Monitoring, Evaluation, and Learning Plan

Modernization of Crop Breeding Programs in Arab Countries

December 2020

RESEARCH PROGRAM ON Wheat

RESEARCH PROGRAM ON Grain Legumes and Dryland Cereals

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Authors

Laura Becker, Enrico Bonaiuti, Miguel Sanchez Garcia, Zakaria Kehel, Andrea Visioni, Ajit Govind

Project

Modernization of Crop Breeding Programs in Arab Countries

Funded by

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Prepared by

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A manual is any type of technical documentation that describes handling, functionality and architecture of a technical product or a product under development or use. Source: COAR

About “Modernization of Crop Breeding Programs in Arab Countries”
This project focuses on the modernization of crop breeding programs at ICARDA following the recommendations of the CGIAR *Excellence in Breeding* platform to achieve three core outputs: (1) speed breeding, (2) high throughput precision data collection, and (3) BigData mainstreamed in breeding programs. The new technologies and strategies developed will be first tested and finetuned addressing Product Profiles developed in partnership with the NARS in Morocco, Tunisia, Egypt, Sudan and Lebanon. These outputs will enable ICARDA and NARS to more effectively support farmers in the Arab countries to increase the productivity and resilience of agricultural production in response to the accelerating challenges of the region.

About AFESD
Established in 1974, the Arab Fund for Economic and Social Development (AFESD) focuses on funding economic and social development by financing public and private investment projects and providing grants and expertise. Aiming to support cooperation across Arab countries, projects that increase the interdependence of Arab countries and Joint Arab projects are a priority. AFESD has supported ICARDA over the years by investing in ICARDA’s decentralization process, capacity development activities, and the recent funding for innovation and technology dissemination in the Arab countries in close partnership with the NARS of the region. This project provides AFESD a unique opportunity for AFESD to build on its prior investments in ICARDA by assisting its positioning within the CGIAR to serve the countries and NARS in the region. For more information on AFESD, visit http://www.arabfund.org.

About ICARDA
Established in 1977, the International Center for Agricultural Research in the Dry Areas (ICARDA) is a non-profit, CGIAR Research Center that focusses on delivering innovative solutions for sustainable agricultural development in the nontropical dry areas of the developing world.
We provide innovative, science-based solutions to improve the livelihoods and resilience of resource-poor smallholder farmers. We do this through strategic partnerships, linking research to development, and capacity development, and by taking into account gender equality and the role of youth in transforming the non-tropical dry areas.

Address: Dalia Building, Second Floor, Bashir El Kasser St, Verdun, Beirut, Lebanon 1108-2010.
www.icarda.org

Acronyms

AFESD	Arab Fund for Economic and Social Development
BMS	Breeding Management System
BrAPI	Breeding Application Program Interface
CCT	Cross-Cutting Theme
CRP	CGIAR Research Program
FP	Flagship Program
GLDC	Grains, Legumes, and Dryland Cereals
GRS	Genetic Resources Section
ICARDA	International Center for Agricultural Research in the Dry Areas
ICT	Information & Communications Technology
IDO	Intermediate Development Outcome
IPM	Integrated Pest Management
MEL	Monitoring, Evaluation, & Learning
MOU	Memorandum of Understanding
MSS	MEL Support Supervision
N/A	Not applicable
NARS	National Agricultural Research Systems
PoWB	Plan of Work & Budget
PP	Product Profile
SLO	System Level Outcome
SRP	Strategic Research Priority
TBD	To be determined
ToC	Theory of Change
ToR	Terms of Reference

Table of Contents

1. Introduction

This document provides an overview of the monitoring, evaluation, and learning (MEL) plan for the project, "Modernization of Crop Breeding Programs in Arab Countries." Implementation of MEL in research for development projects ensures that the results are accurately reported, analyzed, and shared. This process is essential for donor reporting and accountability. Additionally, it works to ensure that the investment translates into sound research outcomes and shared learning. This establishes stronger, results-based projects, which together work to improve development outcomes.

1.1. Project Overview

1.1.1. Project Goals and Objectives

The project "Modernization of Crop Breeding Programs in Arab Countries" runs from May 2020 through December 2022 funded by the Arab Fund for Economic and Social Development (AFESD) and implemented by ICARDA. Recognizing the need for updating ICARDA breeding programs with new state of the art technologies and strategies developed in the last years to better serve the Arab region and the Dry Areas of the World. Through the support of AFESD, the project focuses on the renovation of ICARDA crop breeding programs in order to withstand the effects of climate change in the Arab region and feed a growing population.. Project activities and outputs are focused around three components: (1) speed breeding, (2) high throughput precision data collection, and (3) BigData mainstreamed in breeding programs. Project outputs will enable ICARDA and National Agricultural Research Systems (NARS) to more effectively support farmers in the Arab countries to increase the productivity and resilience of agricultural production in response to the accelerating challenges of the region.

Goal

To increase the productivity and resilience of agricultural production in the Arab world in response to the accelerating challenges of the region (climate change, water scarcity, heat stress, emerging new pests and diseases) by developing new crop lines through faster and more accurate breeding and to demonstrate and train NARS scientists in the new technologies.

Objectives

To strengthen ICARDA's ability to efficiently serve the national agricultural research centers (NARS) in the Arab countries by developing state-of-the-art breeding accelerating technologies and facilities, supporting high throughput germplasm characterization at ICARDA's research stations, and strengthening ICARDA's ability to gather, store and use big data for breeding purposes.

1.1.2. Project Components

The project consists of three components:

1. Speed breeding: The time needed from the design of a product profile to the registration of a variety is reduced through accelerated breeding strategy
2. High throughput precision data collection: Selection accuracy is increased through mechanization, automation and high-level expertise for better genotypic and phenotypic evaluation
3. BigData mainstreamed in breeding programs: Relevance, effectiveness and efficiency of breeding programs are enhanced through integrative big data management and analysis

Each component has corresponding activities, outputs, outcomes, and indicators. The pathways from these activities to the corresponding outputs and outcomes are further described in section 2, and the indicators are detailed in section 3.

1.1.3. Project Management Structure

ICARDA will implement this project, which has received NARS support prior to this project through the development of product profiles. In order to ensure relevance, effectiveness, and develop country capacities for breeding, the NARS partners of these countries will be engaged in the following project activities: (1) training NARS scientists in speed plant breeding technologies, and (2) delivering fixed lines representing the new product profiles at the end of the project. The project will strengthen already existing collaborations between ICARDA and NARS focused on germplasm testing, such as parental selection for the development of new varieties based on product profiles. The collaboration with NARS partners will also offer the possibility of testing germplasm at specific locations of interest at the end of the project, such as hot spots for disease screening or key locations for selection of germplasm with enhanced tolerance to abiotic stress. The project has secured a memorandum of understanding (MOU) for refurbishing and using old buildings belonging to the Moroccan Ministry of Agriculture and also has MOUs for shipping germplasm at the end of the project.

Table 1: Country NARS partners

Country	Main partner
Morocco	Institut National de la Recherche Agronomique
Tunisia	Institut National de la Recherche Agronomique de Tunisie
Lebanon	Lebanese Agricultural Research Institute
Sudan	Agricultural Research Corporation
Egypt	Agricultural Research Center

1.2. Purpose of the Project MEL Plan

The purpose of this document is to set a plan in place for how MEL activities will be structured and approached for the Modernization of Crop Breeding Programs in Arab Countries project. The project activities, outputs, and outcomes are linked in an impact pathway, showing how the project activities ultimately lead to the end goals, as well as any risks and assumptions along the pathway. For each activity, output, and outcome, indicators and data sources are defined, as well as the corresponding parties responsible. Together, this system will aid in tracking project progress and whether the intended outcomes were achieved at the end of the project.

2. Project Results Framework

This section outlines the logical and theoretical frameworks for the p0roject. The logical framework (section 2.1) outlines project outputs in relation to the three project components and the theory of change (section 2.2) describes the pathway from activity to outcome, linkages across project outputs, and key risks and assumptions. This section also analyses the project’s alignment with the CGIAR Strategic Results Framework and the ICARDA Strategic Plan.

2.1. Project Logical Framework

The logical framework for this project includes outputs, outcomes, and indicators for the three main project components:

Table 2: Logical Framework

Component	Outputs	Indicators
1. Speed Breeding	• 1.1 A new facility is established, providing capacity for new speed breeding activities • 1.2 Crop lines are developed • 1.3 NARS scientists trained	o Plant capacity at the new speed breeding facility (ICARDA-Rabat) (baseline = 2,000, target = 100,000) o Number of plant lines advanced from F1 stage to preliminary trial under speed breeding (baseline = 0, target = 35,000 (5,000 per crop)) o Number of people trained in the use of new breeding technologies and phenotyping pipeline (baseline = 0, target = 30)
2. High throughput precision data collection	• 2.1 Genotyping and phenotyping data collected with reduced experimental error • 2.2 Improved data for making better selection decisions • 2.3 Earlier identification of disease resistant lines	o Number of parental lines for ICARDA's six breeding programs evaluated with genome-wide genotyping technology (baseline = 0, target = 2,520 (360 per program)) o Number of mid-breeding cycle breeding lines genotyped with a small marker set to improve selection decisions (baseline = 0, target = 21,000 (3,000 per program) o Number of preliminary and advanced yield trials plots and number of traits phenotyped with high-throughput physiological tools (baseline = 300 per program, target = 5,600 plots (800 per program) with 3 new tools/tests) o Coefficient of variance (experimental error) points decreased on average at each ICARDA breeding program as result of improved mechanization (baseline = 17%, target = 12%) o Number of crop-specific eco-physiological databases with information on crop response under variable micro-climatic and stress scenarios based on experiments and observations at the Advanced Yield Trial stage (baseline = 0, target = 7) o Number of plants screened at early stage as part of the speed breeding strategy for pests and diseases to identify resistant lines (baseline = 2,000 (1 disease), target = 5,000 (2 diseases per crop)
3. Big Data mainstreamed	• 3.1 Data systems and tools are developed • 3.2 Assessments and maps are produced on yield and scalability	o Number of tools created for data interoperability, throughput phenotyping data analytic, management, and validation pipeline to combine climatic, genotypic and phenotyping data (baseline = 0, target = 8) o Minimum number of High Throughput Phenotype data-points stored integrated and processed (baseline = 10,000, target = 5 million) o Number of novel varieties for which performance under climate change and stress factors has been assessed ex-ante, to steer and streamline future breeding activities (baseline = 0, target =20) o Number of scalability maps produced to support the development of operational seed systems (baseline = 0, target =10)
Project Outcomes	• Outcome 1 (CRP-WHEAT 2.5) Breeders develop improved varieties more efficiently via access and use of germplasm and tools • Outcome 2 (CRP-WHEAT 3.3) Partner breeding teams improved breeding processes by adopting new technologies, methodologies, approaches and genetic resources • Outcome 3 priority regions and varieties identified, supporting scaling the seed systems of the 5 crops.	o Number of breeders who report reduced time needed to make selection decisions o Number of breeders who have mainstreamed new data and tools from ICARDA into their work o Number of NARS that are confident to plant the new fixed lines

2.2. Theory of Change

2.2.1 Impact Pathway

The impact pathway for this project consists of activities and outputs that correspond to the three project components: (1) speed breeding, (2) high throughput precision data collection, and (3) BigData mainstreamed into breeding programs. These three components are interrelated, as the crop lines developed under component 1 provide the basis for genotyping and phenotyping data collection in component 2, and the improved data for making selection decisions under component 2 feeds back into the development of crop lines in component 1. The other main link across project components is that the data systems and tools developed under component 3 facilitate genotyping and phenotyping data collection in component 2, which yields the data necessary to conduct yield and scalability assessments under component 3. Two of the outputs are from CGIAR Research Program (CRP)-WHEAT Flagship programs 2 Novel diversity and tools for improving genetic gains and 3 Global breeding partnerships for bread and durum wheat – researchable issues. Figure 1 below shows these pathways and is followed by descriptions outlining the linkages between activities, outputs, and outcomes. The risks and assumptions, other inputs needed, and unintended effects are also discussed.

