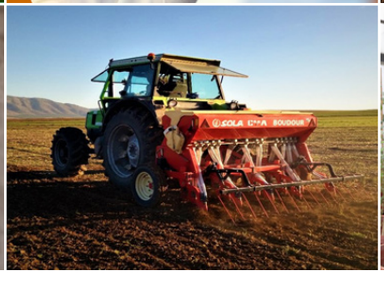
ICARDA 2030 Research & Innovation Strategy

Sustainable dryland agriculture for a resilient and prosperous future



ICARDA
Science for resilient livelihoods in dry areas

CGIAR

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FOREWORD

BOARD CHAIR AND DIRECTOR GENERAL

Mr. Aly Abousabaa
ICARDA Director General / CGIAR Regional Director, Central and West Asia, and North Africa

Dr. Neal Gutterson
Chairperson of the ICARDA Board of Trustees

The climate crisis is reaching a critical tipping point, impacting vulnerable populations and economies, particularly those in global drylands dependent on agriculture. Political unrest, rising costs, migration, and the unsustainable use of natural resources add to their challenges.

While effective, our 2017-2026 strategy now lags behind the speed of these interconnected and escalating challenges. Yet new opportunities arise through new agri-innovations and digital technologies. We must swiftly adapt to equip dryland farmers for a resilient and prosperous future.

A collective global effort is essential, so we now leverage the knowledge and resources of our existing networks to generate new kinds of partnerships - above all with the private sector and the communities we serve - that can help us to test and scale our ideas and ensure farmers' voices and needs are reflected in innovations that are relevant, affordable, and competitive. We particularly acknowledge the contributions made by our partners in reshaping this strategy to focus our strategic priorities and align with CGIAR's new global innovation portfolio and other regional and global climate initiatives.

For the science, while maintaining our research focus on climate-smart crops, mixed farming and agrosilvopastoral systems, and better land, soil, and water management, we've added a vital climate research component to inform future innovations to target specific climate agri-challenges while measurably reducing emissions and environmental impacts. We also acknowledge political tensions, inadequate governance, or drylands that become devastated through slow response. This bold and pragmatic approach allows us and our partners time to prepare, manage, and even avoid their worst effects.

Exciting advancements in technology also feature. Precision tools, green energy, smartphone apps, big data, and artificial intelligence play a crucial role as we digitize our science while ensuring that farmers benefit from new and affordable tech.

> **"THE CLIMATE CRISIS IS REACHING A CRITICAL TIPPING POINT, IMPACTING VULNERABLE POPULATIONS AND ECONOMIES, PARTICULARLY THOSE IN GLOBAL DRYLANDS DEPENDENT ON AGRICULTURE."**

Most importantly, our updated strategy recognizes and celebrates the potential of the non-tropical drylands in global agri-science, hardy biodiversity, green technology, and resilient dryland farming practices. And it seeks to empower dryland communities, specifically women, youth, and marginalized groups, for inclusive employment and climate resilience.

As a key science convener, we commit to driving transformative change in agriculture for food, nutrition, and water security in the region and beyond. We are dedicated to generating thriving and resilient dryland livelihoods alongside our partners. Now is the time for ICARDA to act.

Executive Summary

The ICARDA 2030 Research & Innovation Strategy (ICARDA 2030) provides a roadmap for future endeavors. It builds on more than forty years of experience working with partners on dryland system transformation, gathering the evidence that the right investments, science, and innovation can make to vulnerable populations. It will ensure that our research remains at the forefront of agricultural research and innovation and that we maximize investments as we work towards catalyzing change and delivering impact.

Our vision in the non-tropical drylands is of thriving communities and resilient livelihoods through our research. We envision people with adequate incomes, secure access to nutritious food, and the capacity to manage natural resources in equitable, sustainable, innovative ways.

Our mission is to generate meaningful research that actively contributes to reducing poverty while strengthening food, water, and nutritional security and promoting environmental health in the face of global challenges like climate change and fragility in the non-tropical drylands.

To deliver on our vision and mission, our strategy is organized around **four Strategic Research Priorities** (SRPs) and **four Cross-Cutting Research Priorities** (CCRPs) that will act as **catalysts for transformation** and priority areas for investment.

ICARDA 2030 also builds on the foundations laid in our 2017-2026 strategy[1], which sought to address urgent issues arising from an anticipated +4°C future, particularly in non-tropical dry regions. To inform our new priorities, we conducted a foresight analysis to explore potential changes in dryland areas and identify the critical challenges over the next seven years. We also looked to CGIAR's 2030 Research and Innovation Strategy[2], which places collaboration, knowledge-sharing, and ambitious partnerships at its center to ensure our impact areas align. And we integrated valuable input from our stakeholders, including policymakers, development partners, research partners, resource partners, investment banks, NGOs, and private sector companies.

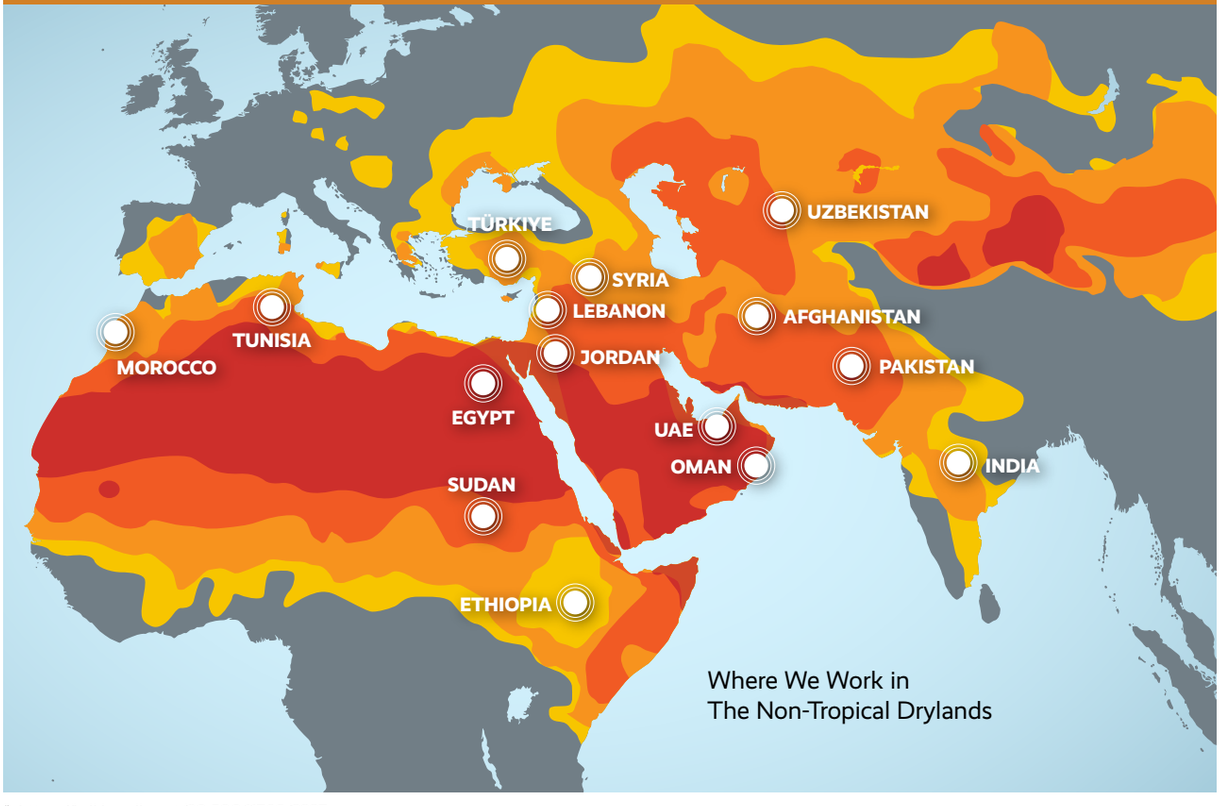
To implement our strategy, we also commit to investing in people to ensure we have the right skills and expertise in new approaches, such as using Artificial Intelligence (AI) and embedding knowledge sharing across our science areas. As well as this, we are looking to ambitious new partnerships, particularly with the private sector, to help us test and scale our ideas and with disruptive thinkers, startups, and young researchers who can bring fresh ideas to help us solve old, new, and evolving problems. We are also investing in increased policy engagement, advocacy, and strategic communications as a critical pathway to help us achieve our vision and mission.

