contribution to improving livelihoods and jobs of those working in breeding programs through its capacity building activities. Adoption of TTSS will require skill development, increasing the job opportunities for those trained in modernized breeding.

- ***Measuring performance and results***

Developing a new improved variety to release can take up to 10 years, with additional time for adoption (i.e., significant time lags and assumptions to measure performance). To overcome: the BPIMS will monitor progress across the breeding process for each EOI outcome and Impact Areas; and modelling of TTSS adoption to forecast expected results. The relevant SMART outcomes are:

- Cost-effectiveness is improved at 70% of ABI's targeted breeding programs by at least 25%.
- Performance of varieties is improved with the average age of varieties in farmers' fields reduced for 50% of ABI's targeted crops to below 15 years.
- Quicker variety development with breeding cycle to biological limits reduced at 70% of ABI's targeted breeding programs by at least 30%.

- ***Partners***

ABI, CGIAR-NARS, other GI Initiatives

- ***Human resources and capacity development of Initiative team***

See Section 9.

5.3 Gender equality, youth & social inclusion

- ***Challenges and prioritization***

There are several ways that breeding solutions can improve gender equality, youth and social inclusion. The precise opportunity for impact is culture, crop, and region specific. For example, cassava breeding can improve root architecture, reducing the physical strength required to lift tubers making cassava a possible option for women smallholders. However, identifying strategic priorities is best led by MIPP and implemented by ABI, using the TTSS made available through N4ETTSS. N4ETTSS will enable ABI and breeding programs to meet strategic gender, youth and social inclusion priorities and deliver meaningful impacts effectively and efficiently.

- ***Research questions***

To what extent can increased transparency on Impact Area contribution from breeding motivate improved performance on impacts?

- ***Components of Work Packages***

All WPs will be increasing the adoption of TTSS across the CGIAR-NARS breeding network, with modernization increasing the impacts of breeding programs either by bringing forward results or improving the results achieved.

WP 3 will take a leading role in monitoring the performance of breeding programs, including performance of the products released. This will collate data from across the Initiatives and other CGIAR investments and report the results in an informative dashboard.

Gender will also be directly addressed. WP 1 will review the gendered impacts of the TTSS innovations as part of its TTSS and benefits modelling. WP 5 will promote women's participation in capacity building activities by designing female appropriate training (timing, location, format) that allows women to balance their work and non-work responsibilities.

- ***Measuring performance and results***

Developing a new improved variety to release can take up to 10 years, with additional time for adoption (i.e., significant time lags and assumptions to measure performance). To overcome: the BPIMS will monitor progress across the breeding process for each EOI outcome and Impact Areas; and modelling of TTSS adoption to forecast expected results. The relevant SMART outcome is:

- CGIAR-NARS leadership on Impact Areas demonstrated by improvement at 70% of ABI's targeted breeding programs in at least 50% of Impact Area tracking indicators

- ***Partners***

ABI, CGIAR-NARS, other GI Initiatives

- ***Human resources and capacity development of Initiative team***

See Section 9. Capacity development will include specific emphasis on women's participation in breeding decisions, as incorporated in change management (WP5), process management (WP3) and Modernization Facilitation (WP5). Mentoring will occur through research exchange (WP5) and Communities of Practice (WP5).

5.4 Climate adaptation and mitigation

- ***Challenges and prioritization***

Climate adaptation increases the complexity of traits that need to be combined to produce improved varieties. Modernized breeding that uses TTSS is the only way to deliver improved varieties that are climate adapted in a timely manner[41]. The specific combination of traits needed will vary with each crop based on regional forecasts for climate, pests and diseases. Identifying strategic priorities is best led by MIPP and implemented by ABI, using the TTSS made available through N4ETTSS. N4ETTSS will enable ABI and breeding programs to meet strategic climate adaptation priorities and deliver meaningful impacts effectively and efficiently.

- ***Research questions***

To what extent can increased transparency on Impact Area contribution from breeding motivate improved performance on impacts?

- ***Components of Work Packages***

All WPs will be increasing the adoption of TTSS across the CGIAR-NARS breeding network, with modernization increasing the impacts of breeding programs either by bringing forward results or improving the results achieved.

WP 3 will take a leading role in monitoring the performance of breeding programs, including performance of the products released. This will collate data from across the Initiatives and other CGIAR investments and report the results in an informative dashboard.

- ***Measuring performance and results***

Developing a new improved variety to release can take up to 10 years, with additional time for adoption (i.e., significant time lags and assumptions to measure performance). To overcome: the BPIMS will monitor progress across the breeding process for each EOI outcome and Impact Areas; and modelling of TTSS adoption to forecast expected results. The relevant SMART outcome is:

- Increased capacity to address climate change, with data driven breeding at 70% of ABI's targeted breeding programs at more than one decision point.

- ***Partners***

ABI, CGIAR-NARS, other GI Initiatives

- ***Human resources and capacity development of Initiative team***

See Section 9.

5.5 Environmental health and biodiversity

- ***Challenges and prioritization***

Improved environmental health and biodiversity can result directly from improved varieties (e.g., greater pest resistance reduces chemical use), and indirectly by increasing productivity on arable land to reduce pressure on marginal lands and land clearing. The prioritized traits for each crop and region will need to be reviewed for environmental impacts, and this is best led by the MI and implemented by ABI, using the TTSS made available through N4ETTSS. N4ETTSS will provide access to the TTSS for ABI and breeding programs to meet strategic priorities and deliver meaningful impacts effectively and efficiently.

A minor direct impact will occur though operational standards for field trials (WP3). These trial sites are often local exemplars of best practice, used for local capacity building.

- ***Research questions***

To what extent can increased transparency on Impact Area contribution from breeding, motivate improved performance on impacts?

- ***Components of Work Packages***

All WPs will be working towards increasing the adoption of TTSS across the CGIAR-NARS breeding network, with modernization increasing the impacts of breeding programs either by bringing forward results or improving the results achieved.

WP 3 will monitor the performance of breeding programs, including performance of the products released. This will collate data from across the Initiatives and other CGIAR investments and report the results in an informative dashboard.

WP 3 will also develop standardize operational guides, including minimum environmental management standards for field research.

- ***Measuring performance and results***

Developing a new improved variety to release can take up to 10 years, with additional time for adoption by targeted populations (i.e., significant time lags and assumptions to measure performance). To overcome: the BPIMS will monitor progress across the breeding process for each EOI outcome and Impact Areas; and modelling of TTSS adoption to forecast expected results. The relevant SMART outcome is:

- Increased capacity to address climate change, with data driven breeding at 70% of ABI's targeted breeding programs at more than one decision point.