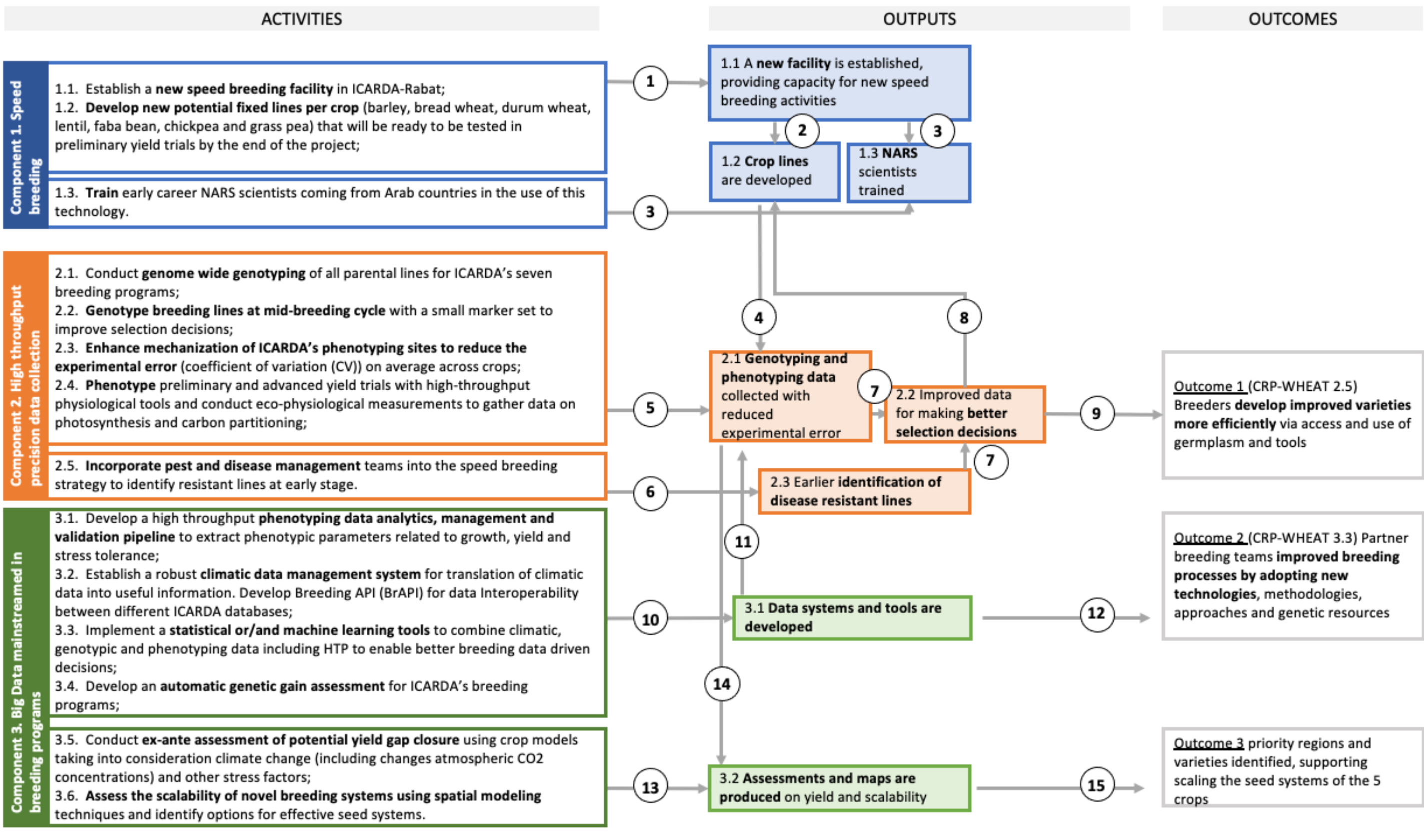

Figure 1: Impact linkages between activities, outputs, and outcomes

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Table 3: Risks and Assumptions along the impact pathway

Link	Assumption	Risk	Risk mitigation measure	Other inputs needed	Unintended effects
1	N/A	The work plan originally scheduled the completion of the new facility by the end of April 2020, however this has been delayed due to date of project approval and COVID-19. The revised aim for the completion of the facility is by the end of 2020, however this is uncertain due to COVID-19.	Start speed breeding activities in existing facility	N/A	This expanded facility could also potentially provide the space and equipment needed for other research projects, so it is important that this expanded facility is "earmarked" for this research project to ensure that space and resources aren't overtaken by another research project.
2	It is assumed that the only inputs needed for the development of new crop lines are new facility from output 1.1, data from output 2.2, and skilled	Reduced time to develop lines due to delayed project start	Project manager has suggested starting from F2 or F3 plants issued from crosses targeting product profiles (PPs)	Need to ensure adequate staff capacity for the development of 5,000 crop lines.	N/A
3	It is assumed that 20 scientists are able to attend a speed breeding training.	The primary risk is that individuals may not be able to attend the training due to COVID-19 travel restrictions.	Virtual training or postponing training.	It will be necessary to develop a curriculum, determine how to select scientists for the training, and budget for any associated travel, lodging, and catering costs.	N/A
4	In this step it is assumed that the equipment and tools needed for collecting genotyping and phenotyping data are readily available.	Some of the technology (i.e. High Throughput phenotyping tool or phenomobile) requires training and the trainer has to come from Europe, so there could be problems due to COVID-19 travel restrictions.	Delay of data collection or use of alternative data collection techniques/tools.	The execution of these activities at a high-quality requires the time of skilled scientists.	N/A
5	In this step it is assumed that all of the technologies and tools needed for genotyping and phenotyping data collection are available.	Because the completion of the new breeding facility has been delayed, this may also delay the development of crop lines and thus also the collection of genotyping and phenotyping data.	For activity 2.4, breeders will collect phenotyping data in a phased approach, starting with barley and durum, and completing remaining crops by the end of next season	The execution of these activities at a high-quality requires the time of skilled scientists.	N/A
6	In this step an assumption has been made about the amount of time it takes pest	Because the completion of the new breeding facility has been delayed, this may also delay the development of crop	Data collection will not be delayed as ICARDA IPM (Integrated Pest Management) are starting protocol	This step may require additional equipment for the assessment of pest/disease resistant lines.	An unintended effect is that this work takes experts away from other pest and disease

	and disease management teams to identify pest/disease resistant lines.	lines and thus also the identification of resistant lines.	development on plants in existing facility		management activities and needs, such as the locust crisis.
7	In this step it is assumed that besides this data on phenotypes, genotypes, and disease resistant lines, there isn't any additional data collection needed to support selection decisions. We are also assuming that better data is the key component driving selection decisions, without weighing in other factors that may influence decision-making, such as time and cost.	N/A	The data used to make selection decisions will be further explored through the breeder survey in Annex C.	Skilled scientists are needed to interpret the data and make selection decisions.	N/A
8	N/A	N/A	N/A	N/A	N/A
9	In this step two things are assumed, (1) that the varieties will be improved (as the decisions are based on genotyping and phenotyping data and identification of disease-resistant lines), and (2) that this will occur efficiently, due to the speed breeding approach leveraged by this project.	N/A		N/A	N/A
10	N/A	The data tools, systems, and analyses proposed in these activities are complex and may be at risk of not reaching full development or functionality by the end of the project.	This risk can be mitigated by breaking down deliverables into achievable milestones across the course of the project	This step will require staff who are skilled in software development and computer modeling, with the adequate time and equipment needed for development of the outlined tools, systems, and analyses.	N/A
11	In this pathway it is assumed that these new tools and systems will be useful and desired by scientists who are doing the genotyping and phenotyping data collection. It will be key to do user testing on these tools and systems in order to ensure that they are helpful and cohesive within the process.	N/A	N/A	It will be necessary to assess what data tools and systems for genotyping and phenotyping already exist and how these new tools will complement, upgrade, or replace these tools. Additionally, users of these tools will need to be trained.	An unintended effect is if these data tools and systems are added to an already complex data collection and management system without replacing or retiring old tools.

12	The main assumption in this pathway is that the new data tools and systems developed in output 3.1 will be adopted.	The risk in this pathway is that tools are developed, but not adopted across ICARDA.	This risk will be measured by indicator #15, which measures the number of breeders that have mainstreamed new data and tools from ICARDA into their work.	N/A	N/A
13	In this step it is assumed that the data and software needed to conduct these assessments are available.	N/A	N/A	This step will require the time of staff who are capable of operating and analyzing these models.	N/A
14	It is assumed that the genotyping and phenotyping data will be ready in a timely manner for analysis in these models.	N/A	N/A	This step will require the time of staff who are capable of operating and analyzing these models.	N/A
15	In this step we assume that the results of the yield gap closure assessment and scalability map will be positive (i.e. showing that the new varieties will perform at a "good" level in several regions)	N/A	N/A	N/A	An unintended effect related to the assumption is that the outputs of the yield gap and scalability assessments are negative (predicting "poor" performance of the variety across several regions), and therefore the scaling of seed systems is not supported.

2.3 Project Alignment to CGIAR and ICARDA Strategic Frameworks

The outputs and outcomes of this project are closely aligned with CGIAR and ICARDA strategic frameworks.

Within the CGIAR framework, this project supports System Level Outcome (SLO) 7. Capacity Building through the training of NARS scientists (Output 1.3). Project outputs contribute to SLO 1. Reduced Poverty through two pathways, (1) by reducing production risk and thus increasing resilience of the poor to climate change and other shocks, and (2) by increasing productivity through genetic gain and increased conservation and use of genetic resources. Increased production also contributes to SLO 2, Improved Nutrition and Food Security for Health. Climate change is a key cross cutting area along both of these pathways, as reduced production risk and genetic gains contribute to enhanced ability to deal with climatic risks and extremes. These pathways are shown in Figure 2 below, followed by pathway descriptions, risks, and assumptions.

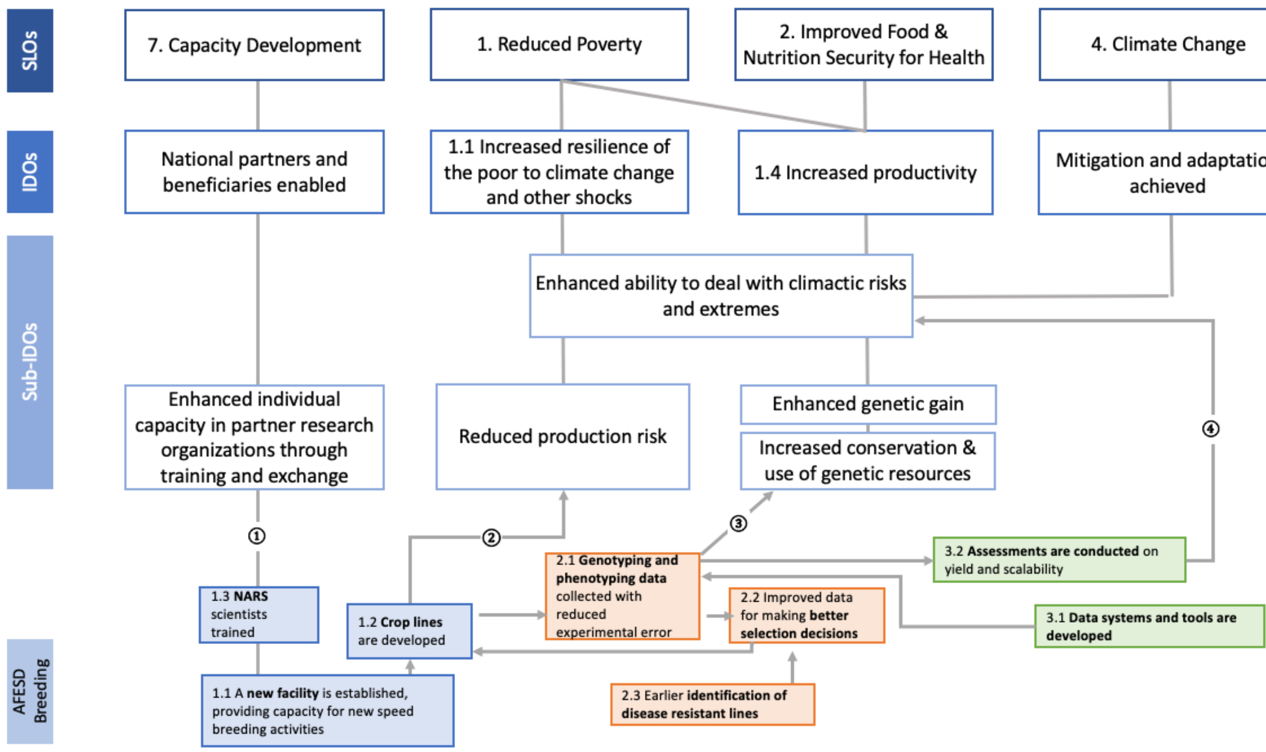

Figure 2: Linkage between project outputs and the CGIAR strategic framework SLOs, Intermediate Development Outcomes (IDOs), and sub-IDOs

① Link between output 1.3 and sub-IDO Enhanced individual capacity in partner research organizations
Output 1.3, training of NARS scientists on the use of technologies, supports the sub-IDO "Enhanced individual capacity in partner research organizations through training and exchange", leading to the IDO "National partners and beneficiaries enabled" under SLO 7. Capacity Development.

- **Assumptions:** Assume that the NARS scientists will understand and retain information from the training and that eventually some of this knowledge will be useful at their country NARS.
- **Risks:** The risk is that the new knowledge and skills obtained by the scientist never have the chance to be applied.
- **Risk mitigation:** Not within project scope

② Link between output 1.2 and sub-IDO Reduced production risk
As discussed in the project impact pathway, the development of more crop lines is a key output of the project which is enabled by the new breeding facility from output 1.1 and improved by better selection decisions enabled in output 2.2. In theory, these new crop lines should contribute to sub-IDO "reduced production risk", as new crop lines are developed with a higher resilience to disease, pests, and climate change. This in turn results in IDO 1.1 Increased resilience of the poor to climate change and other shocks, supporting SLO 1. Reduced Poverty.

- **Assumptions:** To move from output 1.2 Crop lines are developed to Reduced production risk, we are making two assumptions: (1) we are assuming that during the crop development phase, scientists will have correctly predicted which pests, diseases, and climate factors will be the main risks for crops in the future. (2) After these new crops are developed, we are assuming that they will be desirable, available, and accessible to farmers, which would occur after this project as this project does not include the delivery phase.
- **Risks:** Two risks corresponding with the assumptions above include (1) if new pathotypes of current diseases or new diseases arise (2) if new crops are not desirable, accessible, and available to farmers.
- **Risk mitigation:** (1) scientists breed for many regions and using diverse genetic material which increases the odds that if a new pathotype comes to a region, they would have a genotype maybe targeting a different region that would be resistant. Also breeding is cyclical so it adapts to new stresses. (2) outside the scope of this project, but can include marketing campaigns and distribution systems

③ Link between output 2.1 and sub-IDO Increased conservation and use of genetic resources
This project enables Genetic Resource use by increasing our knowledge of the breeding traits of interest and its genetic control which coupled with Speed Breeding can incorporate them faster from a landrace to a modern line.