ICARDA 2030 is our guiding framework in the context of evolving challenges. It integrates end-user feedback loops to ensure our research and innovations are demand-led, relevant, fit-for-purpose, and can be scaled. It is geared to stimulate incomes, employment, and entrepreneurship opportunities, particularly for women, young people, and other marginalized groups, and to ensure a thriving and productive future in the global dryland regions.

Non-tropical drylands are characterized by a scarcity of water, which affects both natural and managed ecosystems and constrains the production of livestock as well as crops, wood, forage and other plants and affects the delivery of environmental services. Dryland soils tend to be vulnerable to wind and water erosion, subject to intensive mineral weathering, and of low fertility (due to the low content of organic matter in the topsoil).

The United Nations Environment Programme defines drylands according to an aridity index, which is the ratio between average annual precipitation and potential evapotranspiration; drylands are lands with an aridity index of less than 0.65. Drylands are found in most of the world's biomes and climatic zones and constitute 41 percent of the global land area.

United Nations Food and Agriculture Organisation
https://www.fao.org/dryland-forestry/background/what-are-drylands/en/



[1] https://hdl.handle.net/20.500.11766/8237
[2] https://hdl.handle.net/10568/110918

Introduction

The 2030 context

Two billion people live in the global dryland areas[3] which account for more than 40% of the world's land surface. Drylands have complex and fragile ecosystems vulnerable to the adverse effects of the changing climate, land degradation, and biodiversity loss. Much of the Middle East and North Africa region (MENA) is also particularly exposed to political and economic crises, especially in fragile and conflict-affected countries such as Syria and Yemen, exacerbating these environmental challenges.

In 2023, it is estimated that one in five people in the region will be food insecure, including 8 million children for whom the effects of prolonged hunger may last a lifetime[4]. Food insecurity is also a concern in Central Asia, particularly in Afghanistan, Tajikistan, and Turkmenistan. Global conflicts add to the challenges, disrupting food supply chains and driving mass migration of populations seeking refuge across borders. More locally, rural-to-urban migration is taking many young people away from agriculture in search of employment.

With the right investments, transformative science, and innovation, the drylands have the potential to sustain food production and livelihoods and provide a resilient and prosperous future for vulnerable rural populations, including young people, women, and marginalized groups. Our updated strategy will ensure no one in the drylands is left behind.

Why update our strategy?

Given accelerating climate change and other impacts, the ICARDA 2030 Research and Innovation Strategy now recognizes and addresses the need to adapt our work to evolving global challenges and to better deploy new digital technologies to deliver impact quickly in a climate crisis. It has four new strategic research priorities and crosscutting themes that catalyze transformation and investment priorities. It builds on many elements from our former strategy[5] and remains focused on vulnerable people in the non-tropical drylands of low- and middle-income countries, ensuring they have adequate incomes, access to food, markets, and nutrition, and the capacity to manage natural resources in equitable, sustainable, innovative ways.

[3] https://www.fao.org/dryland-assessment/en/
[4] https://openknowledge.worldbank.org/server/api/core/bitstreams/8e31828f-f062-4a40-a929-fabe7d1b17cd/content
[5] https://www.icarda.org/publications/11367/icarda-strategic-plan-2017-2026

Identifying priorities for transformative action

To define our new strategic priorities and crosscutting themes, we conducted a foresight study to set out four global 2030 dryland scenarios, gathered valuable input from our partners and scientists, and looked at how best we could deliver on the impact areas set out in the CGIAR 2030 Research and Innovation Strategy.

CGIAR is a global research partnership for a food-secure future dedicated to transforming food, land, and water systems in a climate crisis . The recent One CGIAR transition resulted in a dynamic reformulation of its partnerships, knowledge, assets, and global presence for greater integration and impact. Each component of our updated strategy relates to and serves an aspect of the CGIAR 2030 Strategy. ICARDA's 2030 strategy also has a common foundation with the CGIAR Global Dryland Strategy.

Four global 2030 dryland scenarios

A foresight study helped us to identify opportunities and constraints to achieving our vision. The study looked ahead to 2030 to identify the potential impacts of demographic shifts, urbanization, rising temperatures, water scarcity, youth unemployment, and social inequality on agricultural productivity in global drylands. It considered drivers of change, including the socio-economic context, land and water management, governmental institutions and infrastructure, input and output markets, biodiversity loss, agricultural investment and innovation, and water dynamics, which we embedded into the framework of a set of 2030 Global Food and Agriculture Scenarios.

This meant we could better understand how they could evolve, resulting in four global dryland scenarios, each representing a possible future for agri-food systems in a global dryland context.

Figure 1. Foresight analysis scenarios for global drylands by 2030[6]

Climate-conscious food production and consumption patterns are established and underpinned by innovations in the global food system and new technologies.

Greater stability in global governance as great power tensions plateau, trade moves more freely, but pockets of fragility and civil unrest flare during economic contractions.

Step up: The resilient drylands

Enhanced stability in dryland regions, prioritization of sustainable trade, conservation, equitable climate finance, and agriculture fosters cross-border cooperation and resilience and reduces poverty and inequality.

Two worlds: Divided drylands

Conflict-ridden dryland regions struggle to implement sustainable agriculture. Stable countries address vulnerabilities and adapt to climate change, with grassroots efforts attempting to alleviate poverty and malnutrition.

Continuation, not transformation: Stagnation in the drylands

Global drylands face persistent issues: special interests dominate, marginalized farmers struggle, inequalities persist, governance is weak, and resources are limited.

Retrogression: Devastated drylands

Conflict engulfs global drylands, causing devastation through inequality, migration, disease, and land degradation. Resource mismanagement, violence, and governance failure worsen suffering, leaving urgent international intervention necessary for recovery.

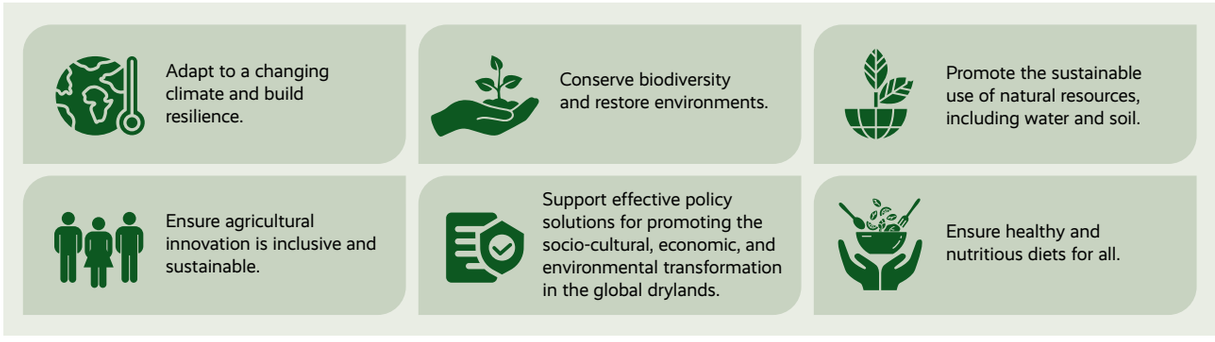
Intensifying conflict, civil unrest (including high government turnover), and rising poverty levels create substantial displacement and continue to disrupt trade in key commodities.