- ***Partners***

ABI, CGIAR-NARS, other GI Initiatives

- ***Human resources and capacity development of Initiative team***

See Section 9.

6. Monitoring, evaluation, learning and impact assessment (MELIA)

The MELIA details provided below are preliminary. Work is ongoing on the GI Action Area (AA) outcomes, and once these are confirmed refinement of GI AA indicators is expected.

MELIA planning for the purposes of this proposal template and within the time restraints, has omitted the critical step of describing and defining success, including setting rubrics for Initiative outcomes[42]. The absence of articulated descriptions of success has limited the identification of breeding pipeline improvement indicators that capture both quality and quantity gains. Currently, the majority of indicators used in the result framework are standard indicators.

More specific breeding indicators will need to be developed for ambiguous outcomes such as capacity. Further complicating this, the combination of the breeding pipeline and the TOC creates a third dimension of breeding indicators, if the results are to be material for breeding program management decisions. It is intended that the BPIMS will lead this complex design work, to establish breeding specific metrics for the GI AA in collaboration with the other Initiatives.

N4ETTSS faces significant MELIA challenges associated with contribution and time lags.

Contribution: End impacts from N4ETTSS will result from a combination of investments, including the other GI Initiatives. Contribution analysis that applies a 'plausible association' and recognition of other factors influencing impacts will benefit from a series of detailed tracking indicators that demonstrate improvement to speed and precision through the breeding pipeline as a result of N4ETTSS[43]. These indicators will be developed in the inception phase, as part of BPIMS.

Time lags: Time is just one factor that means that MELIA must embrace the complexity of N4ETTSS and its causal pathways[44]. There is an extended time between N4ETTSS activities and final impacts for smallholders. While adoption of modernized breeding will reduce this time lag, impacts will still only be measurable after the conclusion of the current three years of funding, well after reporting to CGIAR and funders is required for N4ETTSS accountability and learning. To overcome this, N4ETTSS has incorporated a detailed modelling exercise in WP1. Modelling will be used to forecast and report the impacts expected in 2035 (10 years after the current Initiative is scheduled to end).

6.1 Result framework

CGIAR Impact Areas				
Nutrition, health and food security	**Poverty reduction, livelihoods and jobs**	**Gender equality, youth and social inclusion**	**Climate adaptation and mitigation**	**Environmental health and biodiversity**
Collective global 2030 targets				
The collective global 2030 targets are available centrally here to save space.				
Common impact indicators that your Initiative will contribute to and will be able to provide data towards				
# people benefiting from relevant CGIAR innovations	# people benefiting from relevant CGIAR innovations	# women benefiting from relevant CGIAR innovations	# people benefiting from climate-adapted innovations	# ha under improved management

Action Area title (Systems Transformation/ Regional Agrifood Systems/Genetic Innovation)	
Action Area outcomes	**Action Area outcome indicators**
GI 4 - CGIAR & partner breeding programs use best practices and shared services to rapidly and efficiently produce new varieties with in-demand traits.	Gii 3.2 Increase in the capacity of CGIAR-NARES-SME breeding networks
GI 3 - CGIAR & partner breeding programs use state-of-the art technologies to accelerate variety development and quality.	Gii 3.2 Increase in the capacity of CGIAR-NARES-SME breeding networks
GI 2 - CGIAR & partners use high-quality market intelligence to guide the development of new varieties to meet the needs and expectations of a wide-range of users, with special attention to marginalized groups.	GIi 2.1 Proportion of new released varieties developed in alignment with market intelligence-informed product profiles
GI 5 - Cooperation and co-investment by CGIAR, public- and private-sector seed-system actors support coordinated and effective research and investment in the sector	Gii 5.1 Number of genetic innovations commercialized through public/private sector cooperation agreements.
	Gii 5.2 Number of public/private sector cooperation agreements
ST & RAFS & GI 1 Women and youth are empowered to be more active in decision making in food, land and water systems	STRAFSGIi 1.3 Number of farmers who grow market intelligence-informed new crop varieties, disaggregated by gender and age.

Initiative and Work package outcomes, outputs and indicators								
Result type (outcome or output)	**Result**	**Indicator** GI indicators are noted with precursor 'GII' All indicators are **global** in geographic scope and will be measured on an **annual basis**.	**Unit of measurement**	**Data source or data collection method**	**Baseline value**	**Baseline year**	**Target value**	**Target year** (end of)
EOI Outcome	Improved cost-effectiveness of breeding	Cost of variety development: Area weighted average age of varieties in farmers' fields forecast for 2035 (10 years after Initiative ends)	Ratio	Costing tool developed in WP1 KPIS on breeding speed, age of parents, and breeding accuracy, gathered from BPIMS Forecasting function	NA	2022	70% of ABI's targeted breeding programs will be improved by at least 25%	2024
EOI Outcome	Improved performance of varieties	Area weighted average age of varieties in farmers' fields forecast for 2035 (10 years after Initiative ends)	Generic number	KPIS on breeding speed, age of parents, and breeding accuracy, gathered from BPIMS Forecasting function	NA	2022	Below 15 years for 50% of ABI's targeted crops	2024
EOI Outcome	Quicker variety development	Length of breeding cycle: biological and logistical limit (Note, a good result is closer to a ratio of 1 and below 1 is not possible.)	Ratio	Survey to be conducted in October 2022 by EiB Module 2	NA	2022	70% of ABI's targeted breeding programs will improve their breeding cycle to limit ratio by 30%	2024
EOI Outcome	Increased capacity of NARS	Access to TTSS through N4ETTSS and number of times per year	Generic number	EiB Module 3, 4, and 6 gap analyses, example here	NA	2022	70% of ABI's targeted breeding programs, with at least 15	2024

							different NARS accessing more than one type of TTSS through N4ETTSS	
EOI Outcome	Ongoing breeding program improvement	Number of breeding programs increasing their modernization targets each year	Generic number	existing continuous improvement plan	0	2022	70% of ABI's targeted breeding programs increase at least one modernization target by 2025	2024
EOI Outcome	CGIAR-NARS leadership on Impact Areas	Number of Impact Area tracking indicators in BPIMS improved BPIMS tracking indicators for Impact Areas will include: ● proportion of professional roles within targeted breeding teams occupied by women ● proportion of people contributing to major breeding decisions that are women	Generic number	BPIMS	0	2022	70% of ABI's targeted breeding programs improve in at least 50% of Impact Area tracking indicators in BPIMS	2024
EOI Outcome	Improved capacity to address climate change	Number of breeding programs making data driven decisions using genomic, phenotypic and environmental data at more than one major decision point (parent selection, advancement, experimental design, marker-trait association)	Generic number	Survey	NA	2021	70% of ABI's targeted breeding programs will make data driven decisions using genomic, phenotypic and environmental data at more than one major decision point	2024