- **Assumptions:** In this step, the key assumptions lie around "conservation" and "use" as stated in the sub-IDO. In order to conserve the genetic resources developed by this project, proper data storage and access will need to be ensured. Use of the genetic resources developed by this project (i.e. crop lines) requires ensuring that preliminary yield trials are properly planned for after this project, and successful lines are made available to farmers at scale.
- **Risks:** N/A
- **Risk mitigation**: N/A

④ Link between output 3.2 and sub-IDO Enhanced ability to deal with climatic risks and extremes
In this pathway, the assessments that are conducted on yield and scalability (output 3.2), which include the use of crop models which take into consideration climate change (including changes atmospheric CO2 concentrations), leads to sub-IDO Enhanced ability to deal with climatic risks and extremes, a cross cutting theme that affects the pathways to both SLOs 1. Reduced poverty and 2. Improved Food and nutrition security for health.

- **Assumptions:** For the assessments generated in output 3.2 to enhance ability to understand the response of the new and existing varieties to specific abiotic stresses related to climate change and therefore allows anticipating new genotypes better adapted the risks and extremes and for it they need to (1) be technically sound, and (2) lead to action. First, these models must be built with variables and data that accurately reflect future climate change scenarios. Second, the information generated by these assessments must be put to action, informing resilient plant breeds and effective seed systems.
- **Risks:** N/A
- **Risk mitigation**: N/A

Within CGIAR, this project is linked to CRP-WHEAT Flagships 2 Novel diversity and tools for improving genetic gains and 3 Global breeding partnerships for bread and durum wheat – researchable issues. In Flagship 2, the project contributes to Outcome 2.1: 'Increased innovative use of novel germplasm and tools by CRPs scientists' through the development of crop lines, and directly fulfills Outcome 2.5: 'Breeders develop improved varieties more efficiently through greater access and use of documented germplasm and tools' through the generation of improved data for decision making and NARS capacity building. Under Flagship 3, the project contributes to Outcome 3.1 'partner breeding teams improved exchange and utilization of germplasm and data' through the sharing of new product profiles and data tools, and directly fulfils Outcome 3.3 'Partner breeding teams improved breeding processes by adopting new technologies, methodologies, approaches and genetic resources' through the development of new data systems and tools. These pathways are shown in Figure 3 below, followed by descriptions, risks, and assumptions.

**Yellow* boxes indicate outcomes that are directly fulfilled by the project and thus also included in the project impact pathway*

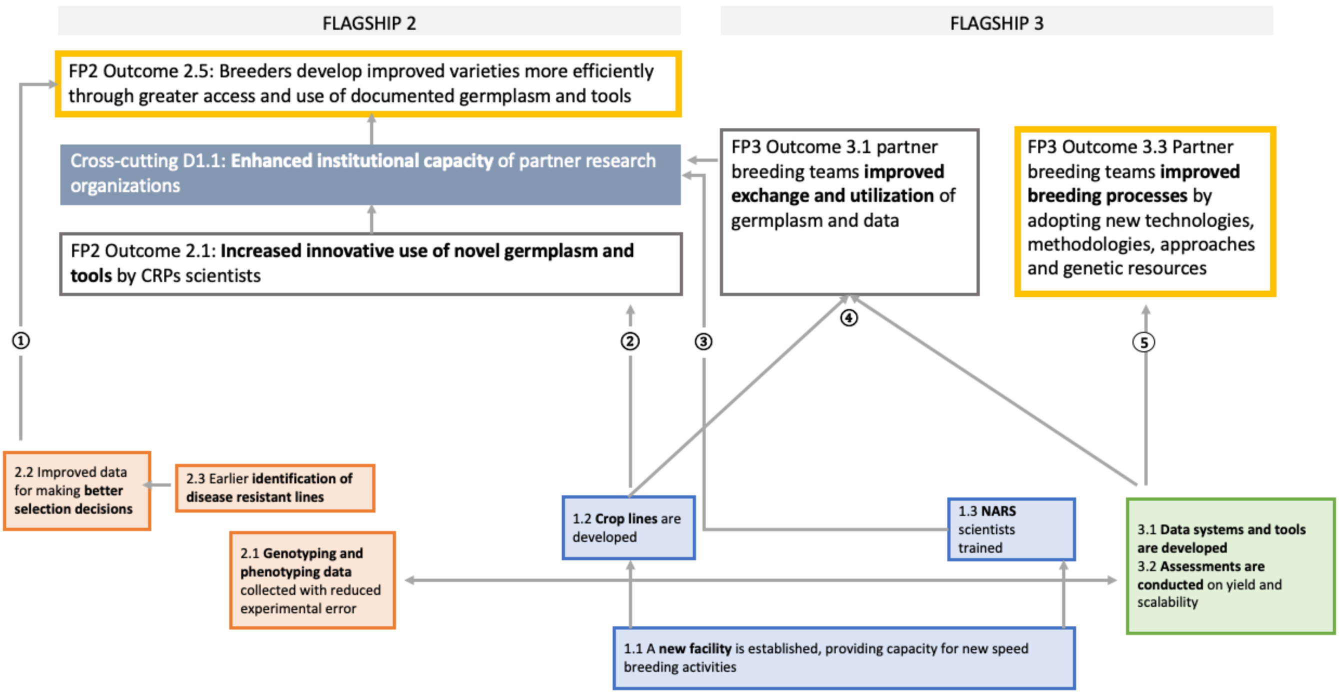

Figure 3: Linkage between project outputs and the CGIAR CRP-WHEAT Flagships 2 'Novel diversity and tools for improving genetic gains' and 3 'Global breeding partnerships for bread and durum wheat – researchable issues' outcomes

① Link between output 2.2 and Flagship Program (FP)2 Outcome 2.5: Breeders develop improved varieties more efficiently through greater access and use of documented germplasm and tools

Project output 2.2 'Improved data for making better selection decisions' should result in the ability of breeders to develop improved varieties more efficiently. Achievement of this full outcome is within the scope of the project and directly links to project outputs, therefore it is also included in the project impact pathway.

- **Assumptions:** In this step it is assumed that better data results in better decisions, which results in developing improved varieties more efficiently.
- **Risks:** The risk in this step is that other outputs besides improved data for making better selection decisions are needed to develop improved varieties more efficiently.
- **Risk mitigation**: Through the breeder survey we will assess if the new tools and corresponding data produced by this project have helped them make decisions, as well as the efficiency of selection decisions.

② Link between output 1.2 and FP2 Outcome 2.1: Increased innovative use of novel germplasm and tools by CRPs scientists

As discussed in the project impact pathway, the development of more crop lines is a key output of the project which is enabled by the new breeding facility from output 1.1 and improved by better selection decisions enabled in output 2.2, but also feeds into the collection of genotyping and phenotyping data in output 2.1. These activities are described by FP2 Outcome 2.1: Increased innovative use of novel germplasm and tools by CRPs scientists, as new tools and crop lines are being used. As mapped in the original CRP-WHEAT FP2 Theory of Change (ToC) pathway, this outcome ultimately feeds into Outcome 2.5, Breeders develop improved varieties more efficiently through greater access and use of documented germplasm and tools.

- **Assumptions:** Here it is assumed that the new crop lines developed are considered to be novel germplasm.
- **Risks:** N/A
- **Risk mitigation**: N/A

③ Link between output 1.3 and Cross-cutting D1.1: Enhanced institutional capacity of partner research organizations

In this pathway, the training of NARS scientists supports improved capacity at the NARS.

- **Assumptions:** Assume that institution will make available the tools and resources for them to accomplish what they learnt
- **Risks:** The risk is that the tools and resources needed to accomplish what they learned are not available
- **Risk mitigation:** Not within project scope

④ Links between output 1.2, 3.1 and FP3 Outcome 3.1 partner breeding teams improved exchange and utilization of germplasm and data

In this pathway, the product profiles developed in output 1.2 and the data and tools developed in 3.1 are shared with country NARS, thus exemplifying 'exchange' of germplasm and data as outlined by the FP3 outcome.

- **Assumptions:** It is assumed that the delivery of these product outputs will be "improved", i.e. greater than the average or "business as usual" support provided by ICARDA to NARS through the use of product profiles and the rapid cycling.
- **Risks:** The risks to achieving this outcome primarily lie in the delivery stage, during which (1) logistical issues could prevent the delivery of new product profiles to country NARS, (2) issues with data interoperability could prevent the exchange of data and (3) the NARS are not able technically to assess some of the value added to the new genotypes (for instance, micro-nutrient content).
- **Risk mitigation:** (1) Follow ICARDA protocol for shipping product profiles and plan in advance, (2) Pilot and test the tools using different systems before finalizing to ensure interoperability, (3) not within the project but the traditionally strong exchange of data and information between ICARDA and NARS breeders and the common trust built through time as well as NARS using ICARDA facilities to confirm traits.

⑤ Link between output 3.1 and FP3 Outcome 3.3 Partner breeding teams improved breeding processes by adopting new technologies, methodologies, approaches and genetic resources

In this step, the new tools and methodologies produced under output 3.1 will support improved breeding processes as these tools are adopted. Achievement of this full outcome is within the scope of the project and directly links to project outputs, therefore it is also included in the project impact pathway.

- **Assumptions:** It is assumed that the new tools and methods will be adopted by breeding teams and that these will result in improved breeding processes. The uptake and helpfulness of these tools will be measured in the baseline and endline Plant Breeder Survey.
- **Risks:** N/A
- **Risk mitigation:** N/A

Additionally, this project contributes to CRP-Grains, Legumes, and Dryland Cereals (GLDC) Flagship programs 4 on Variety and hybrid development and flagship program 5 on Pre-breeding and trait discovery. In Flagship 4, the project contributes to the output ‘Efficient and effective breeding pipelines provide diversified breeding material corresponding to prioritized traits’ through the development of crop lines. Under Flagship 5, the project supports the output ‘Traits mapping, markers and pre-breeding material with desirable traits developed’ through the collection of genotyping and phenotyping data. Lastly, the project supports the Flagship 5 outcome ‘Integrated breeding program produces high-yielding, climate-resilient and nutrient-dense varieties’ through the assessments on yield and scalability. These pathways are shown in Figure 4 below, followed by pathway descriptions, risks, and assumptions.

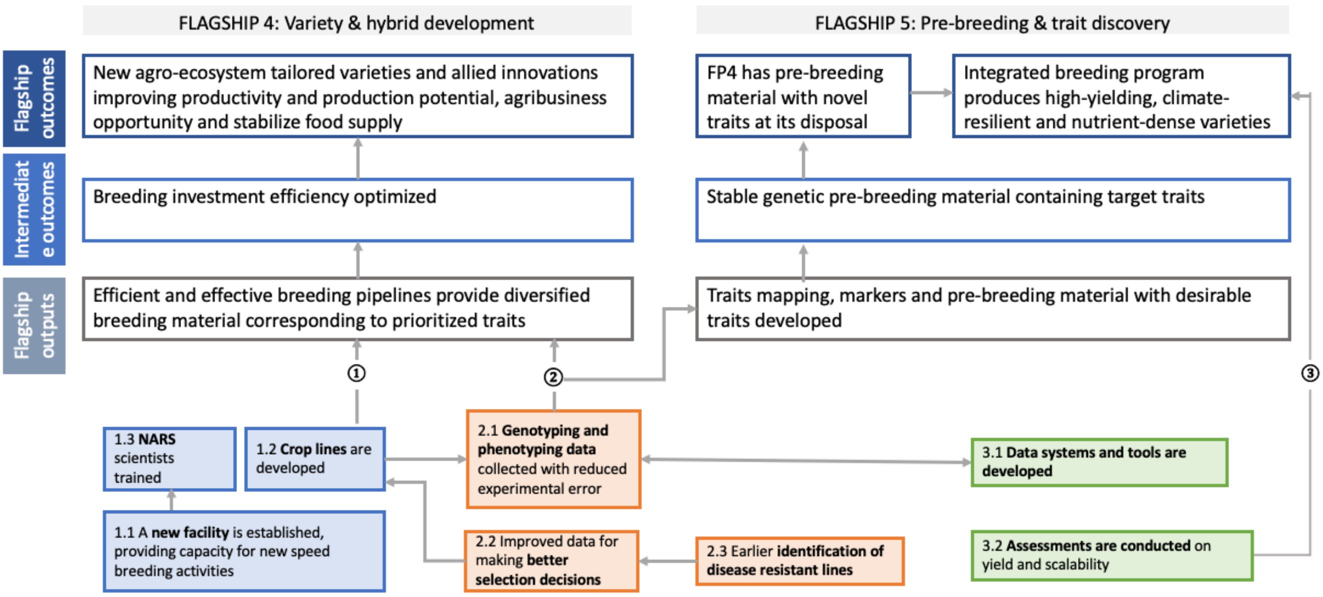

Figure 4: Linkage between project outputs and the CGIAR CRP-GLDC Flagships 4 Variety and hybrid development and 5 Pre-breeding and trait discovery

① Link between output 1.2 and FP4 output ‘Efficient and effective breeding pipelines provide diversified breeding material corresponding to prioritized traits’

Project output 1.2 ‘Crop lines are developed’ is generating diversified breeding material corresponding to prioritized traits including pest, disease, and climate-change resiliency.

- **Assumptions:** In this step it is assumed that the process of developing these crop lines is part of effective and efficient breeding pipelines.
- **Risks:** A risk here is that the developed material is not considered to be diverse enough or adequately including the prioritized traits mentioned in the Flagship outcome.
- **Risk mitigation:** Clarify with CRP-GLDC what counts as “diversified breeding material” and “prioritized traits”

② Link between output 2.1 and FP4 output: ‘Efficient and effective breeding pipelines provide diversified breeding material corresponding to prioritized traits’ and FP5 output ‘Traits mapping, markers and pre-breeding material with desirable traits developed’

In this step, project output 2.1 collection of genotyping and phenotyping data with reduced experimental error supports breeding pipelines in FP4 and is considered to include the mapping of traits and markers as specified in the FP5 output.