Inefficient food production and excessive consumption patterns accelerate; technological innovation is focused on decreasing inefficiencies at the margins and is not transformative.

[6] These scenarios were created by CIMMYT during the production of their 2030 Strategy: Science and Innovation for a Food and Nutrition Secure World.

The dynamics explored in these scenarios highlight critical challenges to transforming food systems in the global drylands. Further analysis by CGIAR staff and partners resulted in the prioritization of six key issues that our updated research and innovation strategy seeks to address.

Figure 2. Six key issues prioritized by ICARDA and our partners



Consultation with stakeholders and partners

ICARDA's leadership team initiated a roadshow in the fall, visiting all corners of the non-tropical drylands to obtain critical feedback from hundreds of partners, donors, policymakers, academics, and other key stakeholders, including farmer associations, global research institutions and agencies, and other CGIAR Centers working in dryland areas. We held in-person stakeholder consultations in Egypt, India, Jordan, Lebanon, Morocco, Syria, Tunisia, Türkiye, and Uzbekistan.

The remaining countries received surveys to ensure we captured their perspectives and feedback on our strategy. The overwhelming feedback from these consultations was that ICARDA needs to expand its portfolio of crops to include cacti and forages and explore new ways of working with our partners on integrating new technologies – such as machine learning and green energy solutions – into dryland agriculture.

Four Strategic Research Priorities

We updated our Strategic Research Priorities to reflect our progress since their design in 2016. We adapted them to the challenges our analysis and partner consultation consider the most pressing for smallholder farmers in the drylands over the coming decades. To meet these challenges, achieve our vision, and realize our mission, we have structured our strategy around four SRPs, reshaped to emphasize our systems approach. We have also added a new SRP to highlight our work on livestock.

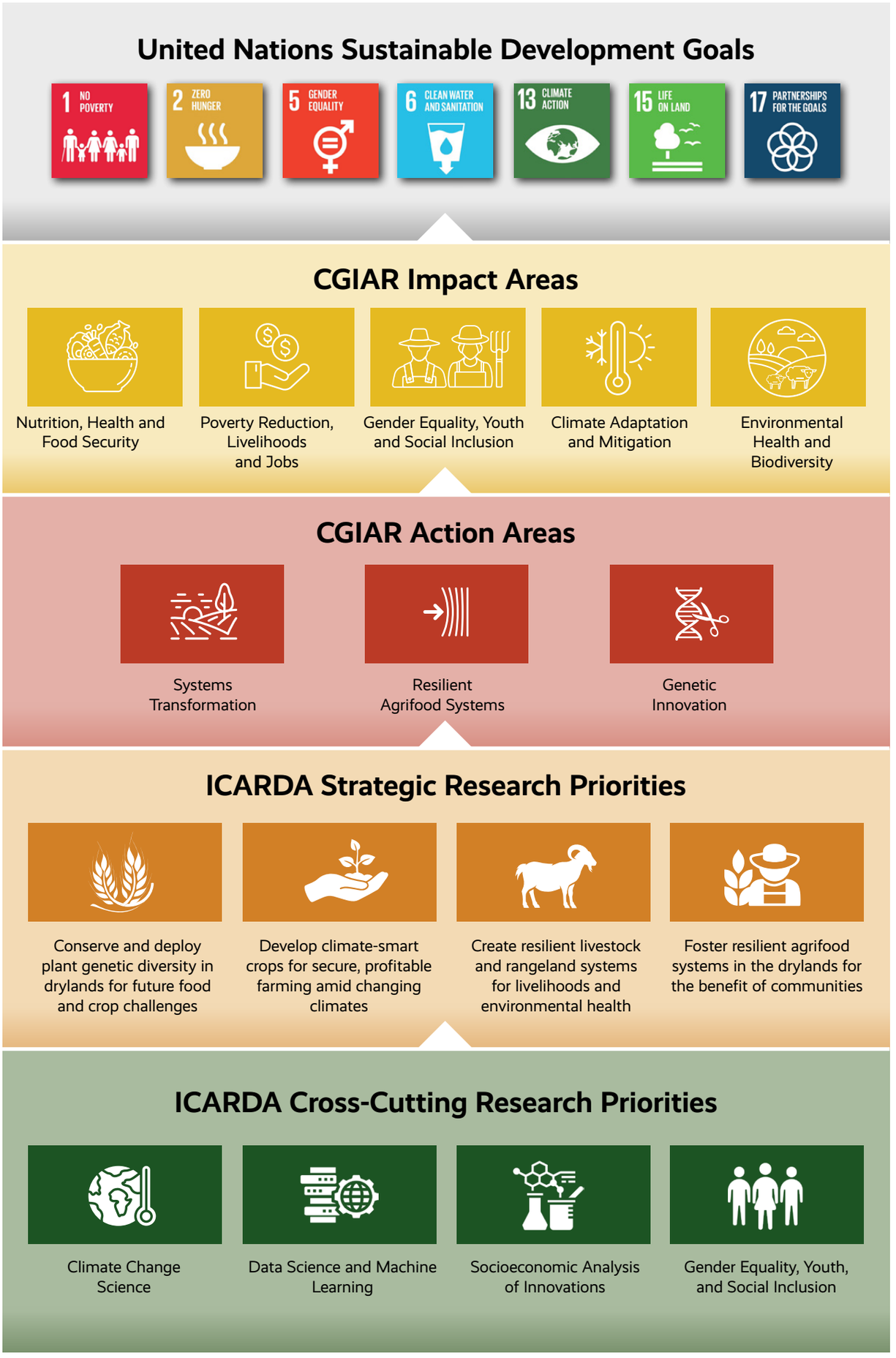
We have also identified four Cross-Cutting Research Priorities which are areas of cross-cutting research that will act as catalysts for transformation. Each component outlines how ICARDA will implement its work and work in concert with its partners. These catalysts for transformation are essential areas of research in and of themselves, and they will also drive forward our work and increase the impact of our research by supporting our efforts under each of the SRPs.

Our updated SRPs and and CCRPs outline an ambitious science and innovation strategy that will guide the Center's work to 2030.

Figure 3: Updated Strategic Research Priorities and Cross-Cutting Research Priorities

STRATEGIC RESEARCH PRIORITIES (SRPs)	CROSS-CUTTING RESEARCH PRIORITIES (CCRPs)
SRP1: Conserve and deploy **plant genetic diversity** in drylands for future food and crop challenges.	**CCRP1:** Climate Change Science (CCS)
SRP2: Develop **climate-smart crops** for secure, profitable farming amid changing climates.	**CCRP2:** Data Science and Machine Learning (DSML)
SRP3: Create **resilient livestock and rangeland systems** for livelihoods and environmental health.	**CCRP3:** Socioeconomic Analysis of Innovations (SAI)
SRP4: Foster **resilient agrifood systems** in the drylands for the benefit of communities	**CCRP4:** Gender Equality, Youth, and Social Inclusion (GEYSI)

Figure 4: ICARDA contributions to CGIAR Action and Impact Areas and SDGs



ICARDA's 2030 roadmap to resilient drylands – our new approaches

The ICARDA 2030 Strategy leverages new technologies, global research trends, and groundbreaking approaches, to better adapt to evolving climate challenges:

- Collect novel genetic diversity, conserve, and make available to users including breeders, researchers, and farmers, including plants, medicinal and aromatic plants, rangeland shrubs and forage, neglected crops, rhizobium, and rhizosphere resources as well as beneficial insects including biocontrol agents and honeybees.