Outcome	Maximized improvements in breeding programs	Number of breeding programs implementing highest rated improvements in TTSS modelling	Generic number	Survey	NA	2021	increase	2024
Outcome	Improved prioritization of TTSS and improvements	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	Survey	NA	2022	increase	2024
Outcome	Improved financial forecasting	Number of financial forecasts within 25% of actual expenditure GII 6.1 Amount invested in impactful breeding pipelines	Generic number	Costing and forecasting tool and database developed in WP1	NA	2023	increase	2024
Outcome	Increased adoption of TTSS	Number of beneficiaries using the innovation, disaggregated by gender.	Generic number	BPIMS	NA	2023	increase	2024
Outcome	Increased collective TTSS capacity and resources	Change in the capacity of key (ii) Organizations and (iii) Networks	Generic number	EiB Module 3, 4, and 6 gap analyses, example here	NA	2022	increase	2024
Outcome	Increased cost-competitiveness of TTSS	Price of current CGIAR-NARS TTSS: Price of commercially available TTSS	Ratio	Cost database from WP1 Procurement cost matrixes, example here and here	NA	2022	Ratio > 1	2024
Outcome	Improved TTSS available to the CGIAR-NARS network	Number of beneficiaries using the innovation, disaggregated by gender	Generic number	BPIMS	NA	2022	increase	2024
Outcome	Increased access to latest knowledge and research	Change in the capacity of key (i) Individuals, (ii) Organizations, and (iii) Networks.	Generic number	Survey	NA	2022	increase	2024
Outcome	Locally tailored, coordinated support available	Change in the capacity of key (i) Individuals, (ii) Organizations, and (iii) Networks.	Generic number	Survey	NA	2022	increase	2024

Outcome	Increased readiness for TTSS	Change in the capacity of key (i) Individuals, (ii) Organizations, and (iii) Networks.	Generic number	Survey	NA	2022	increase	2024
Outcome	Improved Health, Safety & Environment	Number of beneficiaries using the innovation, disaggregated by gender.	Generic number	BPIMS	NA	2022	increase	2024
Outcome	Improved data integrity (consistency, comparability)	Number of beneficiaries using the innovation, disaggregated by gender.	Generic number	DMS	NA	2022	increase	2024
Outcome	Increased transparency and accountability for performance	Number of beneficiaries using the innovation, disaggregated by gender.	Generic number	BPIMS	NA	2022	increase	2024
Outcome	Increased motivation to improve	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	Survey	NA	2022	increase	2024
Outcome	Improved breeding decisions	Number of beneficiaries using the innovation, disaggregated by gender.	Generic number	BPIMS	NA	2022	increase	2024
Outcome	Bigger more powerful data sets	Number of data points stored in DMS	Generic number	DMS	NA	2022	increase	2024
Outcome	Increased use of data and DMS	Number of beneficiaries using the innovation, disaggregated by gender.	Generic number	DMS	NA	2022	increase	2024
Output (WP2)	One CGIAR Shared Services Unit	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	NA			NA	2023
Output (WP2)	TTSS Procurement Team	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	NA			NA	2022
Output (WP2)	TTSS Functional Teams	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	NA			NA	2023

Output (WP2)	Specialist Technical Support	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	NA			increase	2024
Output (WP5)	Regionally tailored innovation and tools	Number of innovations	Generic number	NA			increase	2024
Output (WP5)	Facilitated partnerships	Number of CGIAR-NARS breeding programs participating in collaborative research, as brokered by N4ETTSS GII 5.2 Number of public/private sector cooperation agreements	Generic number	NA			increase	2024
Output (WP5)	Emerging innovation trials	Number of innovations	Generic number	BPIMS			increase	2024
Output (WP5)	Communities of Practice	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	NA			NA	2024
Output (WP5)	TTSS Change Management	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	Survey			increase	2024
Output (WP5)	Modernization Facilitators	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	Staffing lists			increase	2024
Output (WP5)	Research exchange	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	Survey			increase	2024
Output (WP5)	Capacity building strategies	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	NA			NA	2022
Output (WP3)	SOPs, BMPs and quality controls	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	Quality Management System for Breeding Operations			increase	2024

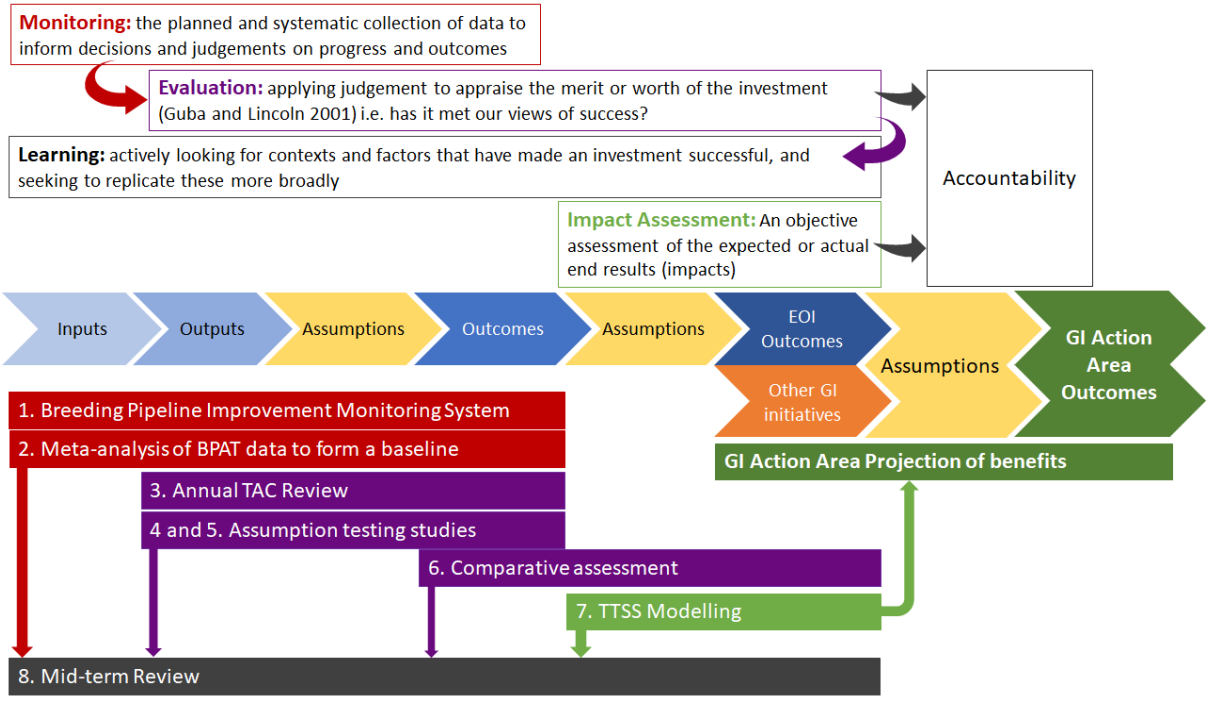
Output (WP3)	Dashboard Report Cards	Number of other information products	Generic number	NA			NA	2024
Output (WP3)	Breeding Pipeline Improvement Monitoring System (BPIMS)	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	NA			NA	2024
Output (WP3)	Process Management Team	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	NA			NA	2022
Output (WP4)	Data Management System	Number of other information products	Generic number	NA			NA	2022
Output (WP4)	Data governance	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	NA			NA	2022
Output (WP4)	Breeding IT Strategy	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	NA			NA	2022
Output (WP4)	Regional DMS Support Team	Number of people trained, long-term (including Masters and PhDs) and short-term, disaggregated by gender.	Generic number	NA			NA	2023
Output (WP1)	Breeding program TTSS simulations	Number of other information products	Generic number	NA			NA	2023
Output (WP1)	CGIAR-NARS network modelling	Number of other information products	Generic number	NA			NA	2024
Output (WP1)	TTSS Strategic Plan	Number of policies/ strategies/ laws/ regulations/ budgets/ investments/ curricula modified in design or implementation, informed by CGIAR research.	Generic number	NA			NA	2022