- **Assumptions:** Here it is assumed that the data activities capture all of the outputs mentioned in the Flagship: ‘Traits mapping, markers and pre-breeding material with desirable traits developed’
- **Risks:** N/A
- **Risk mitigation:** N/A

③ **Link between output 3.2 and FP5 outcome 'Integrated breeding program produces high-yielding, climate-resilient and nutrient-dense varieties'**

Because these assessments are specifically investigating yield gap closure in relation to climate change models and assessing scalability, they contribute to Flagship outcome 'integrated breeding program produces high-yielding and climate resilient varieties'. Additionally, per the FP5 ToC pathway, this outcome is also supported by traits mapping, as discussed in the previous pathway.

- **Assumptions:** There is a significant jump from the assessments developed in this step to actually achieving the FP4 outcome, because while output 3.2 generates new *information* on yield and scalability, this project scope does not include *implementation* of an integrated breeding program at scale, nor an assessment of climate resiliency of developed crops in the long-term. Therefore this project contributes to the FP5 outcome, (integrated breeding program produces high-yielding and climate resilient varieties), but does not fully achieve this outcome.
- **Risks:** The climatic shocks could be exceptionally severe.
- **Risk mitigation:** Outside the scope of this project, but could include appropriate climate adaptations, such as changes to irrigation methods or pest management

Finally, this project is also well-aligned with the Strategic Plan 2017-2026 of the International Center for Agricultural Research in the Dry Areas (ICARDA). Project outputs contribute to Strategic Research Priority (SRP) 1. Collect, conserve, and use agricultural biodiversity through two sub-SRPs: 1.1 Collect, conserve and mine genes and 1.2 Focus on phenotyping and genotyping plant genetic resources. Project outputs also contribute to SRP 2. Develop improved and resilient crops for greater food security through sub-SRP 2.3 Understand the mechanisms of resistance to key pests of cereals and food legumes and identify alleles associated with this resistance. ICARDA cross-cutting themes are key intermediaries to achieving these SRPs, including capacity development, scaling up proven technologies, and big data and information and communications technology (ICT). These linkages are shown in Figure 5 below, followed by pathway descriptions, risks, and assumptions.

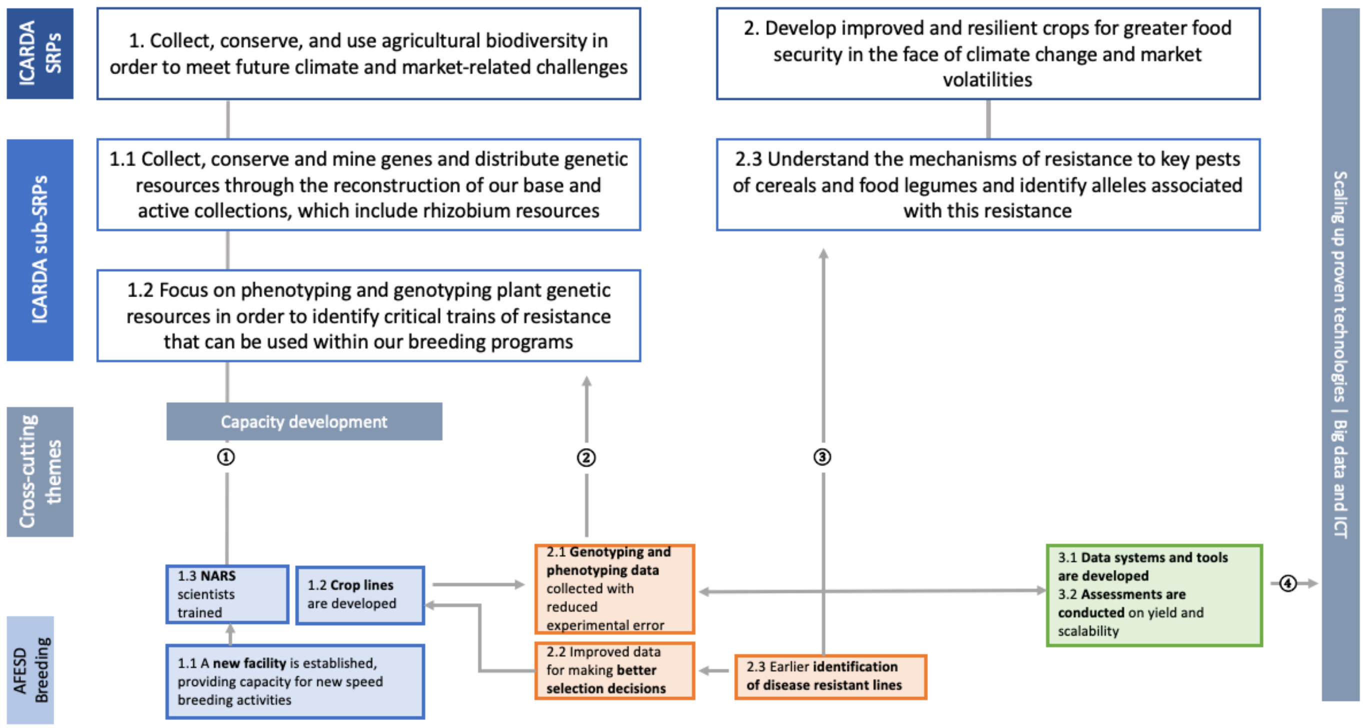

Figure 5: Linkage between project outcomes and the ICARDA strategic framework (SRFs) and cross-cutting themes (CCTs).

① **Link between output 1.3 and CCT Capacity development**

Output 1.3, training NARS scientists supports ICARDA's CCT of capacity development. This also aligns with ICARDA's specific capacity development emphases on training young men and women and fostering South-South partnerships.

- **Assumptions:** Similar to the pathways to capacity building in other frameworks above, this pathway is based on the assumption that the NARS scientists will understand and remember information from the training and that eventually some of this knowledge will be useful at their country NARS.
- **Risks:** The risk is that the new knowledge and skills obtained by the scientist never have the chance to be applied.
- **Risk mitigation:** Not within project scope

② Link between output 2.1 and ICARDA sub-SRP 1.2

Output 2.1 Genotyping and phenotyping data collected with reduced experimental error directly supports ICARDA sub-SRP 1.2 Focus on phenotyping and genotyping plant genetic resources in order to identify critical traits of resistance that can be used within our breeding programs.

- **Assumptions:** N/A
- **Risks:** N/A
- **Risk mitigation:** N/A

③ Link between output 2.3 and sub-SRP 2.3

In this pathway, Output 2.3 Earlier identification of disease resistant lines, directly contributes to ICARDA sub-SRP 2.3 Understand the mechanisms of resistance to key pests of cereals and food legumes and identify alleles associated with this resistance.

- **Assumptions:** The process through which the pest and disease management teams identify disease resistant lines is not elaborated upon in the protocol, therefore I am assuming that it is through identification of alleles associated with resistance.
- **Risks:** N/A
- **Risk mitigation:** N/A

④ Link between outputs 3.1 & 3.2 and cross cutting themes Scaling up proven technologies & Big data and ICT

Scaling up proven technologies and big data and ICT are two cross cutting themes that are prevalent in this project. They most clearly link to project outputs 3.1 Data systems and tools are developed and 3.2 Assessments are conducted on yield and scalability. Big data use and collection are enabled in this project by the genotyping and phenotyping data collected in output 2.1, and also feed back into the development of crop lines through new data management tools, systems, and analyses.

- **Assumptions:** While the analysis generated under output 3.2 assesses the scalability of novel breeding systems, the actual implementation of scaled up breeding systems are not within the scope of this project. Therefore, while this project does contribute to the cross cutting theme of scaling up proven technologies, it will not fully achieve at-scale implementation.
- **Risks:** The risk of the development of data tools and systems is that they do not fit cohesively within the ICARDA data "ecosystem" and are therefore cumbersome or do not transfer data in other cross-cutting platforms.
- **Risk mitigation:** Biometricians will explore what they will replace, upgrade, or complement.

3. Performance Monitoring System

The project MEL system includes indicators to track the project's overall progress and provide measurable means of verifying whether or not the outputs and outcomes are achieved. Because indicators are integrated along the impact pathway, they also assist in identifying project components that have enabled or disabled predicted project outputs and outcomes. Indicators will be collected on a routine (frequently collected, measured, and assessed throughout the project) or periodic (measured biannually or annually) basis. The following sections include details on these indicators and how they will be collected. Table 4 provides an overview of all indicators, noting when an indicator has a matching or similar ICARDA indicator. A table with indicator targets every 6 months may be found in Annex A.

Table 4: Summary of Routine AFESD Breeding Project Indicators

Relation to impact pathway	No.	Indicator	Baseline	Target	Monitoring frequency	Reference ICARDA or CGIAR CRP indicator or milestone
Output 1.1	**1**	Plant capacity at the new speed breeding facility (ICARDA-Rabat)	2,000	100,000	Annually	
Output 1.2	**2**	Number of plant lines advanced from F1 stage to preliminary trial under speed breeding	0	35,000	Quarterly	**Supports GLDC FP4 2022 milestone:** New populations/lines for adaptation to heat and water deficit stress and emerging diseases in climate change scenarios developed.
Output 1.3	**3**	Number of people trained in the use of new breeding technologies and phenotyping pipeline	0	30	Annually	**Direct match to ICARDA indicator**: OP-4 Number of people trained/ Number of people attending capacity development events **Supports GLDC FP4 2022 milestone**: NARS staff trained in new advances and analytics, limited infrastructure development. Annually at least 100 staff trained 10 per crop for Africa and Asia respectively[3]. **Supports GLDC FP5 2022 milestone:** Capacity development of partners in using various technologies in gene discovery and breeding
Output 2.1	**4**	Number of parental lines for ICARDA's six breeding programs evaluated with genome-wide genotyping technology	0	2,520	Quarterly	
Output 2.1	**5**	Number of mid-breeding cycle breeding lines genotyped with a small marker set to improve selection decisions	0	21,000	Quarterly	
Output 2.1	**6**	Number of preliminary and advanced yield trials plots and number of traits phenotyped with high-throughput physiological tools with 3 new tools/tests	300 per program	5,600 plots	Quarterly	**Supports ICARDA indicator**: OP-1 Number of research and development innovations **Supports GLDC FP5 2019 milestone**: Precision phenotyping for key traits for these collections and genotyping to identify novel

						alleles for 2 traits in 2 crops that have limited variability in breeding populations[1]. **Supports WHEAT FP2 2017 milestone:** improved precision of GS models using high throughput phenotyping and/or environmental data
Output 2.1	**7**	Coefficient of variance (experimental error) points decreased on average at each ICARDA breeding program as result of improved mechanization	17%	12%	Quarterly	
Output 2.1	**8**	Number of crop-specific eco-physiological databases with information on crop response under variable micro-climatic and stress scenarios based on experiments and observations at the Advanced Yield Trial stage	0	7	Annually	**Supports GLDC FP5 2022 milestone:** All GLDC trait discovery programs migrate data to IBP, BMS, GOBII to manage genotypic and phenotypic data
Output 2.3	**9**	Number of plants screened at early stage as part of the speed breeding strategy for pests and diseases to identify resistant lines (baseline = 2,000 (1 disease), target = 5,000 (2 diseases per crop)	2,000 (1 disease)	5,000 (2 diseases per crop)	Quarterly	
Output 3.1	**10**	Number of High Throughput Phenotype data-points stored integrated and processed	10,000	5 million	Quarterly	**Similar to ICARDA indicator**: OP-3 Number of datasets generated by ICARDA scientists **Supports WHEAT FP2 2020 milestone:** Centralized breeding data management system and associated tools deployed to provide breeders with better access to germplasm, genealogical, phenotypic, and genotypic data
Output 3.1	**11**	Number of tools created for data interoperability, throughput phenotyping data analytic, management, and validation pipeline to combine climatic, genotypic and phenotyping data	0	8	Endline	**Supports ICARDA indicator**: OP-1 Number of research and development innovations **Supports WHEAT FP2 2020 milestone:** Centralized breeding data management system and associated tools deployed to provide breeders with better access to

[1] Indicators for CRP GLDC are currently under development, therefore GLDC milestones have been used as proxies for indicators.

						germplasm, genealogical, phenotypic, and genotypic data **Supports WHEAT FP2 indicator:** Number of new or improved methods or tools for validation and use in breeding programs **Supports WHEAT FP3 2020 milestone:** Fully operational, integrated network of 6-8 precision phenotyping platforms developing and sharing information & germplasm with partners. **Supports GLDC FP5 2022 milestone:** Develop and validate genomic selection tools for at least 1 cereal and 2 legumes
Output 3.2	**12**	Number of novel varieties for which performance under climate change and stress factors has been assessed ex-ante, to steer and streamline future breeding activities	0	20	Annually	**Supports ICARDA indicator** PR-3: Number of accessions in long-term storage and safely duplicated at 2 levels **Supports ICARDA indicator**: OP-1 Number of research and development innovations **Supports WHEAT FP1 2017 milestone**: Ex-ante impact assessments identify potential opportunities, threats and game changes for WHEAT
Output 3.2	**13**	Number of scalability maps produced to support the development of operational seed systems	0	10	Annually	**Similar to/supports ICARDA indicator** OP 2 – Number of research papers published

3.1 Routine monitoring

Project staff will collect routine data regularly as part of project activities and the MEL Research Fellow will be responsible for obtaining data and uploading into MEL to ensure up-to-date documentation. There are four platforms that will be used for routine data collection and storage:

- **Breeding Management System (BMS):** The primary hub for collection, storage, and analysis of plant breeding data. The majority of breeding data collected in this project will be uploaded and accessed here.
- **Gigwa:** A management system for molecular genomic data. While this system will be used by scientists during the plant breeding process, it will not be a direct source for any of the indicators mentioned in this plan.
- **High throughput phenotyping data analytics, management & validation pipelines:** Pulls data from other systems directly for analysis. Stores phenotypic parameters related to growth, yield and stress tolerance. Includes statistical or/and machine learning tools to combine climatic, genotypic and phenotyping data.
- **MEL:** A web-based knowledge sharing and monitoring, evaluation and learning (MEL) platform utilized by all ICARDA projects. MEL will host the full MEL strategy, indicators, and impact pathway. Key data outputs related to the outlined indicators and project summary documents and deliverables will be regularly uploaded into MEL.