- Contribute to the development of new open-access tools for electronic data capture, predictive characterization, and data-driven decision support, thereby making available data and tools on genetic resources.

- Prioritize breeding for critical food and forage crops cultivated in non-tropical drylands including biofortification for iron and zinc where applicable and the novel addition of prickly pear cactus and nitrogen-fixing forages.

- Increase the rate of genetic gain of ICARDA's mandate crops through the deployment of efficient breeding tools, genomic strategies (genomic selection, genomic editing), and decreased cycle length.

- Develop and implement community-based sheep, goat, and camel breeding programs and dissemination strategies of improved genetics, to increase productivity, adaptation to environmental stress, and ensure sustainable use of indigenous animal genetic resources.

- Develop agile and robust small ruminant phenotyping platforms for different production systems and use cutting-edge genomics research to enhance breeding efficiency for reproductive fitness, reduced methane emissions, and adaptive traits to cope with climate change.

- Quantify potential GHG emissions of indigenous sheep and goat populations including building a database on methane gas emissions for different feeding rations.

- Ensure farming systems are climate-proofed for the future by means of carbon farming, low-cost plant-based alternative proteins, regenerative agriculture, reintroducing neglected and underutilized crop species for low environmental footprint crop diversification, ecological intensification, precision agriculture, agroforestry, integrated pest management, agricultural waste utilization, circular agriculture, and agroecological approaches in the face of land, water, and climate crises. Special consideration will be given to the sustainable intensification of date palm – a major component of the production system in desert and dryland farming.

- Increase freshwater availability through alternative water resources such as treated wastewater, desalination, new technologies for non-conventional water such as water harvesting, including from the atmosphere, managed aquifer storage and recovery, and others.

- Deploy green energy solutions for dryland agriculture such as solar-powered agrivoltaics – where agriculture and solar energy generators share the same land – desalination of saline water using emerging technologies such as electrodialysis, ultra-low energy drip irrigation, atmospheric water generation, and hydroponics and root zone cooling for controlled environment agriculture.

Updated Cross-Cutting Research Priorities
Climate Change Science
Socioeconomic Analysis of Innovations
Data Science and Machine Learning
Gender Equality, Youth, and Social Inclusion

Strategic Research Priorities (SRPs) in detail

Our four SRPs focus on crops, livestock, sustainable integration, and value chains. By considering crops and livestock within mixed systems and encouraging efficient value chains for farmers, we aim to maximize the impact of investments. This holistic approach fosters synergy between various agricultural aspects, enhancing sustainability and profitability. Aligning research and practice in these areas, ICARDA aims to provide practical solutions that directly benefit farmers and contribute to the broader goals of agricultural development and sustainability. Knowledge sharing and collaboration between the SRPs will ensure that our research is carried out in an integrated way.

SRP1: Conserve and deploy plant genetic diversity in drylands for future food and crop challenges.

Plant Genetic Diversity focuses on collecting, conserving, and utilizing plant-related diversity in non-tropical drylands to address food security and crop diversification challenges through higher crop yields and improved nutritional quality, increased climate resilience, and enhanced national conservation efforts.

1.1 Collect, conserve, and make novel genetic diversity available to users, including breeders, researchers, and farmers, including plants, medicinal and aromatic plants, rangeland shrubs and forage, neglected crops, rhizobium, rhizosphere resources and beneficial insects including biocontrol agents, and honey-bees.

1.2 Enrich the genebank collection with added-value information and apply state-of-the-art technologies to mine genetic resources for valuable climate-resilient traits with the potential to benefit end-users.

1.3 Strengthen pre-breeding activities by introgressing adaptive traits from wild relatives and landraces into elite germplasm of ICARDA-mandated crops emphasizing biotic and abiotic stresses, water and input use efficiency, and nutritional quality, including intergeneric hybridization using embryo rescue, tissue culture as well as genomic tools.

1.4 Contribute to developing new open-access tools for electronic data capture, predictive characterization, and data-driven decision support, making available data and tools on genetic resources.

1.5 Join efforts with NARES to assess the status and threats to crop-related diversity in non-tropical drylands, recommend management plans for conserving diversity niches, and contribute to global systems of conservation of genetic resources.

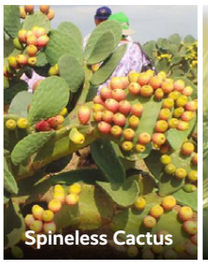
1.6 Use the Farming with Alternative Pollinators' approach to sustain indigenous pollinator diversity and enhance pollination services to increase yields. Strengthen the focus on securing nesting. Proceed with cross-sector action plans enabling low-income countries to protect native pollinators and strengthen climate change resilience.

1.7 Build capacity for national programs to conserve and use genetic resources by applying standard operating procedures, hosting long-term individual trainees and organizing regional and thematic training workshops.

SRP2: Develop climate-smart crops for secure, profitable farming amid changing climates.

ICARDA's CGIAR-Mandated Crops

Other ICARDA Target Crops



Climate-Smart Crops focuses on breeding climate-resilient crops and forages that can withstand environmental changes, including water scarcity, to address food, feed, and nutritional security, resulting in more profitable farms.

2.1 Prioritize breeding for critical food and forage crops – with a focus on the genetic improvement of orphan dryland crops adapted to climate extremes – including bread wheat, durum wheat, barley, chickpea, lentil, faba bean, and grasspea, as well as biofortification for iron and zinc where applicable and the novel addition of prickly pear cactus and nitrogen-fixing forages.

2.2 Increase the rate of genetic gain of ICARDA's mandate crops through the deployment of efficient breeding tools, genomic strategies (genomic selection, genomic editing), and decreased cycle length.

2.3 Accelerate the delivery of climate-resilient germplasm for more profitable farms by understanding the systemic challenges and opportunities addressing policy, regulatory, institutional, and technical challenges to design inclusive and effective seed systems for rapid varietal replacement measured by average age of varieties in farmers' fields and the performance of the seed sector in availing quality seed of newer improved varieties.

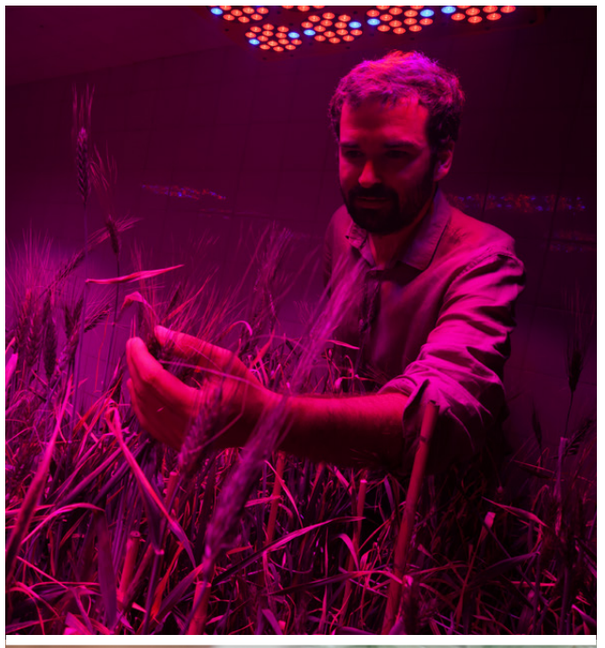
2.4 Ensure new varieties meet nutrition, market, and value chain needs for strong food sovereignty by keeping targeted product profiles up to date to deliver fit-for-purpose new varieties by understanding the needs of all the actors of the whole value chain, deploying participatory approaches, and avoiding social, gender, and age biases.