6.2 MELIA plan

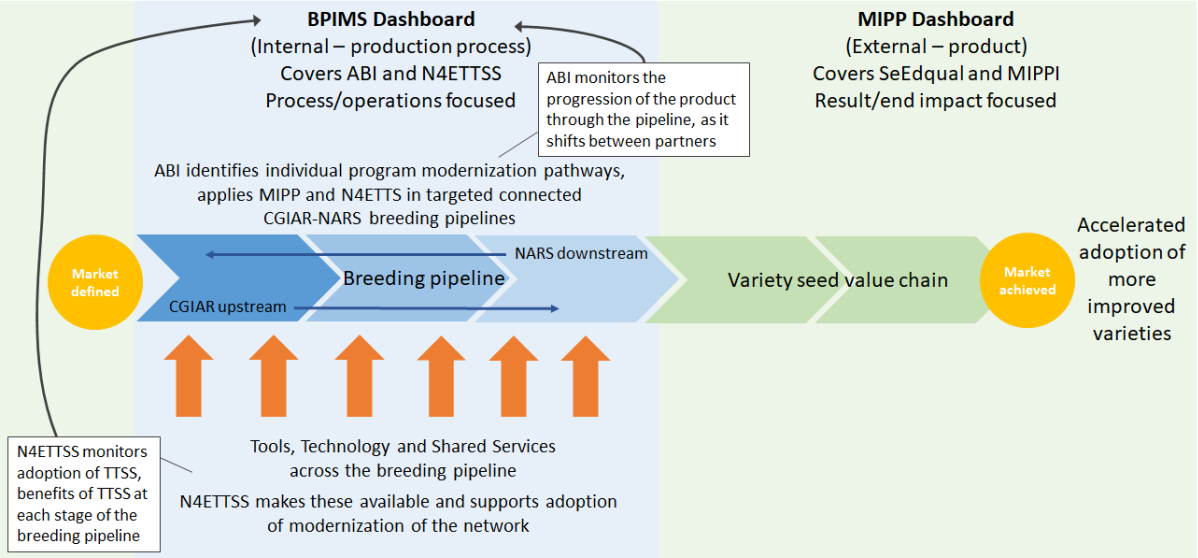
- ***Narrative for MEL plans***

Outputs and lower outcomes will be directly measurable within the Initiative timeframe but evaluating the outcomes and impacts achieved by modernization of breeding programs will be difficult within the Initiative timeframe. Three years is a tight timeline for modernization across an extensive network of variable baseline capacity and resource availability. Modernization will feed into breeding efforts (a longer-term activity with up to 10 years to develop a new variety), requiring time from TTSS adoption to variety release, adoption and impact on final beneficiaries.

To overcome these challenges N4ETTSS has designed a strategic MELIA plan that examines each part of MELIA across the TOC. It embeds activities to promote a culture of MELIA and aligns with other GI Initiative MELIA to contribute to whole-of-GI Action Area MELIA, while remaining focused on the scope of N4ETTSS and its EOI outcomes.



1) The Breeding Pipeline Improvement Monitoring System (BPIMS) in WP3 will collate data from ABI and N4ETTSS. A cross-Initiative approach will streamline monitoring and minimize monitoring burden, building on the close collaboration between these Initiatives. The BPIMS will be pivotal for embedding a culture of active MELIA in the GI Initiatives. The BPIMS will need to include progressive indicators that measure the results of TTSS adoption at each stage of the breeding process for each of the outcomes. This will enable tracking of both modernization (activities and outputs, TTSS adoption) and the emerging results of modernization (e.g., increased heritability of individual trials, reduced breeding cycle time).



Evaluation activities (when judgement and interpretation are applied to monitoring data)

3) Each year, on publication of the BPIMS dashboard, the TAC will review the results to address the evaluation questions:

- Has progress been sufficient? (Is the Initiative on track to be successful?)
- What areas of the breeding pipeline most need to be improved?

The recommendations will guide adaptive management and continuous improvement across the GI Initiatives. The first BPIMS dashboard will rely more heavily on baseline data and modelling results, will be delivered in 2023 and then refined in 2024.

4,5 and 6) Three Initiative level assumptions have been identified for explicit study.

4) That increased knowledge of breeding performance will motivate improvement - The study will address the question 'To what extent can increased transparency on Impact Area contribution and breeding pipeline performance motivate ongoing improvement?' The study will need to assess the experiences and views of involved breeding programs and also undertake comparative analysis with other breeding programs that have not been covered by BPIMS.

5) That building connections across the technology adoption curve (between technology users in an innovation ecosystem and others) to create a network of differing TTSS users and readiness levels can increase adoption of innovations - The study will need to test the theory of technology diffusion and how adjustments to relationships and connections both within an innovation ecosystem and with the broader adoption curve (ready-for change and low readiness breeding programs) has impacted adoption. One option would be to compare current pathways for emerging technologies with historical pathways.