3.1.1 Routine Indicator Definitions

1. Plant capacity at the new speed breeding facility (ICARDA-Rabat)
Description
Definition: This indicator measures the number of plants in the new speed breeding facility in Rabat, Morocco. **Unit of Measure:** Count **Method of Calculation**: Based on total planting area available in facility, divided by the area needed per plant. **Disaggregated by:** Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea) **Baseline:** 2,000 **Target**: 100,000 **Rationale**: This indicator is helpful to demonstrate the usefulness and outputs of the new speed breeding facility.
Data Collection and Analysis
Data sources: Facility breeding records (documents showing how many individual crops are under breeding at any one time) **Data collection method:** Enter in MEL **Timing/Frequency of data collection and report:** Annually **Primary data collection responsibility:** Miguel Sanchez-Garcia **Evidence required:** Facility breeding records (documents showing how many individual crops are under breeding at any one time) **Comments and limitations**: Having a baseline different from 0 recognizes that there is an existing facility doing already speed breeding. This may have implications on the baseline knowledge.

2. Number of plant lines advanced from F1 stage to preliminary trial under speed breeding
Description
Definition: This indicator refers to the number of crops that moved from the F1 hybrid stage (the generation resulting from a genetically controlled mating that is successive to the parental generation) to being ready for preliminary trial by the end of the project due to the speed breeding approach. A plant is ready for preliminary trial once a pure line with desirable traits has been produced. The preliminary trial will include testing the candidate variety for a range of

characteristics which together determine its distinctness from other varieties, as well as its value to growers and end-users. **Result level:** Output **Unit of Measure:** Count **Method of Calculation**: Counting the number of plants that are ready for preliminary trial **Disaggregated by:** Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea) **Baseline:** 0 **Target**: 35,000 (5,000 x crop) **Rationale**: This indicator will help track how close the project is to achieving its aim of 35,000 plants ready for preliminary trial by the end of the project
Data Collection and Analysis
Data sources: Project reports **Data collection method:** Obtain latest project report with strategy including the number of populations per PP, number of plants per cross and strategy to advance. Enter # of lines in MEL. **Timing/Frequency of data collection and report:** Quarterly data collection by project staff **Primary data collection responsibility:** ICARDA breeders + Breeding support staff **Evidence required:** Project report **Comments and limitations:** N/A

3. Number of people trained in the use of new breeding technologies and phenotyping pipeline
Description
Definition: This indicator counts the number of NARS scientists from the 5 target countries that have been trained in the use of new breeding technologies by attending a full 1.5 day training at the annual Molecular Breeding Conference, and the number of ICARDA staff trained on the new phenotyping pipeline. **Unit of Measure:** Count **Method of Calculation**: Counting the number of scientists that attended the training **Disaggregated by:** Country; Age category; Gender; **Baseline:** 0 **Target**: 30 **Rationale**: This indicator measures the capacity building component of the project and the risk that the people who attend the training are not the target population.
Data Collection and Analysis
Data sources: Training reports, registration forms **Data collection method:** On-site registration on MEL through mobile data collection devices and forms and attendance sheet during training **Timing/Frequency of data collection and report:** While this data will be collected at the training, it will be reported in the semi-annual project report and final evaluation. **Primary data collection responsibility:** The ICARDA staff leading the training. **Evidence required:** Registration forms/attendance sheets, training report **Comments and limitations:** Will exclude individuals from the count if they did not attend the full training. Note ICARDA staff training will only include training on the new phenotyping pipeline.

4. Number of parental lines for ICARDA's six breeding programs evaluated with genome-wide genotyping technology
Description
Definition: This indicator refers to the number of parental lines for ICARDA's 6 breeding programs (barley, bread wheat, durum wheat, lentil, faba bean, and chickpea) that have been evaluated with genome-wide genotyping technology, which searches for desirable plant traits **Result level:** Output **Unit of Measure:** Count **Method of Calculation**: The number of each plant type that has been evaluated with genome-wide genotyping will be summed **Disaggregated by:** Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea) **Baseline:** 0 **Target**: 2,520 (360 per program)

Rationale: This indicator tells us whether to what degree this new technology was used to search for desirable plant traits. Use of this technology improves the efficiency of breeding by reducing the number of field trials and improving the accuracy of selection

Data Collection and Analysis

Data sources: Project Excel sheet with pedigree and selection history
Data collection method: Data will be entered in to MEL
Timing/Frequency of data collection and report: Quarterly data collection by project staff
Primary data collection responsibility: ICARDA breeders
Evidence required: Project Excel sheet with pedigree and selection history with paragraph per crop describing the genotyping platform and the reason
Comments and limitations: N/A

5. Number of mid-breeding cycle breeding lines genotyped with a small marker set to improve selection decisions

Description

Definition: This indicator refers to the number of breeding lines that have been genotyped mid-cycle (before stage 3) with a smaller marker subset to be used in the marker-assisted selection and genomic selection pipelines.
Unit of Measure: Count
Method of Calculation: Counting the breeding lines that have been genotyped mid-cycle with a smaller marker set.
Disaggregated by: Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea)
Baseline: 0
Target: 21,000
Rationale: The information produced by this activity will support improved selection decisions, therefore it is important to measure how many breeding lines have been genotyped.

Data Collection and Analysis

Data sources: Project Excel sheet with the markers and sequence per crop
Data collection method: Data will be entered in to MEL.
Timing/Frequency of data collection and report: Quarterly data collection by project staff.
Primary data collection responsibility: ICARDA Biometrics team
Evidence required: Project Excel sheet with the markers and sequence per crop
Comments and limitations: "Mid-cycle" and "smaller marker set" need to be defined.

6. Number of preliminary and advanced yield trials plots phenotyped with high-throughput physiological tools

Description

Definition: This indicator measures the phenotyping output of the new high-throughput physiological tools by counting the number of traits phenotyped and the number of preliminary and advanced yield trial plots phenotyped.
Result level: Output
Unit of Measure: Count
Method of Calculation: This indicator will count the number of traits and plots phenotyped in preliminary and advanced yield trials
Disaggregated by: Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea); Trait; Type of plot (preliminary, advanced); type of tool/test used to phenotype
Baseline: 300 per program
Target: 5,600 plots (800 per program)
Rationale: This indicator is helpful for assessing the use and application of new tools.

Data Collection and Analysis

Data sources: Primary data for this indicator can be retrieved from the new phenotyping pipeline
Data collection method: Data will be entered in to MEL
Timing/Frequency of data collection and report: Quarterly data collection with reporting in semi-annual reports and final project evaluation.
Primary data collection responsibility: ICARDA Biometrics team
Evidence required: Confirmation of phenotyping, breeding program, and type of yield trial in new phenotyping pipeline
Comments and limitations: As baseline is already 300, it is implied that some preliminary and advanced yield trial plots and traits have been already phenotyped with high-throughput physiological tools.

7. Coefficient of variance (experimental error) at ICARDA breeding program

Description

Definition: This indicator is the average point decrease in the coefficient of variance (experimental error) for each of the six ICARDA breeding programs.
Unit of Measure: Percent
Method of Calculation: Data on coefficient of variance will be automatically calculated in the pipeline.
Disaggregated by: Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea)
Baseline: 17%
Target: 12%
Rationale: This indicator helps measure if the improved mechanization of the speed breeding process is resulting in reduced experimental error.

Data Collection and Analysis

Data sources: This indicator can be retrieved from the pipeline.
Data collection method: Data will be entered in to the MEL platform.
Timing/Frequency of data collection and report: Quarterly
Primary data collection responsibility: ICARDA Biometrics team
Evidence required: BMS reports.
Comments and limitations: N/A

8. Number of crop-specific eco-physiological databases with information on crop response under variable micro-climatic and stress scenarios based on experiments and observations at the Advanced Yield Trial stage

Description

Definition: This indicator is the number of databases with information on crop response to climate and stress scenarios.
Unit of Measure: Count
Method of Calculation: Summation of count of databases established.
Disaggregated by: Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea)
Baseline: 0
Target: 7
Rationale: This indicator measures the integration of stress and climate data within the breeding program databases, which will provide valuable information on which crops may be better suited to a given region given pest and climate forecasting.

Data Collection and Analysis

Data sources: the 7 breeding program databases.
Data collection method: Review of program databases and documenting indicator in MEL.
Timing/Frequency of data collection and report: This will be collected annually.
Primary data collection responsibility: ICARDA Biometrics team
Evidence required: Evidence of crop response to climate and stress scenarios in each of the six breeding program databases.
Comments and limitations: A limitation to this indicator is that there is some subjectivity on what level of data on these topics is sufficient.

9. Number of plants screened at early stage as part of the speed breeding strategy for pests and diseases to identify resistant lines

Description

Definition: The number of plants that were screened at segregating generation stage for pests and diseases.
Unit of Measure: Count
Method of Calculation: N/A
Disaggregated by: Pest type; disease type; Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea)
Baseline: 2,000 (1 disease)
Target: 5,000 (2 diseases per crop)

Rationale: By assessing the number of plants screened for pests and diseases at an early stage, this indicator aids in improving efficiency by learning of vulnerability to pests and diseases earlier than later and in generating resilient, climate-adaptive crops, thus contributing to project outcomes.

Data Collection and Analysis

Data sources: This indicator can be accessed from the BMS.
Data collection method: Plants will undergo the screening process and data will be recorded in the BMS and BMS reports generated for upload to the MEL Platform
Timing/Frequency of data collection and report: The primary data will be collected while plants are in the early stage, and updates on the number of plants screened at an early stage will be reported in semi-annual reports and the final project evaluation. The summary data will be recorded in the MEL Platform quarterly
Primary data collection responsibility: ICARDA breeders
Evidence required: BMS reports
Comments and limitations: It is important to define what counts as an early stage and what data point (e.g. time) allows for determination of early stage to ensure that all data needed to generate this indicator is selected. As baseline is already 2,000 plants screened for 1 disease, this indicates that this activity has already started which may have implications on data available for developing crop lines and tools.

10. Number of High Throughput Phenotype data points stored, integrated, and processed

Description

Definition: The sum of the number of high-throughput phenotype data points that are entered into the pipeline, integrated (combining data from different sources into a single, unified view) and processed (carrying operations on data, to retrieve, transform, or classify information),
Unit of Measure: Count
Method of Calculation: Summation of the number of high throughput phenotype datapoints in the hhigh throughput phenotyping data analytics, management & validation pipeline
Disaggregated by: N/A
Baseline: 10,000
Target: 5 million
Rationale: This indicator tracks whether or not data that is being collected is properly stored, integrated, and processed. Thus, this indicator is key for enabling "use" of the extensive data collected. This indicator is related to ICARDA Indicator: OP-3 Number of datasets generated by ICARDA scientists, but differs as this indicator counts datapoints, not datasets.

Data Collection and Analysis

Data sources: High throughput phenotyping data analytics, management & validation pipeline
Data collection method: Accessing the pipeline and counting the number of datapoints that are entered, integrated, and processed. Documenting in MEL.
Timing/Frequency of data collection and report: This routine data should always be visible to any user of the pipeline and will be reported in the semi-annual reports, and recorded in semi-annually in the MEL Platform
Primary data collection responsibility: ICARDA Biometrics team
Evidence required: Information from pipeline on number of datapoints that are entered, integrated, and processed
Comments and limitations: Storage, integration, and processing of data have been defined to avoid subjectivity during collection of this indicator. As baseline is already 10,000, this indicates that this activity is already underway and that the data may already be supporting selection decisions.

11. Number of tools created for data interoperability, high throughput phenotyping data analytic, management, and validation pipeline to combine climatic, genotypic and phenotyping data

Description

Definition: This indicator counts the number of tools generated under component 3. Big Data that suit the following purposes (1) data interoperability, (2) throughput phenotyping data analytics, (3) project or product management, and (4) validation pipelines that consolidate climatic, genotypic, and phenotypic data.
Unit of Measure: Count
Method of Calculation: Summation of the count of tools developed under this project that suit one or some of the purposes listed above.
Disaggregated by: N/A
Baseline: 0

Target: 8
Rationale: This indicator is important for measuring the outputs of component 3. Big Data, and tracking outputs to ensure that the extensive data collected is entered into databases and functional tools. This is also linked to ICARDA OP-1 Number of research and development innovations, as these will be new tools that enable the analysis and use of data.

Data Collection and Analysis

Data sources: Project databases and tools
Data collection method: Review of databases and tools, and consultations with project staff, document indicator in MEL.
Timing/Frequency of data collection and report: Semi-annual technical reports are completed twice a year, and the final project evaluation will be conducted upon project completion.
Primary data collection responsibility: Project staff are responsible for the semi-annual technical reports, and an external project evaluator will investigate upon project completion.
Evidence required: Information on each tool, its functionality, purpose, and link if publicly accessible. The investigator should note how this tool is different from other tools already used, and what it may be used for.
Comments and limitations: To consistently measure this indicator, it will be important to define the purposes of (1) data interoperability, (2) throughput phenotyping data analytics, (3) project or product management, and (4) validation pipelines.