2.5 Deploy pre-emptive approaches to protect farms from emerging pests via genetic resistance through surveillance and forecasting insect and pathogen population changes for anticipatory plant breeding and understanding resistance mechanisms to deliver resistances as defined by the crop product profiles.

2.6 Deploy useful allelic diversity to fight evermore challenging pests and climatic stresses using pre-breeding approaches focused on pyramiding useful alleles, generating knowledge for them, and deploying genomic-enhanced methods to produce better parents for breeders to use.

2.7 Use effective data integration to guide the development and deployment of novel varieties, ensuring breeding is a data-driven science supported with size-appropriate databases, integrating complex biometrical approaches, and digitalizing records to increase precision and accuracy development and integration of new tools and approaches where required.

2.8 Guarantee a skilled next generation of plant scientists through short- and long-term training models tailored to partners' needs to build their capacities, including using strategic investments.



SRP3: Create resilient livestock and rangeland systems for livelihoods and environmental health.

Livestock and Rangeland Systems focuses on developing ecosystem health in climate-resilient livestock and rangeland systems, emphasizing the empowerment of local communities, especially women, through evidence-based policies.

3.1 Develop and implement community-based sheep, goat, and camel breeding programs and dissemination strategies of improved genetics to increase productivity, adaptation to environmental stress, and ensure sustainable use of indigenous animal genetic resources.

3.2 Develop agile and robust small ruminant phenotyping platforms for different production systems. To cope with climate change, use cutting-edge genomics research to enhance breeding efficiency for reproductive fitness, reduced methane emissions, and adaptive traits.

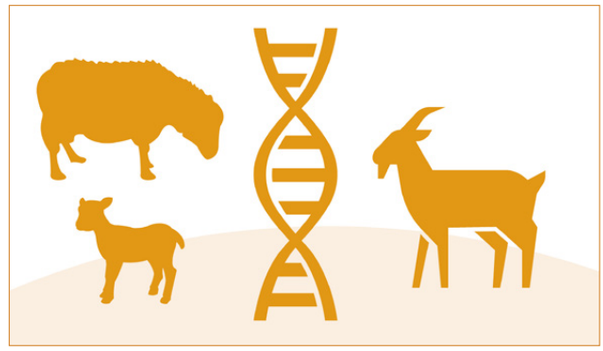
3.3 Quantify potential greenhouse gas (GHG) emissions of indigenous sheep and goat populations, including building a database on methane gas emissions for different feeding rations.

3.4 Develop new feed solutions with the potential to reduce GHG emissions, including and applying secondary metabolites to manipulate rumen methanogenesis.

3.5 Develop and promote climate-resilient, multipurpose rangeland species and forage crops considering the 'pharmacological' virtues of rangeland species that can generate additional income for local communities.

3.6 Develop bundles of integrated solutions for water, land, and livestock management and restoration of rangeland-based ecosystems considering climate change, institutions, social norms, and governance.

3.7 Assess the environmental health of rangeland-based ecosystems, including expansion of invasive species, carbon sequestration potential, impact of afforestation, and provision of environmental services.



3.8 Assess the costs of inaction and the returns on investment for ecosystem restoration and develop new financial mechanisms to support investment in ecosystem restoration.

3.9 Strengthen national capacity and institutions and influence national strategies and policies, particularly land tenure-related policies, with science-based evidence to empower local communities to manage and govern their rangelands.

SRP4: Foster resilient agrifood systems in the drylands for the benefit of communities

Resilient Agrifood Systems focuses on building climate-resilient crop-based and mixed farming systems to optimize economic, social, and environmental gains in a water-scarce environment while balancing economic, social, and environmental needs.

4.1 Develop context-specific scalable agronomic solutions for reducing yield gaps and improving yield stability and resilience for crop-based systems in drylands along the water availability continuum.

4.2 Create sustainable livelihood and entrepreneurship opportunities through desert farming technology, such as protected agriculture, vertical farming, solar farming, hydroponics, and high-value plants.

4.3 Ensure farming systems are climate-proofed utilizing carbon farming, low-cost plant-based alternative proteins, regenerative agriculture, reintroducing neglected and underutilized crop species for low environmental footprint crop diversification, ecological intensification, precision agriculture, agroforestry, integrated pest management, agricultural waste utilization, circular agriculture, and agroecological approaches. Special consideration will be given to the sustainable intensification of date palm – a major component of the desert and dryland farming production system.

4.4 Build farmers' resilience to climate change-related water risks through crops and varieties that require little water, and that can withstand climatic stresses of heat, drought, and soil salinity, improve irrigation methods and systems using modern irrigation techniques to raise land and water productivity, manage salinity and stay within water-energy-food-environment limits.

4.5 Increase freshwater availability through alternative water resources such as treated wastewater, desalination, new technologies for non-conventional water such as water harvesting, including from the atmosphere, managed aquifer storage and recovery, and others.

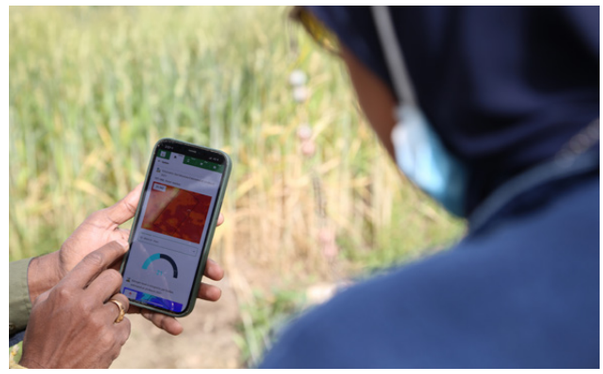
4.6 Focusing on women and youth, promote climate-smart mechanization and automation solutions for reducing drudgery, land degradation, and GHG emissions, improving energy use efficiency, income-generating opportunities, and sustainability of small-scale agriculture.

4.7 Develop and use modern digital tools such as digital agriculture, big data, and artificial intelligence and deploy state-of-the-art earth system observation systems and technologies to monitor soil health, identify yield gap determinants, forecast yields, weather, water availability, climate impacts, crop resilience, and to design solutions for staying within planetary boundaries.

4.8 Deliver last-mile knowledge and information through digital extension services, including the use of on-the-spot diagnostics of crop and soil health, and dashboards

and applications that employ artificial intelligence and machine learning for crop, soil, and water management, including advisory services, decision support, and early warning systems.

4.9 Deploy green energy solutions for dryland agriculture such as solar-powered agrivoltaics – where agriculture and solar energy generators share the same land – desalination of saline water using emerging technologies such as electrodialysis, ultra-low energy drip irrigation, atmospheric water generation, and hydroponics and root zone cooling for controlled environment agriculture.