6) That TTSS adoption will increase the cost-effectiveness, speed and results achieved by breeding programs - The study will use a quasi-experimental design to undertake a comparative assessment of four 'treatments': breeding programs that have been directly involved with N4ETTSS, breeding programs that have not been directly involved with N4ETTSS, CGIAR breeding programs and NARS breeding programs. Comparison across these 'treatments' is necessary to identify lessons for future expansion or other similar breeding program improvement interventions.

Impact assessment

7) TTSS modelling is further explained in the Impact Assessment narrative. It will be the first stage-gate (see Management Plan).

Learning

8) While there will be minor learnings generated at the TAC annual reviews, a Mid-term Review to be completed in 2023 will be an opportunity to reflect and critically analyze the MELIA results to date. It will review the TOC and associated pathways (focusing on questions of effectiveness and appropriateness) and check current assumptions. The timing of the Mid-term Review will coincide with the conclusion of EiB and CtEH.

The Mid-term Review findings will:

- assess the benefits gained from linkages with EiB and CtEH, identify opportunities and risks associated with the conclusion of these investments;
- assess modernization progress and any improvements required to maximize N4ETTSS impacts;
- identify final refinements to the N4ETTSS in preparation for its own completion at the end of 2024;
- identify legacy options for breeding program modernization and direct any preparations required;
- be a significant stage-gate and point of adaptive management (see Management Plan).

- ***Narrative for impact assessment research plans***

N4ETTSS has embedded Impact Assessment, ensuring the results remain central to the ongoing adaptive management of the Initiative. The core Impact Assessment activity is modelling the expected benefits of TTSS at a whole-of-network scale (WP1). The model will inform strategic prioritization of investments, with forecasting of TTSS impacts central to this prioritization.

Impact Assessment of N4ETTSS will require data gathering on the assumptions within the N4ETTSS part of the breeding pipeline (e.g., breeding speed, breeding performance gains). The model will refine the parameters that are relevant to N4ETTSS that have been applied in the GI Action Area Projection of Benefits. These parameters will be incorporated into the BPIMS so that progress is actively tracked each year. The parameters are expected to also refine proposed MELIA targets for maximum alignment and use of performance data.

6.3 Planned MELIA studies and activities

Type of MELIA study or activity	Result or indicator title that the MELIA study or activity will contribute to.	Anticipated year of completion (based on 2022-24 Initiative timeline)	Co-delivery of planned MELIA study with other Initiatives	How the MELIA study or activity will inform management decisions and contribute to internal learning
Modelling the impacts of modernization	Modernization model to estimate the benefits of TTSS adoption, informing improved prioritization of TTSS and improvements.	2022 (initial) 2024 (refined)	EiB, CtEH, MITTI	Will inform the TTSS Strategic Plan and WPs 2-5. In response, prioritization will promote those TTSS with greater modelled impacts.
Comparative assessment using a quasi-experimental design	Contribution on Impact Areas with and without breeding modernization, using breeding programs that have been engaged and those not engaged by N4ETTSS. Will use metrics identified in BPIMS.	2024	Coordination with ABI and CGIAR-NARS	Promote further adoption of TTSS by CGIAR-NARS breeding programs by WP5. Findings will contribute to mid-term review
Change analysis/ assumption testing	Tests the assumption that increased transparency of breeding performance will motivate improvements and reports on research question “To what extent can increased transparency on Impact Area contribution from breeding motivate improved performance on impacts?”	2024	-	Will inform ongoing development and use of the BPIMS to track and motivate improvements. Contribute to mid-term review
Change analysis/ assumption testing	Tests the assumptions that the technology adoption curve and innovation ecosystems can be used to drive innovation and adoption across a network. The results are expected to confirm that multiple types of capacity building interventions are needed, including investment in high-capacity programs.	2024		Will inform future modernization strategies. Contribute to mid-term review
Performance Management System – design	Designs detailed GI applied, breeding specific MELIA to increase transparency and accountability for performance and increase motivation to improve.	2022 (pilot) 2023 (refined)	All GI Initiatives	Results will inform updates to change management plans
Baseline study	Meta-analysis of expanded BPAT assessment across all CGIAR-NARS breeding programs to form a baseline of TTSS adoption. Number of assessments included in meta-analysis.	2022	All GI Initiatives	Inform N4ETTSS’s 2024 targets
Mid-term Review	Improve performance across all outcomes and collate evidence to date against the within N4ETTSS assumptions (i.e., not assumptions between the EOI outcomes and Impact Areas).	2023	-	Findings will inform refinement to final year activities of N4ETTSS to promote Initiative legacy.

7. Management plan and risk assessment

7.1 Management plan

Governance will include the following:

- Technical Advisory Committee (TAC) consisting of public and private breeding experts and practitioners, including representatives from ABI (N4ETTSS primary client), EiB and CtEH that will guide the strategic and technical directions of N4ETTSS.
- Project Advisory Committee (PAC) consisting of senior managers from each WP, ABI, EiB, CtEH and other GI Initiatives that will maintain working relationships, Initiative alignment and timely feedback from main project collaborators.

For further details, see Research Governance.

Initiative implementation and associated governance has been organized into three phases, punctuated by two stage gates, coordinated with the first and second wave Innovation and Scaling tracks.

1) **Baseline and inception phase** (to Q4 2022) - Detailed planning such as MELIA planning (including design of the BPIMS), updated projection of benefits, first wave light track Innovation and Scaling Plans for Innovation Package 2, along with foundational plans and strategies (TTSS Strategic Plan, Breeding IT Strategy, Capacity building strategies). At the end of the inception phase a first iteration of the TTSS model will be completed, baseline MELIA completed and the One CGIAR Shared Services Unit (including Procurement Team, Functional Teams, Specialist Support) will be established.

Minor stage gate: Annual progress review (Q4 2022) by TAC to assess progress and identify improvements.

2) **Implementation phase** (from Q3 2022 to Q3 2024) - MELIA studies will need to commence, refinement of BPIMS and model, all WP activities. Includes first wave standard track Innovation and Scaling Plans for Innovation Package 1.

Main stage gate: Mid-term review (from Q3 2023 to Q4 2023) including annual progress review.

1) **Legacy preparations and closure** (from Q1 2024 to Q4 2024) - This phase will focus on making adjustments as recommended by the Mid-term Review and preparing for the completion of the Initiative. It is expected that adjustments to N4ETTSS will be made, informed by the final evaluations of EiB and CtEH, and to incorporate any legacy activities required. This phase includes second wave standard track Innovation and Scaling Plans for Innovation Package 3.