12. Number of novel varieties for which performance under climate change and stress factors has been assessed ex-ante

Description

Definition: This indicator counts the ex ante assessment of the performances of 20 varieties (5 crops 4 varieties) under climate change in various agrometeorological contexts.
Unit of Measure: Count
Method of Calculation: Counting the number of novel varieties that have undergone modelled/predictive assessments for climate change and stress factors.
Disaggregated by: Breeding program (barley, bread wheat, durum wheat, lentil, faba bean, chickpea).
Baseline: 0
Target: 20
Rationale: This ex-ante assessment helps identify priority regions and varieties that can help in future breeding activities.

Data Collection and Analysis

Data sources: Outputs of the ex-ante assessment which may be found in the climatic data management system.
Data collection method: Primary data for this indicator will be generated by leveraging the new predictive assessment tool for a given novel variety to generate information on plant performance under climate change and stress factors. Secondary data collection for this indicator will involve searching the climatic data management system for novel varieties that have undergone these ex-ante assessments, then noting the type of assessment(s) (climate and/or stress) and documenting in MEL.
Timing/Frequency of data collection and report: Primary data will be collected after the new statistical or/and machine learning tools have been developed, and secondary data on number of novel varieties that have been assessed using this tool will be collected annually.
Primary data collection responsibility: ICARDA breeders
Evidence required: Outputs of the assessment with details on the novel variety assessed, and what stressors were included in the assessment (e.g. climate, pests, disease)
Comments and limitations: N/A

13. Number of scalability maps produced to support the development of operational seed systems

Description

Definition: This indicator counts the number of scalability maps that have been produced using spatial modelling techniques. Scalability maps are geographical maps that shows regions where a variety could perform in 3 classes “good” , “medium”, “poor” under climate change.
Unit of Measure: Count
Method of Calculation: Counting the number of scalability maps produced.
Disaggregated by: Geographic scope (region, country, sub-national)
Baseline: 0

Target: 10 **Rationale**: These maps can help in scaling the seed systems of these 5 crops accordingly.
Data Collection and Analysis
Data sources: Secondary data (the number of maps produced) may be acquired from MEL. **Data collection method:** Documenting the number of scalability maps in MEL. **Timing/Frequency of data collection and report:** Maps produced will be recorded in MEL (as deliverables) upon completion of each map. **Primary data collection responsibility:** ICARDA Biometrics team **Evidence required:** Scalability maps showing regions where a variety could perform in 3 classes "good" , "medium", "poor" under climate change. **Comments and limitations:** N/A

3.1.2 Reporting planned and unplanned deliverables

All planned project deliverables will be configured in MEL to facilitate reporting by project staff. This will make it easier to report on the planned deliverables assigned to respective project staff. There will also be the option for staff to report unplanned deliverables. Research-related deliverables will go through internal controls to ensure that they meet the required standards (i.e. compliance with science quality standard, ensuring proper metadata fields, proper licenses applied etc.). Once this is done, each deliverable will be pushed on DSpace (Publications) and Dataverse (data). It is recommended that project staff make deliverables Open Access, however, where there is reason to restrict access, staff will have the option to save deliverables internally and fix an embargo period if needed.

3.1.3 Data access & privacy

Data and datasets that are project deliverables should be uploaded into MEL as soon as possible (or maximum 6 months after publication of products supported by this data, or 12 months after data collection), following consultation and approval from project manager. Project staff must ensure compliance with AFESD's policies relating to open access and research data management.
In accordance with CGIAR policy, when possible, all information products generated from this project should be shared in Open Access repositories or journals. To ensure that information products are accessible to all, metadata or contextual information should be shared and file formats should support interoperability.

The Plant Breeder survey requests personal data (participant name) for follow-up purposes, therefore in alignment with General Data Protection Regulation policy, the intent of the survey will be communicated and consent will be requested prior to the surveys. Personal identifier data will be removed from such datasets before archiving to the repository.

3.2 Periodic Evaluation

This project will conduct periodic monitoring through biannual reports and evaluations at project baseline and endline to assess project achievements and impact. The following sections describe the timeline of project periodic monitoring measures, suggested evaluation questions and definitions of relevant indicators. Periodic monitoring will consist of the following:

(1) NARS scientist survey: This survey aims to understand the skills and knowledge obtained by NARS scientists at the training. It will be completed by the trainees after completion of the training.

(2) Plant Breeder Selection Decision Survey: Baseline, end of year 1, and endline surveys will be completed by all ICARDA breeders involved in this project. A key output of this project is that the data collected under project component 2: High throughput data collection, supports better selection decisions (output 2.2). To assess whether and how this improved data is supporting the selection decision process, this survey aims to understand how selection decisions are made, what data and tools support the process, and the overall time and ease of the selection decision process. A comparison of responses to these questions at baseline and endline will allow for assessment of any changes in the selection decision process and insights on whether the improved data actually results in better selection decisions. The draft plant breeder survey data collection tool may be found in Annex D.

(3) Project evaluations: The baseline project evaluation will consist of collecting and analysing all baseline indicators referenced in the project, as well as responding to the evaluation questions in table 5. The final project evaluation will be conducted at the end of the project to look at the entirety of the project and assess if it met the original targets and objectives, as well as how this fits in with wider AFESD and ICARDA goals.

3.2.1 Key Evaluation Questions

The final project evaluation will be undertaken by an independent consultant(s) to complete the following:

(i) Appraise the activities and outputs achieved by ICARDA and partners,
(ii) Identify and assess outcomes of the project,
(iii) Identify the enablers and/or constraints to the attainment of project results and lessons learned

The selected evaluator(s) will make reference, but not be limited, to the following evaluation questions. To our knowledge, AFESD does not have an evaluation guidance document, therefore evaluation questions have been adapted from CRP-WHEAT, CRP-Grains Legumes, and CRP-Dryland Cereals evaluation questions[2].

Table 5: Project Evaluation Questions

AFESD Breeding Project Evaluation Questions	
Relevance	
1	Was the project design appropriate to improve the situation at hand?
2	Did the project address or contribute to the priorities of NARS in the 5 target countries?
Effectiveness	
3	Has this project achieved its target outputs and contributed towards the identified CRP-WHEAT and CRP-GLDC outcomes, GGIAR SRF, and ICARDA SRPs?
4	Did the impact pathway logically link the activities to outputs and outcomes through plausible theories of change that take risks, and assumptions into account?
Efficiency	
5	Were financial, material, and human resources used in the best possible way?

[2] Note that GLDC was formerly separated as two CRPs: Grain Legumes and Dryland Cereals. The latest evaluations were conducted while these CRPs were still separate, thus evaluation questions from both CRP evaluations were reviewed.

6	Have the resource allocation processes and timing affected the implementation of the program's research activities?
Capacity Building	
7	How did the training activities in this project contribute to building the capacity of NARS scientists?
8	To what extent is ICARDA's ability to efficiently serve the national agricultural research centers (NARS) improved?
Sustainability	
9	Are financial, material, and human resources secured to continue speed breeding activities at ICARDA-Rabat?
Scaling Up	
10	Is the project adequately addressing enabling factors for scaling up speed breeding activities at ICARDA facilities?

The project evaluation will be based on secondary data collection and potentially primary data (field visits). Although the evaluator(s) will propose their own methods, it is expected that the consultants apply both quantitative and qualitative methods and maintain an objective and holistic approach to evaluating the project.

3.2.2 Periodic Indicators

Table 6: Summary of Periodic AFESD Breeding Project Indicators

Relation to impact pathway	No.	Indicator	Baseline	Target	Monitoring frequency
Outcome 1	**14**	Number of breeders who report reduced time needed to make selection decisions	TBD by Breeder survey	TBD	Baseline End of Year 1 Endline
Outcome 2	**15**	Number of breeders who have mainstreamed new data and tools from ICARDA into their work	N/A	TBD	Endline
Outcome 3	**16**	Priority regions and varieties identified	N/A	N/A	Endline

14. Number of breeders who report reduced time needed to make selection decisions

Description

Definition: This indicator measures the amount of time it takes to make selection decisions by assessing (a) how long it takes to make a single selection decision, and (b) how many selection decisions are made in 1 week.
Unit of Measure: Count
Method of Calculation: The baseline responses from breeders will be subtracted from their endline responses to determine if the amount of time to make selection decisions has been reduced.
Disaggregated by: Breeding program
Baseline: TBD
Target: TBD
Rationale: This indicator helps measure efficiency, per Outcome 1 (CRP-WHEAT 2.5): Breeders develop improved varieties more efficiently via access and use of germplasm and tools.

Data Collection and Analysis

Data sources: Plant Breeder Survey
Data collection method: This information will be collected at baseline and endline by analysing responses to questions C1 and C2 in the plant breeder survey. Alternatively, if it is possible to measure the time needed to make selection decisions within one of the databases or tools used, this method will be applied since it is less subjective than breeders' perceived time use.
Timing/Frequency of data collection and report: Will assess at baseline, end of year 1, and endline.
Primary data collection responsibility: MEL staff; project evaluator
Evidence required: Plant Breeder Survey Responses
Comments and limitations: As mentioned above in "data collection method", breeders' perceived time use is subjective and thus not precise. Therefore if possible, this indicator should be automatically collected in the database/tool used for selection decisions.

15. Number of breeders who have mainstreamed new data and tools from ICARDA into their work

Description

Definition: This indicator measures the integration of new data and tools generated in this project by plant breeders, by asking about their use and helpfulness for plant breeding.
Unit of Measure: Count
Method of Calculation: Will be calculated from Plant Breeder survey question B2: "What databases and tools do you use to make selection decisions"? And B4: "If you use the new breeding pipeline, what do you find it helpful for?"
Disaggregated by: Breeding program
Baseline: N/A
Target: TBD
Rationale: This indicator helps measure adoption of tools for Outcome 3.1 (CRP-WHEAT 3.3): Partner breeding teams improved breeding processes by adopting new technologies, methodologies, approaches and genetic resources.

Data Collection and Analysis

Data sources: Plant Breeder Survey
Data collection method: Pull results from Plant Breeder survey into MEL.
Timing/Frequency of data collection and report: Will measure at the end of the project
Primary data collection responsibility: MEL staff; Project evaluator
Evidence required: Plant Breeder Survey responses
Comments and limitations: Additional data on helpfulness of this new pipeline will also be collected in the survey.

16. Priority regions and varieties identified

Description

Definition: This indicator uses the ex-ante assessment and scalability maps produced to identify what are the priority regions for these varieties and which varieties will do best under climate change conditions.
Unit of Measure: Report on the priority regions and varieties.
Method of Calculation: Assessment by scientists weighing the best regions and varieties.
Disaggregated by: Country; breeding program
Baseline: 0
Target: 1
Rationale: This will help in future breeding activities and help in the appropriate scale up of the seed systems for the 5 crops.

Data Collection and Analysis

Data sources: Ex-ante assessment; scalability maps
Data collection method: Will enter in MEL
Timing/Frequency of data collection and report: Endline
Primary data collection responsibility: Miguel Sanchez-Garcia
Comments and limitations: N/A

4. Learning and Adaptive Management

The project team will document, share, and make use of lessons learned for continuous project improvement. The project criteria for identifying lessons learned will be as follows:

a) Lessons that are relevant/related to the **project thematic areas**;
b) Lessons that demonstrate a **clear cause-effect relationship between project actions and results realized**;
c) Lessons whose recommendations have a bearing on **project relevance, effectiveness, efficiency, sustainability and impact**

Learning and adaptive management will be based on (1) operational processes-related lessons learned, which captures more day-to-day learnings as they arise, and (2) research-based learning which is more of a periodic, reflective process that focuses around revisiting the ToC.

4.1 Operational Processes-Related Lessons Learning

1. **Operational experience-based/ After-Action lessons learned identification**
   During their regular roles, project staff shall identify operational experiences that are potential learning experiences per the three topic areas above and document them in the Lessons Learned report template and submit it to MEL staff.

2. **Staff Meeting and Project Review Workshop Pause-and-Reflect sessions:**
   The Project Manager will ensure that pause-and-reflect sessions are incorporated in regular staff meetings, as well as during the Annual Project Review Workshop. These sessions will focus on three questions[3]:

   a) What went right, why, and things that worked that can be continued/repeated
   b) What went wrong, why, and things that didn't work that should be avoided/discontinued
   c) What needs to be improved

Through discussion and brainstorming during these meetings, the meeting chair will seek to determine whether any of the discussed experiences are worth documenting as a lesson learned. The chair or a volunteer from the meeting shall fill out the Lessons Learned template and submit it to MEL staff, who will review all submitted operational processes-based lessons learned documents and provide guidance and feedback to project staff within 14 days. Completed Lessons Learned Report Templates will be uploaded onto the MEL Platform by project MEL staff. The institutional MEL Specialist will review the submitted lesson learned and provide feedback to the project MEL staff and/or approve the lesson learned. The institutional MEL Specialist will approve each lesson learned either internal or public sharing, covered in section 4.3 below.

[3] Adapted from Rowe, S. F. & Sikes, S. (2006). Lessons learned: taking it to the next level. Paper presented at PMI® Global Congress 2006—North America, Seattle, WA. Newtown Square, PA: Project Management Institute.

4.2 Research-Based Lessons Learning

4.2.1 ToC Review and Adaptation

The ToC was developed based on an understanding of how change may happen as a result of the project activities, based upon multiple assumptions, hypotheses, and linkages. However, it is recognized that the understanding of change and the realities of project implementation are not static. Therefore, the project team will routinely test, revise, and adapt the project ToC.