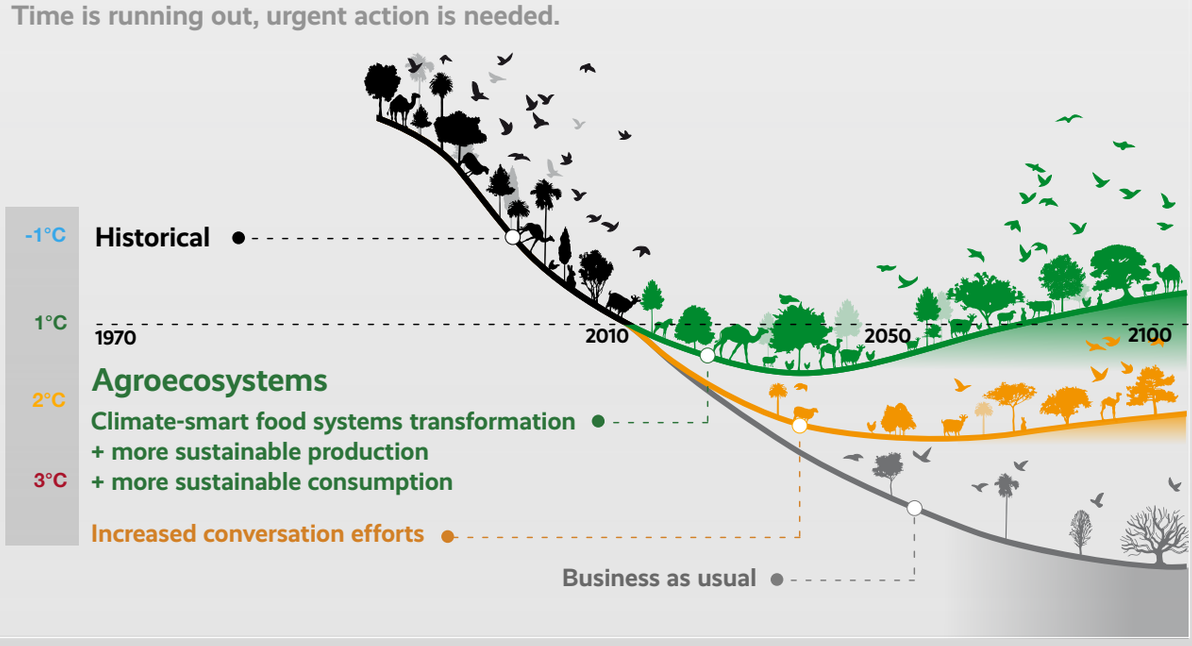


Cross-Cutting Research Priorities (CCRPs) in detail

We have identified four crosscutting research priorities as catalysts for transformation and priority topics for investment. They deliver across all our strategic research priorities and are designed to push ICARDA's work to the forefront of scientific inquiry and impact. They demonstrate our vision and ambition in how we intend to move beyond business as usual and deliver on transformation for the drylands by tackling the most pressing challenges and driving forward the newest innovations and technologies.

ICARDA Cross-Cutting Research Priorities (CCRPs)

- Climate Change Science (CCS)
- Data Science and Machine Learning (DSML)
- Socioeconomic Analysis of Innovations (SAI)
- Gender Equality, Youth, and Social Inclusion (GEYSI)



Based on the IPCC Report 2021: https://www.ipcc.ch/report/ar6/wg1/

CCRP1: Climate Change Science (CCS)

Climate change poses the most significant challenge for sustainable agrifood systems in the global drylands. CCS seeks to enable societies to better manage the risks and opportunities arising from climate variability. It will do this by incorporating climate information and prediction into planning, policy, and practices, particularly in climate-sensitive areas such as agriculture and water, to support countries – particularly in low- and middle-income countries – that lack the resources needed to provide high-quality climate services.

1.1 Assess climate dynamics and explore climate change hotspots to examine different meteorological variables (and indicators) focused on the drylands at different scales for the present and future.

1.2 Develop strategies to downscale climate from global to regional to plot level scales for operational and statistical use, including machine learning, and dynamic techniques.

1.3 Perform modeling-based ex-ante assessments to explore the impacts of climate change in each domain and the optimal best adaptation options specific to each domain.

1.4 Develop and use models on the interaction between soil-plant-animal-water-atmosphere to explore novel systems in the drylands where research is not yet developed to understand the impact of climate in the global drylands.

1.5 Foster Research for Development (R4D) on climate change mitigation and adaption across SRP2, SRP3, and SRP4, including carbon sequestration, reduction of GHG fluxes (both crop and livestock), enhance solar technology, crop physiological modeling to assist foresight breeding, etc., using observations, experimentation, and modeling.

1.6 Employ earth observation systems that use optical, thermal, and microwave sensors to understand various land surface dynamics in connection to climate change to support the SRPs in close collaboration with the catalyst for transformation on data science and machine learning.

1.7 Conduct Target Population Environment (TPE) analysis to support crop improvement and diversification, and land restoration/agrosilvopastoral management.

1.8 Develop climate information systems with various levels of complexities in close collaboration with the catalyst for transformation in data science and machine learning targeting multiple stakeholders.

1.9 Study the microclimates in controlled environments (greenhouses, animal housing, phytotrons) for operational use, anticipating rapid scaling of greenhouse-based farming in Central and West Asia and North Africa (CWANA).

1.10 Promote stakeholder engagement and co-creation of climate initiatives and policies, engaging with governments in the non-tropical drylands, focusing on the agricultural sector.

CCRP2: Data Science and Machine Learning (DSML)

Through DSML, we will maximize research efficiency and outreach, providing technological expertise and experimentation facilities to enable the digital transformation of agrifood businesses and the public sector. This will include using AI, which can significantly contribute to soil and water conservation.

DSML will focus on sharing AI-related best practices and tools for farming systems within three major areas: agricultural robotics, soil and crop monitoring, and predictive analytics, which will be embedded in ICARDA's agricultural research to support the timely and reliable generation of scientific evidence from the wealth of data we generate through our projects and programs.

2.1 Develop frameworks and guidelines for the ethical and productive use of data science and machine learning technologies.

2.2 Build internal and partner capacity to exploit the opportunities that arise from technological advances in artificial intelligence and data science.

2.3 Develop and implement cutting-edge machine learning and data science solutions to solve complex research challenges in dry areas.

2.4 Develop efficient agricultural input-use (i.e., land, water, capital, labor, pesticides, fertilizers, and others) models based on machine learning algorithms adapted to different contexts.

2.5 Design and validate machine learning algorithms to analyze large-scale agricultural research datasets using Apache Hadoop and cloud computing.

2.6 Deliver a set of compelling DSML use cases along focused application areas in dryland agriculture and food systems.

CCRP3: Socioeconomic Analysis of Innovations (SAI)

Through SAI, we will evaluate and provide the credible evidence needed to co-design and develop future-informed and demand-driven innovations that lead to sound and sustainable transformation of dryland agrifood systems. We will focus on understanding the global, nation-al, and local transition dynamics of agrifood systems, including drivers of transitions and rural transformation.

3.1 Compare and evaluate the appropriateness and efficacy of alternative innovations through analysis of primary and secondary socioeconomic data.

3.2 Create conducive adoption and scaling environments by identifying complementary knowledge-based social, institutional, and policy innovations for faster and broader dissemination of technological innovations.

3.3 Perform foresight analysis to align projects' investments with evolving dryland farming needs and uncertainty to aid the ability to anticipate challenges, identify opportunities, and design context-specific, inclusive innovations within our projects' assets.