7.2 Summary management plan Gantt table

Initiative Start Date		Timelines												Description of key deliverables
		2022				2023				2024				
Work Packages, Governance and MELIA	**Lead organization**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**Q 1**	**Q 2**	**Q 3**	**Q 4**	
WP 1: Strategic Modernization	CGIAR		1		2, 3, 4				5				6	1. Global workplan for simulation support 2. TTSS Strategic Plan. 3. global harmonized cost structure database 4. initial CGIAR-NARS network modelling of TTSS adoption, incl. financial forecasting 5. Digital tool for breeding program costing and forecasting. 6. Final model update to inform final projection of benefit
WP 2: Cost-effective shared services	CGIAR				1			2			3			1.TTSS Procurement team establishes a process for increasing cost effectiveness of shared services 2. TTSS Functional teams e.g., biometrics establishes globally coordinated workplans 3. Shared Services Unit establishes continuous improvement plan
WP3: Consistent, connected operations	CGIAR			1					2, 3		4		5	1. Process Management Model 2. SOPs, BMPs and quality controls 3. BPIMS designed 4. BPIMS version 1 5. Dashboard report cards
WP4: Smarter use of more data pathway	CGIAR				1, 2				3, 4					1. Breeding IT strategy 2. Data governance rules 3. Data Management System (DMS) 4. DMS and digitization user support network
WP5: Idare	CGIAR				1				2, 3					1.Innnovation ecosystem establishes process for research exchange, supported by Modernization Facilitators 2. Innovation Scaling projects underway facilitated by change management personnel 3. Regional Capacity Building Strategy builds up operational and technical expertise according to regionally tailored prioritization
MELIA	CGIAR			1	5			1	6	2, 3, 4	1			1. Annual TAC Review 2. Assumption study - BPIMS 3. Assumption study - adoption 4. Comparative assessment 5. Modelling (WP1) 6. Mid-term Review
Project Management		1			2				3				4	1. Establish TAC and PAC 2. Minor stage gate 3. Main stage gate 4. Legacy plan, incl. full cost recovery of shared services
Innovation Packages & Scaling Readiness					1				2				3	1. Innovation Package 1 (First wave, light track) 2. Innovation Package 1 (First wave, standard track) 3. Innovation Package 3 (Second wave, standard track)
Capacity building						1, 2			3	1, 2			3	1. Change management - resilience training 2. Gender awareness in breeding 3. Technical group training events

7.3 Risk assessment

Top 5 risks to achieving impact (relevant WP numbers in brackets)	**Description of risk**	**Likeli-hood**	**Impact**	**Risk score**	**Opportunities**	**Existing controls/ mitigation actions or mechanisms**	**Further controls/ mitigation actions or mechanisms to be taken**
		Rate from 1-5	**Rate from 1-5**	Likeli-hood x Impact			
Benefits from breeding modernization are not carried through the breeding pipeline and into the variety value chain by other GI Initiatives (all WPs)	Low impact on final grower beneficiaries may be caused by development of varieties that growers don't want to use, can't readily access and that don't deliver on the Impact Areas (e.g., nutrition, productivity)	1	5	5	Ongoing coordination between MIPP and N4ETTSS on annual delivery of respective Dashboards will retain focus on demand-driven breeding. Holistic BPIMS tracking of progress towards impacts will identify issues early and promote adaptive management.	The impacts on final grower beneficiaries from N4ETTSS are contingent on TTSS being applied to demand-driven breeding, in CGIAR-NARS partnerships and in connection with the variety seed value chain. There has been close collaboration with GI Initiatives designed to target these critical assumptions across the breeding pipeline and variety value chain.	Coordinate BPIMS Dashboard with MIPP's Dashboard. Monitor performance of the breeding pipeline and variety value chain through the BPIMS, identify any issues early and adaptively manage if required.
Cultural barriers within breeding programs limit TTSS adoption (WP5)	Poor adoption of TTSS by breeding programs could be caused by a lack of CGIAR leadership, mandate for change or a lack of cultural shift by breeders to assume a leadership or oversight role guiding internal and external multidisciplinary teams of experts, resulting in lower speed and rate of variety development.	3	5	15	The BPIMS can be used to reframe notions of individual performance that are focused on breeding outcomes. TAC of highly respected individuals from across private and public breeding can show breeding industry leadership.	Regional consultation identified there is a role change being experienced by breeders and others (Annex D). In response, WP5 includes change management support and capacity development (Section 9.3) includes individual resilience training to increase the ability of people to adapt to modernization changes. Increase stakeholder engagement in design of N4ETTSS, including the TTSS Strategic Plan. Include ABI, EiB and CtEH in PAC and maintain regular communication to keep the collaborations strong.	Share BPIMS with HR for consideration in individual performance management structures/processes Promote TAC leadership on cultural changes. CGIAR mandate for breeding programs to use TTSS.
Capability, and capacity constraints within and across the regions may hinder	Poor adoption of TTSS could be caused by CGIAR and NARS funding and infrastructure	3	4	12	Continued close collaboration with ABI (primary client/audience	Regional consultation identified cost as the major barrier to TTSS adoption, followed by lack of infrastructure Annex D). N4ETTSS will reduce the costs of	Include quarterly Initiative leadership team meetings with

the uptake of innovations (WP 2, 3, 4, 5)	limitations, resulting in lower speed and rate of variety improvement.				for N4ETTSS) will increase TTSS adoption. Continue to build relationships with EiB and CtEH to strategically coordinate infrastructure upgrades.	TTSS (WP2). Modernization project management in WP5 will address the specific challenges facing each breeding program to overcome TTSS adoption barriers, including support to access funding and coordinating technical experts to tailor innovations for local capacities. Regular PAC meetings and ongoing monitoring will detect issues early, promoting timely response.	ABI in Initiative governance. Engage CtEH in WP1 TTSS Strategic Plan.
Failure to attract, engage, develop and retain talent (WP2 and 4)	A lack of talent engagement could be caused by unattractive working conditions (e.g., temporary life of Initiative funded positions), resulting in lack of ability for N4ETTSS to service breeding programs.	2	4	8	Incorporate technical capacity building into each specialized TTSS team through WP5's innovation ecosystem. Develop partnerships across public and private organizations to host specialist teams, creating a sense of belonging and permanency to positions.	Specialized technical experts will be needed to fill roles across N4ETTSS. These need to be structured to create satisfying work environments that both challenge and provide opportunities for personal development as technical specialists. Provide additional training, where required, to ensure Initiative staff have the skills and knowledge needed. A skills audit may be needed to prioritize staff development. To reassess once Initiative positions are filled.	Negotiate agreements with CGIAR and others (ARI, Universities etc.) to host technical specialists.
Reorganization (One CGIAR or other i.e., institutional or programmatic changes) impacts Initiative's execution (WP2)	Inability to restructure existing capacity across CGIAR into specialized technical teams caused by institutional, policy and HR barriers could result in ongoing fragmentation of services and poor accessibility across the CGIAR-NARS breeding network	4	4	16	Voluntary opportunities for existing specialists to take on roles within N4ETTSS technical projects through secondments and research exchange.	It is likely that additional technical expertise will be required once the collective CGIAR-NARS demand for TTSS is established. The new unit to supply these services will have a core group of new recruits that are supported to implement and further develop their skills and rewarded for their expertise, making it an attractive work environment for those seeking to develop as technical specialists. Structures that facilitate cross functional collaboration will promote flexibility.	Implement flexible structures to attract contributions from existing CGIAR specialists (e.g., project-based secondments, research exchange).