The project team will organize a one-day meeting to review and refine the ToC with project staff and stakeholders at two points: (1) after the first three months of the project (approx. August-November 2020); and (2) after the first year of project implementation, during the Annual Project Review and Planning Workshop, further described in section 6.

For the ToC Review process, the meeting participants will break into groups, making sure that each group includes of members with a breadth of expertise and knowledge. The breakout groups will discuss key questions related to the: (1) relevance of outcomes in the ToC, and (2) the rationale of the outcomes and causal pathways. For each outcome, groups should document responses to the following questions:

1. **Relevance of outcome:**
    a) Is the outcome still relevant? If Yes, maintain; If No, delete and document the irrelevant ones and include any new ones.
    b) Is the outcome still achievable within the ICARDA and partners' technical and operational capability, and within the available project resources?
    c) Are the output results critical for achieving the corresponding outcomes?
    d) Are the associated outputs actionable?

2. **Rationale of outcomes and causal pathways:**
    e) Do the assumptions still hold? If Yes, no need to review them; If No, revise the assumptions and the associated risk analysis and risk mitigation measures.
    f) Are there shifts in the risks of the 'unchanged' assumptions? If yes, document these and design appropriate risk mitigation actions.
    g) Do we now have better or worse evidence for the assumptions made? If better, document. If worse, how can we seek/generate better evidence?
3. **Final assessment**
    h) Which of these outcomes to you predict will be at risk of insufficient evidence and why? *(For first ToC review meeting in 2020 only)*
    i) Which of these outcomes have knowledge gaps (insufficient evidence to support the preconditions, assumptions, linkages, and activities) and therefore should be the basis for a learning action plan? *(For Annual Project Review only)*

It is recommended that the initial group of people that conduct ToC analysis do not exceed 5. If a review meeting is comprised of more than 5 people, create breakout groups of equal numbers, with a mix of specializations. The meeting facilitator should spend some time checking on the groups, ensuring that varying viewpoints are considered, and consensus generated. The meeting facilitator will collate the information from all groups and share the joint ToC analysis responses with the project MEL staff, who will make final ToC revisions in consultation with the institutional MEL

Specialist. Changes made in the project ToC will be clearly communicated back to the project staff and AFESD with clear justification.

4.2.2 Identification of Learning Outcomes & Action Plan

As identified in the "final assessment" question from the previous activity, the ToC outcomes for which there is [a risk of] insufficient evidence to support the preconditions, assumptions, linkages, and activities will be considered to represent a knowledge gap and will be the basis for the subsequent year's learning agenda. This activity will be challenging during the first ToC review, as the majority of project activities will not have started yet. Therefore, participants are encouraged to prioritize well and predict areas that may be at risk of insufficient evidence. The learning agenda should be limited to two outcomes. If more than two learning outcomes are initially identified, the project team will prioritize the top two for which the learning will be most useful and actionable and those with the riskiest assumptions and thus endanger the achievement of project outcomes.

To ensure a broad and beneficial learning agenda, each outcome identified will have only one to three learning questions associated with it. Each learning question must have an associated action plan clearly stating the metrics that will be used to measure the different dimensions of the learning questions, the data collection mechanism, timing, and responsible parties. The Learning Question Action Plan shall become an integral part of the subsequent year's MEL Annual Plan. A template for the Learning Question Action Plan is presented in Annex E.

4.3 Storage and Dissemination of Lessons Learned

After approval from the Institutional MEL Specialist, operational and research-based lessons learned may be disseminated to the stakeholders below through the following methods.

Table 7: *Dissemination of Lessons Learned to Internal and External Stakeholders*

Audience	Dissemination methods
Internal	
ICARDA staff	MEL Platform
Project staff and consultants	E-mails
External	
AFESD	E-mails
Country NARS	E-mails, shared databases
Other institutions involved in plant breeding, agriculture, and dryland systems	Conferences, blogs, webinars

ICARDA
Science for resilient livelihoods in dry areas

5. MEL Support Supervision

This section serves to guide MEL system and data quality checks at the project-level. MEL support supervision (MSS) will be conducted to appraise the project MEL system and the data collected and used for routine reporting. The specific objective of MSS will be to assess project reporting systems and routine reporting data, to identify strengths and weaknesses so corrective action can be taken.

The first cycle of MSS will be completed within six months of project initiation and the second cycle will be conducted after completion of year 1. The general approach is explained in section 5.1, the approach for data collection and validation are presented in sections 5.2 and 5.3, deliverables from MSS are included in section 5.4, and guidance on sharing MSS results is provided in section 5.5.

5.1 MSS Approach

The institutional MEL Specialist or Project MEL staff will lead an MSS at the project level. Each time MSS is conducted, an appreciative and supportive inquiry approach will be applied. After introducing the purpose of the MSS to the project staff, the assessment team shall discuss each evaluation criterion and create an understanding of the importance/scores attached to each criterion. Staff will be given ample opportunity to discuss the relevance, purpose and outcomes of each of the assessment criterion so as to ensure maximum benefit from the exercise.

The following steps will be followed in the implementation of MSS:

1. **Identification of the MSS team**: The Institutional MEL Specialist will identify the team to conduct MSS at the project office. The principle that will guide the selection of the team will be to promote learning across the institution and the project and thus other project team members with MEL roles may be invited onto the team.
2. **Developing a schedule** for the MSS as a team: Whereas a tentative schedule may have been developed by the MSS leader, the schedule will be revisited and/or adopted collectively.
3. **Identifying the MEL system components and/or indicators to be included** in the MSS.
4. **Selecting and refining the MSS templates**.
5. **Conducting MSS visits**.
6. **Preparing, presenting & sharing the MSS report** and creation of an action plan.
7. **Follow up** on the implementation of the MSS recommendations.

5.2 MEL System Assessment

The following sections are “checklists” of items to be reviewed during the assessment that should be saved in the MEL system or appropriate project data management system. The MEL staff should record the status of each component, the primary data source, and a brief explanation of how the action exists/is implemented.

5.2.1 MEL Governance/Leadership

a) There is a clear linkage between the MEL plan and the MEL Platform, for recording MEL data;
b) These is sufficient structural MEL oversight and process supervision to minimize errors such as data measurement, recording, transcription, and transmission.

5.3 Data Verification & Validation

This will be done by tracing and verifying (recounting) data collected and used for reporting indicator results. This will help determine if the data was correctly recorded at the primary source and if there were no transcription and transmission errors. The following steps will be followed in the implementation of the data verification/validation component of MSS:

a) Cross-check the data submitted/reported in the quarterly, semi-annual or annual reports and identify indicators that are:
   i. Key for overall project reporting,
   ii. Problematic in measurement and reporting,
   iii. Have not been the subject of MSS before, or
   iv. Whose reported figures seem not to conform to expectations;
b) Ascertain whether the recorded output at the primary data source matches the indicator definition;
c) Check availability and review completeness of all indicator source documents/data collection forms and summary forms at all the data aggregation levels:
   i. Are some source documents missing? If Yes, determine how this might have affected reported numbers;
   ii. Are all available source documents complete? If no, determine how this might have affected reported numbers;
   iii. Review the dates on the source documents. Do all dates lie within the reporting period? If no, determine how this might have affected reported numbers;
d) Recount results from the source documents, compare the verified numbers to the reported numbers;
e) Conduct random verification of the records. For example, if the subject of verification is the number of trainees, randomly select a manageable number of trainees and reach them by telephone or e-mail to verify the authenticity of the records. In case some of the selected trainees for verification refute the claims as contained on the source documents, utilize the ratio of negative responses to the total responses to deflate the 'verified number';
f) Calculate the ratio/percent of the verified numbers to reported numbers, and determine the level of discrepancies (if any);
g) Seek additional information regarding any discrepancies encountered;
h) Document the observed discrepancies (if any) and the reasons provided; and
i) Collegially discuss solutions to the discrepancies.

5.4 Sharing MSS Results

Upon completion of each MSS assessment, a formal report of the results will be developed and shared with project staff and relevant MEL staff. The report will be discussed in a project staff meeting convened specifically for this purpose. An action plan to address the identified issues will then be developed and used as the basis for follow up to check on improvements. The MSS report template in F will be used for this purpose.

5.5 Deliverables

1. Completed MSS checklist, as listed in sections 5.2 and 5.3 above. (Including status of each component and a brief explanation.
2. MSS report (Template in Annex F)

6. Project Review and Planning

The project review and planning process is envisioned to build a common understanding of performance of the project, create shared ownership for the achieved results, set the stage for entrenching corrective measures in subsequent project implementation cycles. The specific objectives of the project review workshops will be to:

1. Inform project and MEL staff of project implementation, progress, and results
2. Identify lessons learned based on the pause-and-reflect approach and the ToC review process outlined in Section 4
3. Plan for the following year
4. Enhance team building, team ownership of strategies, implementation plans, and results

6.1 Project Review & Planning Workshops

To date, a kick-off meeting was held in April 2020 and progress was reported in an October 2020 meeting, and a planning and reporting meeting is planned for January 2021. Due to COVID travel restrictions we have suggested a 1-day virtual workshop during the January 2021 meeting.

6.1.1 Virtual Workshop Agenda

Date: January 2021

Send in advance: Instructions on joining video application, agenda, instructions on Theory of Change review per section 4.2 of MEL plan

After workshop: Ensure all materials (e.g. group notes on ToC) compiled; document any suggestions for annual workshop (such as content or timing changes)

Theory of Change workshop			
Time	Activity	Activity Facilitator	Note taker
9:00-9:30	Introductions & Ice Breaker	Project Manager	-
9:30-10:00	Overview of impact pathway and ToC, relevance, and introduction & questions on ToC review activity (section 4.2 of MEL plan)	MEL staff	-
10:00-11:00	Breakout groups review outcomes	MEL staff	Groups
11:00-11:15	Break	-	-
11:15-12:30	Group discussion & presentations	MEL staff	TBD
12:30-13:30	Break	-	-
13:30-13:40	Overview and questions on Learning Outcomes & Action Plan activity (per MEL plan section 4.2.2)	MEL staff	-
13:40-14:30	Breakout groups: Identification of Learning Outcomes & Action Plan	MEL staff	-
14:30-15:30	Group presentations and Q&A	MEL staff	TBD
15:30-15:40	Wrap up & next steps	MEL staff	-

6.2 Reflection on Progress Results

Reflection on the results achieved by the project will be done at two stages during this workshop: (1) A presentation of progress results; (2) Break-out sessions to reflect on positive and negative results.

6.2.1 Results Plenary Presentations

The following are the guiding principles for all presentations:

a) Start the presentation by celebrating team achievements. This is crucial to cultivate a positive team spirit.
b) The presentation should, as much as possible, relate to the project result areas, activities and targets.
c) The presentation should include time for group comments and questions. Any interactive components (especially during the virtual workshop) will be key for maintaining interest and engagement.

Table 9: Guidance on the presentation themes, content, presenters, and the required resources for the presentations

Theme	Presenter	Content	Key resources
The bigger picture: Setting the stage	Project Manager	- Highlight key sector and program trends; - Strategic developments and frameworks	- Relevant and up-to-date national and international statistics and policy proclamations; - ICARDA, CGIAR, CRP-WHEAT, and CRP-GLDC Strategies; - Project proposal and bi-annual reports; - Project work plan and budget
Implementation progress and results	Project component leaders	- Progress against work plan, budget, and allocated output indicator targets - Milestones achieved and deliverables completed	- Project implementation records - Project work plan and budget
	MEL Research Fellow or MEL Specialist	- Consolidated status of project output and outcome indicators based on quarterly progress data, highlighting the actual achievement per planned result area and pitfalls - Lessons learned	- Project work plan and budget - Implementation reports, evaluation reports, data from the MEL Platform - Lessons learned reports
Finance report	Finance and Procurement Officers	- Expenditure by project component and any variances from plan - Unit cost of deliverables across the project implementation areas and implications thereof - Financial compliance issues and highlight of project or related audit issues - Regulatory developments that require budgetary changes	- Project work plan and budget - Audit reports and correspondences - National regulations, tax reforms etc.

6.2.2 Breakout session: pause-and-reflect

Participants will break up into groups of 5 people maximum with a mix of skills and operational geographies. The groups reflect on result areas that had positive and negative variance as highlighted during the Implementation Progress and Results presentations. Each group works to answer the following questions:

a) What could we have done differently to achieve the planned targets? (Reflect on the planned processes, strategies, activities, partners, resources, etc.)
b) What are the key learning points from this under achievement and the reasons we have put forward?
c) Among the strategies, partners etc., what do we recommend to;
    i. Carry forward,
    ii. Drop/discontinue or,
    iii. Modify and continue, in the coming project implementation cycle (year).

The groups will present their findings in 15 minutes and follow-up 10 minutes for questions and clarifications and a rapporteur takes notes. A volunteer from each group or the MEL staff will summarize key points in the Lessons Learned template.

6.3 Theory of Change Review

Refer to Section 4.2.

6.4 Action Planning / Plan for Next Year

Each thematic group (plant breeders, biometricians, etc.) gathers and creates a plan of work and budget for the upcoming project year/implementation cycle. In doing so they consider:

- the output-level indicator targets that were allocated to them
- the strategies that worked well in the just-ended year/project implementation cycle,
- the lessons learned,
- ToC modifications, and the
- key practices to carry forward, drop and modify items listed by the rapporteur of the group feedback session (section 6.2.2)
- label the strategies and actions for the upcoming year (i.e. by rationale).