3.4 Co-develop system models for synergy, trade-off, and risk analysis using the innovation portfolio across all SRPs. Enhanced system understanding, including risk and uncertainty management, will further increase the scalability of our innovations and optimize transition dynamics and impacts in dryland agrifood systems.

3.5 Conduct adoption studies and ex-post impact assessments to depict efficient technology options and guide effective scaling.

3.6 Perform action research on analyzing, co-designing, and piloting effective innovation systems for well-informed, inclusive solutions, fostering adoption and scaling.

3.7 Analyse market systems, value chain dynamics, and related policy impacts towards improving market efficiency, digital interventions, inclusive business models, alternative financing mechanisms, and reduced food loss.

CCRP4: Gender Equality, Youth, and Social Inclusion (GEYSI)

GEYSI will ensure we deliver a multifaceted approach that includes participatory research, capacity building, and securing dedicated funding to support GEYSI in agriculture and pastoralism. It supports applied research in designing and implementing multiscale and gender transformative strategies to enhance the inclusion of youth, women, and low-income groups in agrifood system transformation.

4.1 Promote legal and social recognition of women as farmers through policy interventions and awareness-raising campaigns.

4.2 Conduct intensive training for local staff in youth and women's empowerment, fostering gender-sensitive innovation and engaging in policy advocacy.

4.3 Promote on-farm conservation and certified local products, emphasizing women and youth empowerment through supporting value addition, entrepreneurship, and startup opportunities.

4.4 Improve women's and youth's access to both land and non-land assets, enable their participation in agricultural cooperatives, study existing cooperatives for replication in the CWANA, and ECA (East and Central Africa) region, and research risk mitigation in farming, emphasizing equity between landowners and women, who are predominantly land users and renters.

4.5 Promote gender equity in agricultural wages and workplace safety and expand social protection for women, such as those introduced during the COVID-19 pandemic. Research ways to increase women's involvement in public agricultural institutions and decision making in countries in the non-tropical drylands.

4.6 Explore opportunities for climate-resilient agriculture and understand women's role and community challenges. Build local research institutions' capacity for evidence-based gender equality and climate-resilient solutions in partnership with NGOs and intergovernmental organizations.

4.7 Research the impact of mechanization on agriculture, develop strategies for effective extension services, understand youth perspectives on agriculture, and work towards revaluing the agricultural sector within the region to avoid its perception as a last-resort occupation, especially for the youth.

4.8 Research challenges faced by farmers in the region displaced by fragility or conflict contexts, paying specific attention to the needs of refugee women in such research projects.

Alignment to the CGIAR Action and Impact Areas

Our SRPs and CCRPs serve the five Impact Areas of the CGIAR 2030 Research and Innovation Strategy, and the work towards them is carried out through the three Action Areas of Systems Transformation (ST), Resilient Agrifood Systems (RAFS), and Genetic Innovation (GI). Ensuring the alignment of ICARDA's strategic and cross-cutting research priorities and our portfolio of projects to the CGIAR Action and Impact Areas is critical to demonstrate our unique contribution to transforming agri-food systems in the drylands.

How our SRPs and CCRPs align with CGIAR Action and Impact Areas

		CGIAR ACTION AREAS		
		Systems Transformation	Resilient Agrifood Systems	Genetic Innovation
CGIAR IMPACT AREAS	Nutrition, Health, and Food Security	SRP1, SRP2, SRP3, SRP4, CCRP2, CCRP3	SRP1, SRP2, SRP3, SRP4	SRP1, SRP2, SRP3
	Poverty Reduction, Livelihoods, and Jobs	CCRP2, CCRP3, CCRP4	SRP1, SRP2, SRP3, SRP4, CCRP1, CCRP3, CCRP4	SRP1, SRP2, SRP3, SRP4, CCRP1, CCRP3
	Gender Equality, Youth, and Social Inclusion	SRP3, SRP4, CCRP3, CCRP4	CCRP3, CCRP4	SRP1, SRP2, SRP3
	Climate Adaptation and Mitigation	SRP1, SRP2, SRP3, SRP4, CCRP1, CCRP2, CCRP3, CCRP4I	SRP1, SRP3, SRP4, CCRP1	SRP1, SRP2, SRP3, CCRP1
	Environmental Health and Biodiversity	SRP4, CCRP1, CCRP2	SRP3, SRP4, CCRP1, CCRP3	SRP1, SRP2

Results-Based Management (RBM)

ICARDA will embrace a Results-Based Management (RBM) approach to enhance the effectiveness of our interventions and ability to demonstrate tangible outcomes and impact to internal and external stakeholders.

The impacts envisaged in the 2030 ICARDA Research and Innovation Strategy are consistent with the CGIAR 2030 Research and Innovation Strategy. ICARDA will contribute to all five CGIAR Impact Areas. The below indicators and targets for the five Impact Areas were adopted from the CGIAR Performance and Results Management Framework 2022-2030[7]. Targets have been developed with the assumptions that ICARDA will experience a steady annual growth for the next seven years. We also assume that fragility and conflict in countries such as Ethiopia, Lebanon, Sudan, Syria, and others may not substantially affect project implementation and that climate events such as droughts, extreme temperatures, and floods will not or only partly disrupt field trials and field work.

CGIAR Impact Area	ICARDA 2030 Targets	ICARDA Indicator
Nutrition, Health, and Food Security (NHFS)	By 2030, end hunger for all and enable affordable healthy diets for 10 million people in the drylands who do not currently have access to safe and nutritious food, through scaling of climate-smart, nutrient-rich, and high-yielding crop varieties and animal breeds.	Number of people benefiting from ICARDA innovations that enhance regular access to safe and nutritious food.
Poverty Reduction, Livelihoods, and Jobs (PRLJ)	By 2030, lift at least 10 million people living in rural dryland areas above the extreme poverty line of US $1.90 per day (2011 PPP) by increasing the productivity of dryland farming systems and creating equitable job opportunities in innovative dryland farming and associated value chains.	Number of people assisted to exit poverty.
Gender Equality, Youth, and Social Inclusion (GEYSI)	By 2030, offer rewardable opportunities to three million young people in the drylands who are not in employment, education, or training, through increased participation in innovative dryland farming-associated value chains and capacity building.	Number of youth benefiting from ICARDA innovations.
	By 2030, close the gender gap in rights to economic resources, access to ownership and control over land and natural resources for 5 million women who work in food, land, and water systems in the drylands, through gender transformative research, policy discourse, and innovations.	Number of women benefiting from ICARDA gender transformative innovations.
Climate Adaptation and Mitigation (CAM)	By 2030, contribute to the reduction of greenhouse gas emissions, and enhance resilience to the vagaries of climate change by equipping six million small-scale producers in the drylands with climate-smart innovations.	Number of people benefiting from climate-smart innovations.
Environmental Health and Biodiversity (EHB)	By 2030, contribute towards the restoration of degraded ecosystems in the drylands by bringing five million hectares of land to more sustainable use, through improved pastoral & agro-silvo-pastoral land management and governance approaches, and integrated ecosystem management models.	Area of land under improved management.
	By 2030, contribute to ex-situ conservation of cereals, food legumes, and their wild relatives, as well as forage and rangeland species in the drylands, by safely duplicating 5,000 accessions in the ICARDA genebank.	Number of plant genetic accessions available and safely duplicated.
	By 2030, contribute to the sustainable use of water for agriculture in the drylands by increasing economic water use efficiency by 50 percent, through climate-proofing water-for-agriculture infrastructure, use of alternative water resources, and climate-smart mechanization.	Percent change in economic water use efficiency.