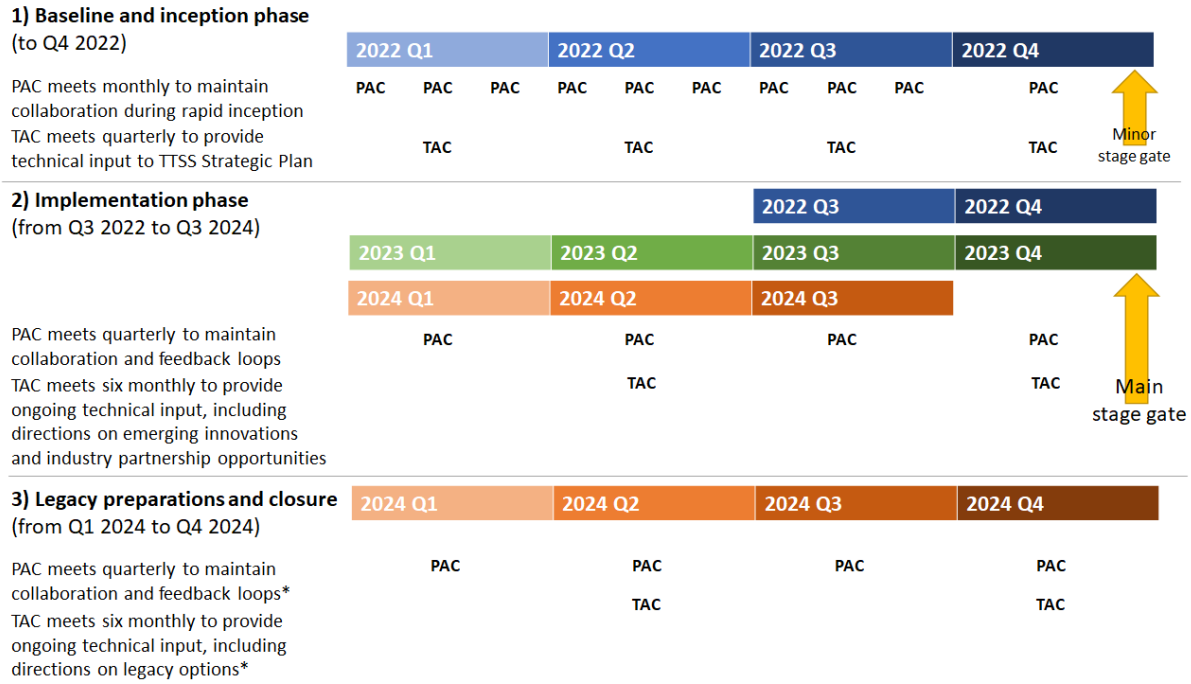
8. Policy compliance, and oversight

8.1 Research governance

Researchers involved in the implementation of this Initiative will comply with the procedures and policies determined by the System Board to be applicable to the delivery of research undertaken in furtherance of CGIAR's 2030 Research and Innovation Strategy, thereby ensuring that all research meets applicable legal, regulatory, and institutional requirements; appropriate ethical and scientific standards; and standards of quality, safety, privacy, risk management and financial management. This includes CGIAR's CGIAR Research Ethics Code and to the values, norms and behaviors in CGIAR's Ethics Framework and in the Framework for Gender, Diversity and Inclusion in CGIAR's workplaces.

Specific governance arrangements have been designed for N4ETTSS. Governance will include a:

- Technical Advisory Committee (TAC) consisting of public and private breeding experts and practitioners, including representatives from ABI (N4ETTSS primary client), EiB and CtEH that will guide the strategic and technical directions of N4ETTSS.
- Project Advisory Committee (PAC) consisting of senior managers from each WP, ABI, EiB, CtEH and other GI Initiatives that will maintain working relationships, Initiative alignment and timely feedback from main project collaborators. Its scope will be operational project management level issues. Any strategic or technical issues will need to be referred to the TAC for advice.



* Additional PAC and TAC meetings may be required to digest the Mid-term Review findings and work through its implications and resulting adaptive management, including changes in response to end of EiB and CtEH

In addition to the governance arrangements in place:

- WP4 will produce data governance rules that will guide the security of data management systems and their interoperability requirements when exchanging information between stakeholders.
- Process Management in WP3 will incorporate applicable legal, regulatory and institutional requirements; appropriate ethical and scientific standards; and standards of quality, safety, privacy, risk management and financial management into the SOPs, BMPs and other TTSS standardization outputs.

8.2 Open and FAIR data assets

Researchers involved in the implementation of this Initiative shall adhere to the terms of the Open and FAIR Data Assets Policy.

N4ETTSS will align with the OFDA Policy's Open and FAIR requirements, ensuring:

- Rich metadata conforming to the CGIAR Core Schema to maximize Findability, including geolocation information where relevant.
- Accessibility by utilizing unrestrictive, standard licenses (e.g. Creative Commons for non-software assets; General Public License (GPL))/Massachusetts Institute of Technology (MIT) for software), and depositing assets in open repositories.
- Wider access through deposition in open repositories of translations and requiring minimal data download to assist with limited internet connectivity.
- Interoperability by annotating dataset variables with ontologies where possible (controlled vocabularies where not possible).
- Adherence to Research Ethics Code (Section 4) relating to responsible data (through human subject consent, avoiding personally identifiable information in data assets and other data-related risks to communities).