6.5 Deliverables

1. Workshop report
2. PoWB for the upcoming project implementation period (draft version)
3. Lessons learned reports

7. Reporting

This section describes the types of reports that are required at different time intervals for both internal and external results communication and accountability purposes. Section 7.1 addresses internal reporting requirements while section 7.2 addresses external (donor) reporting requirements.

7.1 Internal Reporting

The internal reporting process will include:

1) **Monthly reporting by project staff on the status of planned tasks:** The MEL Research Fellow will attend and take notes on the monthly meeting and shall record these in an appropriate repository. During this meeting, the MEL Research Fellow will (1) ensure that indicators requiring monthly reporting frequency are being tracked, (2) probe deviations from the plan of work, (3) provide timely advice to the Project Manager and field team on appropriate remedies, (4) use the meetings as a platform to gather and record lessons learned from the operational processes, and finally (5) ensure that appropriate follow-up is made with the respective field/project team members to record reported deliverables in the MEL Platform.

2) **Quarterly documentation of progress:** This will be achieved through progress reports complemented with recording of output-level indicator values in the MEL Platform. The report should include: (1) a summary of all project activities, (2) physical and financial progress over the previous three months showing targets and achievements, (3) highlighting significant key issues and challenges identified, and (4) lessons learned and recommended solutions to overcome the challenges. The indicator values on the status of output-level results will be recorded in MEL following the pre-recorded indicators definitions as laid out in section 3.1.

7.2 Reporting to AFESD

1) **Semi-Annual Technical Reports:** These are to be completed bi-annually to assess project progress and cover technical and financial aspects of the project, as requested by AFESD.
2) **Evaluation Reports:** Upon completion of the baseline and end-line evaluation processes, an evaluation report will be submitted to AFESD.
3) **Final Project Evaluation:** A final project evaluation will be conducted at the end of the project to look at the entirety of the project and assess if it met the original targets and objectives, as well as how this fits in with wider AFESD and ICARDA goals. See section 3.2.1 for further information on objectives and evaluation questions.

The completed donor reports will be uploaded to the MEL Platform under the 'Donor Reports' section, here.

7.3 Special Cross-Cutting Reports

Given project connections to CRP-WHEAT, CRP-GLDC, and cross-cutting issues of capacity building, scaling up proven technologies, big data, and climate change, special reports may be generated for both internal and external communications. These may be a result of a deliberately and systematically recorded case studies/success stories, or learning agenda implementation.

8. MEL Budget

The total project budget is $3,270,000 USD. Per ICARDA standard practices, projects above $500,000 should have a specific set of activities and a budget for MEL, at least to support data curation. However the project did not budget for M&E costs and a potential reallocation will be assessed in Year 2.
The following table is a draft of estimated MEL costs based on 4 main activities: (1) a virtual workshop, (2) a breeder survey, (3) routine data collection, and (4) end of project evaluation. The total estimated cost for these four MEL activities is $15,850, noting that ICARDA staff costs are based on estimated daily rates of $500 and **represent the cost of staff time-- not additional costs**. The only item listed below that is additional cost is the end of project evaluation, estimated at $7,500.

Activity	Staff	Time total	Staff cost	Inputs	Inputs cost	Total cost	Summary of Results
1 day virtual workshop	1 MEL Research Fellow	**4 days** (including prep, event, and follow up)	$400	N/A	N/A	**$6,150**	1. Project staff become familiar with and help improve the project Theory of Change 2. The MEL support planned for the project becomes strengthened and better aligned
	1 MEL Specialist	**1.5 days** (including review of workshop materials & workshop attendance	$750				
	10 project staff	**1 day**	$5000				
Breeder survey data collection	1 MEL Research Fellow	**5 days** (including survey revision, data collection, and analysis)	$500	N/A		**$1,000**	Generates evidence on whether and how the improved data generated under Component 2 and tools generated under Component 3 are supporting improved selection decisions.
	6 ICARDA Breeders	**1 day** (includes survey completion, estimated to take 15-20 minutes)	$500				
Routine data collection in MEL	1 MEL fellow	**12 days** (1 day per month)	$1,200	N/A	N/A	**$1,200**	Tracks the project's overall progress and provides measurable means of verifying whether or not the outputs and outcomes are achieved. Costs

							are not included as they come out of the MEL budget.
End of project evaluation (no travel)	1 External consultant	**15 days**	$7,500	This current estimate does not include travel per current COVID travel restrictions. However if the situation improves and travel is beneficial to the consultant, this row should be updated.	N/A	**$7,500**	1. Activities and outputs achieved by ICARDA and partners are appraised 2. Outcomes of the project are identified and assessed 3. Enablers and/or constraints to the attainment of project results and lessons learned are identified
Total MEL activity costs						**$15,850**	

Annexes

Annex A: Indicator targets

Routine Indicators

Note-- all values are cumulative

No.	Indicator	Baseline	6 mo. target	12 mo. target	18 mo. target	24 mo. (final) target
1	Plant capacity at the new speed breeding facility (ICARDA-Rabat)	2,000	100,000	100,000	100,000	100,000
2	Number of plant lines advanced from F1 stage to preliminary trial under speed breeding	0	0	15,000	25,000	35,000 (5,000 per crop
3	Number of people trained in the use of new breeding technologies and phenotyping pipeline	0	0	0	30	30
4	Number of parental lines for ICARDA's six breeding programs evaluated with genome-wide genotyping technology	0	1,000	2,520	2,520	2,520 (360 per program)
5	Number of mid-breeding cycle breeding lines genotyped with a small marker set to improve selection decisions	0	5,000	15,000	20,000	21,000 (3,000 per program)
6	Number of preliminary and advanced yield trials plots and number of traits phenotyped with high-throughput physiological tools with 3 new tools/tests	300 per program	400 per program	600 per program	700 per program	5,600 plots (800 per program
7	Coefficient of variance (experimental error) points decreased on average at each ICARDA breeding program as result of improved mechanization	17%	17%	15%	13%	12%
8	Number of crop-specific eco-physiological databases with information on crop response under variable micro-climatic and stress scenarios based on experiments and observations at the Advanced Yield Trial stage	0	0	5	7	7
9	Number of plants screened at early stage as part of the speed breeding strategy for pests and diseases to identify resistant lines (baseline = 2,000 (1 disease), target = 5,000 (2 diseases per crop)	2,000 (1 disease)	2,000 (2 diseases)	3,000 (2 diseases)	4,000 (2 diseases)	5,000 (2 diseases per crop)
10	Number of High Throughput Phenotype data-points stored integrated and processed	10,000	100,000	1 million	2.5 million	5 million
11	Number of tools created for data interoperability, throughput phenotyping data analytic, management, and validation pipeline to combine climatic, genotypic and phenotyping data	0	2	4	6	8

12	Number of novel varieties for which performance under climate change and stress factors has been assessed ex-ante, to steer and streamline future breeding activities	0	5	10	15	20
13	Number of scalability maps produced to support the development of operational seed systems	0	0	5	7	10

Periodic Indicators

No.	Indicator	Baseline	6 mo. target	12 mo. target	18 mo. target	24 mo. (final) target
14	# of breeders who report reduced time needed to make selection decisions	TBD	TBD	TBD	TBD	6
15	# of breeders who have mainstreamed new data and tools from ICARDA into their work	N/A	N/A	TBD	TBD	6
16	Priority regions and varieties identified	N/A	N/A	N/A	N/A	N/A

Annex B: NARS Scientist Survey

Primary Objective: This survey aims to understand the skills and knowledge obtained by scientists who attended the 1.5 day training at the 2021 Molecular Breeding Conference.

Survey Procedure:
Upon completion of the 1.5 day training, the trainees will be requested to complete this survey before leaving the training.

#	Question	Responses	Single (S), or Multiple (M) responses
1.	I agree to participate in this survey, I understand the purpose and nature of this activity and I am participating voluntarily. I understand that I can stop taking the survey at any time, without any penalty or consequences. I understand that my name is only being included for follow-up purposes, and that quotes will not be attributed to me in project publications.	- Yes - No	S
Section A: Workshop Feedback			
B1.	How would you describe your level of knowledge on speed breeding now that you have completed this workshop?	- The same as before, I did not learn anything new about speed breeding in this workshop - Slightly increased, I learned some new information on speed breeding, but not very much - Significantly increased, I learned lots of new information about speed breeding during this workshop	S
B2.	In your current role, will you be able to apply any of the skills or information you learned in this workshop?	[text box)	S
B3.	In the future, how do you think you will apply this knowledge, if at all?	[text box]	S

Annex C: Plant Breeder Survey

Primary Objective: To assess whether and how the improved data generated under Component 2 and tools generated under Component 3 are supporting improved selection decisions by investigating:

- How selection decisions are made
- What data and tools support the process
- The overall time and ease of the selection decision process

Survey Procedure:
Upon approval of the final survey contents by the Project Manager and Monitoring, Evaluation, and Learning Specialist, the survey will be entered into the platform of choice (e.g. Qualtrics, SurveyMonkey…etc.). As the survey is being rolled out at baseline, midline, and endline, it will be important to review the survey before each run to ensure questions are appropriate and added/removed as needed, per notes in red below. After the survey is fully entered in the platform, the Project Manager and/or a plant breeder will pilot the survey to identify any areas for improvement or technical issues.

All plant breeders involved in this project (N=6) will receive an e-mail that explains purpose of the survey and requests their completion of a survey.

Survey: (content in red indicates questions that should be included in baseline or endline survey only)

#	Question	Responses	Single (S), or Multiple (M) responses
1.	I agree to participate in this survey, I understand the purpose and nature of this activity and I am participating voluntarily. I understand that I can stop taking the survey at any time, without any penalty or consequences. I understand that my name is only being requested for follow-up purposes, and that quotes will not be attributed to me in project publications.	- Yes - No	S
Section A: Respondent Background			
A1.	What is your job title?		S
A2.	What is your name?		S
A3.	In which breeding program(s) do you work?	- Barley - Bread wheat - Durum wheat - Lentil - Faba bean - Chickpea	M
Section B: Selection decisions			

B1	What types of information do you use to make selection decisions?	- Physical observation of the plant - Genotyping data - Phenotyping data - Coefficient of Variation - Analytical outputs (AMMI, PCA, AMOVA) - Simple sequence repeat markers - Photosynthesis data - Carbon partitioning data - Other (please specify)	M
B2	What databases and tools do you use to make selection decisions?	A) Breeding management system (BMS) B) Gigwa C) Crop-specific eco physiological databases [developed in component 2, include in end of year 1 or endline only] D) The high throughput phenotyping data analytics, management and validation pipeline [developed in component 3, include in endline only] - Other (please specify)	M
B3	If B2=D → How would you rate the compatibility of this pipeline with existing data and systems you use? [developed in component 3, include in endline only]	- This pipeline just adds to the number of tools and databases I access as a standalone pipeline with no connection - This pipeline is somewhat integrated with existing tools and processes - This pipeline connects data sources thus reducing the need to access multiple sources - (Optional comment box)	
B4	If B2=D →I find/do not find this pipeline helpful for: *(For each purpose, please select 'yes' if you find the pipeline helpful or 'no' if you do not find it helpful.* [developed in component 3, include in endline only]	(Y/N option for each response) - Designing trials - Managing trials - Analyzing trials - Defining target population environments - Combining data from different sources (climatic, phenotypic, genotypic, pedigree) to predict genotype performance - Controlling data quality - Summarizing analytical outputs - Visualizing analytical outputs - Simplifying the workflow for phenotyping procedures - Making selection decisions	M
Section C: Time and ease of selection decision process			
C1	From the moment you have received phenotyping and/or genotyping data	[Drop down option to select number of minutes or hours]	S

	on a given plant, how long on average do you estimate it takes you make a selection decision?	(optional comment box)	
C2	Do you experience any of the following challenges in making selection decisions?	- The data I need is not available in a timely manner - The data I need is not easy to access in tools or databases - The coefficient of variation (CV) is high, so there is greater risk of experimental error - The marker set is too large - Other (please specify)	
C3	Approximately how many selection decisions do you make in the average week?	[Drop down option to select number] (optional comment box)	S
C4	In the past 2 years, have you experienced an improvement in making selection decisions?	- Yes - No - I am not certain (optional comment box)	S
C5	Which of the following statements best describes the timeliness of selection decisions since you started using [tool- include dropdown list]	A) I make selection decisions quickly B) It takes me a longer time to make selection decisions C) There is no change in the time I make breeding decisions; D) I am not certain	S

Annex D: Learning Question Action Plan

Prioritized Outcome: *(Example: <u>Outcome 1</u> (CRP-WHEAT 2.5) Breeders **develop improved varieties more efficiently** via access and use of germplasm and tools)*

Learning question	Metrics/Measures	Data collection mechanism	Data collection timing	Responsible parties	Requires update to MEL plan?	Why w helpfu used fo
[Question 1] *Example: how can we measure efficiency?*	*Currently there are questions on time spend in the breeder survey, but there are also additional measures we can automate in data collection tools to measure this*	*BMS*	*Quarterly*	*Biometrics team (to automate measures)*	*No, does not affect impact pathway or indicators*	*Provide measu*
	[Measure 2]					
[Question 2]						

Annex E: MSS Report Template

This template shall accompany completed checklists from sections 5.2 and 5.3. While the checklists provide details of each criterion, this report should provide a summary of the strengths, weaknesses, and suggested corrective actions for each component assessed by the MSS.

1. MEL Governance Leadership
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions
2. MEL Plan
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions
3. Standard Operating Procedures
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions
4. MEL Work Plan & Budget
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions
5. Human Capacity for MEL
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions
6. MEL Information Systems & Knowledge Management
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions
7. Data Verification & Validation
    a. Strengths
    b. Weaknesses
    c. Suggested Corrective Actions