[7] https://hdl.handle.net/10568/113793

The contribution of each of the SRPs and CCRPs towards the above impacts, through several outcomes and outputs, has been determined using a theory of change approach. The key performance indicators (KPIs) associated with these results are provided below. All ICARDA projects and programs will be aligned with the strategic and crosscutting research areas and adopt associated KPIs. The award-winning web-based MEL Platform[8] will be a useful tool for the implementation of RBM at all programmatic levels. The results of our work will be shared through a publicly accessible dashboard and reports prepared for internal and external stakeholders.

Indicators		Strategic science area relevance								Alignment with CGIAR	
S/N	Indicator statement	SRP 1	SRP 2	SRP 3	SRP 4	CCRP 1	CCRP 2	CCRP 3	CCRP 4	Action Area	Impact Area
Impact Indicators											
1	Number of people assisted to exit poverty			●	●					Universal	PRLJ
2	Area of land under improved management			●	●					RAFS, ST	EHB
3	Percent change in economic water use productivity				●					RAFS, ST	EHB
4	Number of people using ICARDA innovations		●	●	●	●	●	●	●	Universal	Universal
5	Number of plant genetic accessions available and safely duplicated	●								GI	EHB
Outcome Indicators											
1	Value of investment in ICARDA agrifood systems research	●	●	●	●	●	●	●	●	RAFS, ST	Univesal
2	Number of ICARDA-supported MSc & PhD students going on to be employed in national, regional and international agricultural research institutions	●	●	●	●	●	●	●	●	Universal	Universal
3	Realized genetic gains in farmer-relevant conditions		●	●	●					GI	NHFS
4	Number of accessions accessed	●								GI	EHB
5	Number of new or significantly updated policies, strategies, legal instruments, programs, budgets, or investments partially or wholly influenced by ICARDA research.		●			●		●	●	Universal	Universal
6	Number of institutions using ICARDA-developed methods and recommendations	●					●	●		Universal	Universal
7	Number of innovations (supported by ICARDA) being used by next users	●	●	●	●	●	●	●	●	RAFS	Universal
8	Number of ICARDA-derived climate-resilient varieties released by NARES		●							GI	NHFS
9	Quantity of certified and quality-declared seed produced by public and private seed sector partners		●							GI	NHFS, PRLJ
10	Percent change in productivity of ICARDA-mandate crops, forages and livestock			●						RAFS	NHFS, PRLJ
11	Percent change in energy-use efficiency				●					RAFS, ST	EHB, CAM
Output Indicators											
1	Breeding response time to an outbreak		●							GI	NHFS
2	Number of trait-specific subsets developed and made available	●								GI	EHB
3	Quantity of early generation seed produced		●							GI	NHFS, PRLJ, CAM
4	Number of climate adaptation solutions identified					●				Universal	CAM
5	Number of innovations developed/co-developed	●	●	●	●	●	●	●	●	Universal	Universal
6	Number of policy and institutional recommendations developed			●		●				Universal	Universal
7	Number of knowledge products published	●	●	●	●	●	●	●	●	Universal	Universal
8	Number of studies and assessments conducted	●	●	●	●	●	●	●	●	Universal	Universal
9	Number of people and partners participating in capacity sharing for development activities	●	●	●	●	●	●	●	●	Universal	Universal

[8] https://mel.cgiar.org/index/home

Translating our strategy into action

For ICARDA, partnership, capacity building and knowledge sharing, and investing in policy engagement and strategic communication are vital to delivering our strategy effectively and realizing our vision for resilient drylands.

ICARDA is dedicated to building and strengthening partnerships, particularly with National Agricultural Research Extension Systems (NARES) and through the CGIAR system, both of which are fundamental to our ability to expand the reach and impact of our innovations. As a CGIAR center, ICARDA benefits from knowledge-sharing with more than 100 scientists across the globe all working on food systems transformation, as well as more access to resources and implementation partners to help deliver impact on the ground. Meanwhile CGIAR benefits from our scientific expertise on specific dryland issues.

NARES partners are fundamental to ICARDA's success and expanding the reach and impact of our innovations. NARES partners contribute to the creation of new knowledge and innovations tailored to meet local agrifood system needs. To develop scalable agricultural solutions, ICARDA will also undertake partnerships across farmers and communities, governments, civil society, and the private sector. ICARDA highly values the knowledge of communities and understands that through working with them we can integrate indigenous knowledge and increase our impact. Ensuring our 2030 Research and Innovation Strategy aligns with our partners enables us to leverage each other's skills and investments for greater impact.

We are also exploring new and ambitious partnerships (e.g. in genome editing) to stimulate innovation and disruptive thinking including with the private sector to help scale and test ideas in the field and markets and with young researchers from academia and startups. Only by combining our scientific expertise with fresh perspectives can we find new ways to solve problems.

Knowledge-sharing and capacity-building

Knowledge-sharing and capacity-building are where ICARDA can bring value to its partners. To implement our strategy, we are dedicated to learning as much as possible from our partners and farmers at every opportunity and sharing our expertise and innovations to increase our impact. This includes expanding our networks with universities and agricultural research institutes, engaging smallholder farmers with practical research, and building the capacity of young scientists, especially in non-tropical drylands. ICARDA aims to create accredited educational courses and improve access to scientific resources by fostering South-South collaborations and leveraging ICT for knowledge sharing. Capacity-building and knowledge-sharing are streamlined throughout our strategy and will be a continuous priority.

Investing in people

Delivering our updated strategy will require new expertise and skills to match the expansion in research and innovation and ensure the best fit of ICARDA to deliver to the agricultural needs of the global drylands to 2030 and beyond. They will include responsible and ethical use of AI, new ways to accelerate existing and new breeding programs such as breeding research and improving orphan crops, diversified systems research and scaling, and investment into 'best fit' agricultural practices, including agronomy, climate science, and others.

Policy engagement, advocacy, and strategic communication

Effectively communicating our scientific expertise to influential stakeholders is crucial to achieving our vision. Generating evidence-based science and technological innovations while fostering policy dialogue and knowledge sharing propels improvements in policies and agricultural practices, strengthening future generations of rural livelihoods through agricultural transformation in the drylands. Engaging with decision-makers through dialogue, advocacy, and participation in regional forums will cultivate a trusting environment and spark enthusiasm for collaboration and funding for our work.

Conclusion

ICARDA recognizes the critical importance of agricultural research in non-tropical drylands and the pivotal role it can play in bringing about solutions through transformative actions. Our revised strategic and cross-cutting research priorities reflect progress made and outline approaches to address the most urgent issues facing dryland farmers, emphasizing system-wide approaches.

Our new crosscutting research areas enable systematic integration of key issues like climate change science, socioeconomic analysis for transformation, data science and machine learning, and gender equality, youth, and social inclusion into our work. Our commitment to strategic partnerships, capacity-building, proactive policy engagement, science communication, and results-based management will help us to deliver on our scientific ambition. Implementing our ambitious 2030 Research and Innovation Strategy will require us to work efficiently and effectively, leveraging all our resources.

ICARDA's 2030 Research and Innovation Strategy is synchronized with the CGIAR 2030 Research and Innovation Strategy and focuses on demand-driven research addressing real-world challenges, particularly for women and youth. The global drylands have unique and important opportunities and challenges. Through integrated science, innovation, and partnerships, ICARDA is determined to ensure resilient livelihoods in the drylands and progress towards the Sustainable Development Goals.

ICARDA
Science for resilient livelihoods in dry areas

CGIAR

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