9. Human resources

9.1 Initiative team

Category	Area of expertise	Short description of key accountabilities
Research	Research leadership and management	Provide leadership, assemble teams, develop workplans and ensure implementation, establish internal and external collaborations with partner
Research	Initiative project management and MEL	Ensuring effective project / workplan implementation for the Initiative. Tracking M&E. Annual reporting.
Research	Quantitative geneticists	Conduct breeding simulations to guide breeding pipeline design decisions
Non-Research	Finance, legal, and admin staff	Analyze operation costs and budgets for global cost structure database, identify constraints for harmonization, build roadmap to full cost recovery model of shared services, establish TTSS Procurement team
Research	Economist	Guide development of costing and forecasting tool
Research	Service and logistics coordination	Coordinate services for genotyping and sequencing. Manage logistics for delivering high quality and timely service. Roadmap services for HTP and quality/biochemical testing.
Research	Bioinformatics	Support development of marker panels at various densities, all crops. Provide genomics and computational expertise to other Initiatives

Research	Biometrics	Provide biometrics and modelling support to breeding programs. Areas of particular interest: standardize and automate genetic gain calculations, gBLUP estimates, and target profile environment analyses
Research	Business process management experts	Support breeding programs and data management IT teams in describing, harmonizing, and adopting standard operating protocols, workflow charts, and quality controls across the breeding networks, manage documentation, support KPI development, implement transparent change control processes
Research	Continuous Improvement experts	Innovation readiness and scaling support, facilitate breeding programs in adoption of continuous improvement practices such as LEAN
Non-Research	IT Product Manager	Define IT product requirements for breeding DMA and associated tools, lead product roadmap, coordinate inputs from users, stakeholders, and IT technical team, support DMS adoption
Non-Research	Software engineers and IT support	Develop, maintain, and deploy DMS, support business intelligence tool, support GI specific tool development (BPIMS, costing/forecasting tool), support data exchange between DMS
Research	Data managers, data curators, digitization specialists and trainers	Digitization of data collection workflows, curation of data, timely and responsive in-season user support, expertise on digitization equipment, training on DMS and tools, support end-to-end data management
Research	Change management: Communications	Stakeholder engagement through strategic and timely communication of change processes, opportunities, objectives, and motivations
Research	Change Management: Training	Competency assessments, training design, training delivery. Upskill staff in change resilience and effectiveness in a continuous improvement culture
Research	Change Management: Program and Project Management	Organize & execute modernization plans, coordinate process improvement networks, coordinate data governance network, facilitate communities of practice, develop BPIMS.
Research	Change Management: Modernization Facilitators	Support staff for access to TTSS and implementation of modernization plans. Stakeholder management & logistics & coordination.
Research	Operations Experts	Targeted specialist expertise in areas such as health and safety, mechanization, automation, seed production, facility management, agronomic practices. Technical backstopping, gap analysis of needed skills
Research	Technical specialists and experts	Targeted specialist expertise in areas such as high throughput phenotyping, statistical genetics, image analysis, physiology, pathology, biochemistry, crop modelling etc. Technical backstopping, innovation prospecting, gap analysis of needed skills

9.2 Gender, diversity and inclusion in the workplace

The Initiative team is comprised of individuals from diverse origins and backgrounds but does not meet CGIAR's gender target of a minimum of 40% women in professional roles. This Initiative places a new emphasis on specialized roles focused on improving breeding operational excellence and change management as CGIAR-NARS breeding networks transition into the new integrated management structure. Many required skills are new or currently under-resourced, and we will need to train existing staff into new specialized roles or hire new staff. Consideration for hiring or training opportunities for new roles will be gender aware to achieve the 40% target by the end of the Initiative.

Women, minorities, and other under-represented groups will hold leadership roles in the Initiative team. This will be seen in the composition of our senior team and will extend to the fair allocation of leadership activities and accountabilities. The Initiative has women and under-

represented groups in its current leadership. The Initiative lead is an Asian woman, the deputy lead is of Latin American descent, and the MELIA and social impacts expert is a woman. Other leadership roles expected to be held by women include: DMS adoption lead, data management leads, operations management leadership, an IT technical team lead, a lead services coordinator, lead finance officer, and continuous improvement expert. Many of the new required skills are in leadership positions. Consideration for hiring or training opportunities for new roles will be gender aware to achieve the 40% target by the end of the Initiative.

BPIMS will include tracking indicators for participation of women in breeding decisions and employment of women in breeding programs. This will extend CGIAR's influence beyond composition of the Initiative team to composition of the breeding programs that N4ETTSS works with.

9.3 Capacity development

Capacity development in N4ETTSS will include training on:

- Inclusive leadership within 3 months of launch completed by Initiative team leaders and managers.
- Gender, diversity and inclusion, including on whistleblowing and how to report concerns completed by the Initiative team members within 6 months of launch.
- An awareness session on CGIAR's values, code of conduct and range of learning opportunities available within CGIAR at the Initiative kick-off.
- Development opportunities for junior level Initiative team members, partners, and stakeholders, for example:
    - Mentorship and professional exchange, building on communities of practice established by EiB, e.g., Breeding Operations Network for Development, see (https://excellenceinbreeding.org/BOND).
    - An internal program providing training and preparation for specialized roles that support operational excellence e.g., Modernization Facilitators.
    - For interested and qualified staff, support for formal certification in project, process, or program management.
    - Conference, certifications, and workshops directed towards IT professionals, to maintain a high performing and competitive team.
    - Facilitated team building sessions when necessary to foster team cohesion and collaboration .
- For N4ETTSS to achieve its objective of improved breeding performance (genetic, economic, social, and environmental), each member of the Initiative team will need to be able to incorporate social and environmental considerations into decisions across breeding pipelines. (see section 2.3). This will require training on gender, participatory breeding processes and environment. The Process Management team, Change Management and Modernization Facilitators will provide training and leadership for in these areas.

10. Financial resources

10.1 Budget

USD	2022	2023	2024	Total
Crosscutting across Work Packages	1,825,000	1,825,000	1,825,000	5,475,000
Work Package 1	260,000	528,000	900,000	1,688,000
Work Package 2	2,544,000	2,394,000	2,544,000	7,482,000
Work Package 3	1,430,000	1,530,000	1,530,000	4,490,000
Work Package 4	6,550,000	9,179,000	9,492,250	25,221,250
Work Package 5	5,390,000	5,390,000	4,913,750	15,693,750
				0
Innovation packages & Scaling Readiness	650,000	650,000	650,000	1,950,000
Total	**18,649,000**	**21,496,000**	**21,855,000**	**62,000,000**

10.1.2: Geography breakdown

USD	2022	2023	2024	Total
Global (not specific country)	18,649,000	21,496,000	21,855,000	62,000,000
Total	**18,649,000**	**21,496,000**	**21,855,000**	**62,000,000**

11. List of annexes

The following Annexes have been linked to this document:

- Annex A Technical Justification
- Annex B Strategic Visions
- Annex C Consultation Method
- Annex D Consultation Results
- Annex E Support Letters
- Annex F Projection of Benefits

12. References

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