ANNUAL REPORT 2021

ICARDA

Science for resilient livelihoods in dry areas

CGIAR

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ANNUAL REPORT 2021

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Foreword: joint message from CGIAR Regional Director of CWANA and ICARDA Director General, Mr. Aly Abousabaa, and ICARDA Board Chair Dr. Michel Afram

Partnerships for a food-secure future

Dear esteemed partners, supporters, and colleagues,
In a world reeling from COVID-19, the recent escalation in energy and food prices is a new and significant threat to global food and nutrition security. As ever, this latest crisis will disproportionally affect the communities CGIAR serves – those in low- and middle-income countries already vulnerable to the impact of climate change.

In the region where we work, rising temperatures and growing water scarcity already pose an existential threat to agroecosystems and the livelihoods of farming communities. So although we will factor new and unprecedented shocks into our future work, in 2021 we stayed firmly on track with our demand-driven research obligations. By doing so, the innovations we develop can still offer clear scope to address rapidly changing global food production networks. For example, our improved barley and legume varieties can offer an alternative to the grain imports under pressure today.

But if countries are to adopt and scale our new approaches, they need to adopt a systemic approach – more experts, better knowledge-sharing, improved value and supply chains, and more favorable policies – a fully climate-adapted agri-food system is only as strong as its weakest link. To this end, ICARDA worked throughout 2021 with partners to strongly integrate capacity building into our work via numerous trainings, demonstrations, and academic partnerships, reaching thousands of farmers, extension workers, and students – tomorrow's experts. Further, our groundbreaking evidence-based research on value chains and farmers' needs will better inform domestic and international policymakers to optimize newly generated, bold agri-food approaches.

In the following pages, you can also read about our 2021 research covering our high-yielding climate-adapted crops, integrated climate-resilient agrosilvopastoral and livestock farming systems, and improved approaches to managing dwindling water resources. You will also read about how ICARDA is stepping up to raise global awareness of the importance of collecting, conserving, and developing vital genetic resources to protect fragile agrobiodiversity.

As we constantly stress, innovation flourishes in partnerships. It is our partners, not ICARDA, who develop our clear demand-driven research goals, and help leverage the diverse experiences and expertise that ignite new ideas, knowledge, resources and funding, that genuine transformation requires. That made 2021 an important year due to our development of an ICARDA-led desert farming innovation collaboration hub for West Asia and North Africa.

Throughout 2021, ICARDA also continued to support the One CGIAR transformation to help unify CGIAR's governance and global assets for a sharper and more effective research focus. Our research teams successfully transitioned into the new global research teams, getting involved in 17 of the new Global Portfolio of Initiatives, and leading two that specifically address Central Asia, West Asia and North Africa (CWANA) needs.

Global collective action like the One CGIAR transformation and ICARDA's Integrated Desert Farming Innovation Platform is our best hope for addressing tomorrow's agri-food systems needs. In this report, we invite you to discover some of the promising solutions that such collaborations generated last year – the result of diverse actors successfully working together in pursuit of a common goal – a food-secure future for all.

Aly Abousabaa

Michel Afram

HIGHLIGHTS:

2021 in numbers

98
RESEARCH PROJECTS IN 46 COUNTRIES

97
PARTNERSHIP AGREEMENTS SIGNED OR RENEWED

150
ISI JOURNAL ARTICLES PUBLISHED

3,127
PEOPLE BENEFITED FROM TRAINING COURSES

25
CROP VARIETIES RELEASED BY NATIONAL PARTNERS

21,427
PLANT ACCESSIONS REGENERATED

1,169
PUBLICATIONS AND DATASETS

576
BREEDING LINES DISTRIBUTED TO PARTNERS IN 44 COUNTRIES

The integrated desert farming innovation platform:

Integrating game-changing innovation into holistic approaches that revolutionize agri-food systems

If dryland farmers are to keep pace with the impact of rapid climate change on their ability to produce, they must be prepared to integrate game-changing technologies into their approaches. But how to locate and harness relevant innovation, and then help farmers adopt it? The ICARDA-led Integrated Desert Farming Innovation Platform offers a means for countries to collaborate on sourcing, testing, and delivering evidence-based innovation for sustainable and climate-resilient agri-food systems.

While climate challenges for farmers in Central and West Asia, and North Africa (CWANA) are significant, the region offers countless opportunities that can be seized to enhance the productivity of countries' agricultural sectors. Ample renewable and non-renewable natural resources exist, along with abundant biodiversity largely adapted to harsh climates, while individual country know-how on new and traditional approaches already travels the path to climate adaptation. But how to unlock, develop, and scale-out this important knowledge and technology?

Addressing challenges; seizing opportunities

Throughout 2021, ICARDA and its partners joined forces on a new collaborative project – the Integrated Desert Farming Innovation Platform – that optimizes regional knowledge, expertise, and funding to transform approaches at systemic level. With a foundation built on international and regional partnerships, the platform offers a central hub for sharing of scientific innovation and agricultural solutions, including from ICARDA's ongoing research, that will address agri-food systems gaps to strengthen the whole system. The platform is also developing a mechanism for fast-tracking adoption and scale-out of new approaches based on the needs and market demands of countries, including jobs and income, all the while strengthening food and nutrition security.

There is a focus, for instance, on managing increasingly scarce water resources, developing climate-smart crops, and implementing integrated crop and livestock systems, all high regional priorities that unless addressed, reduce the impact of other available innovation. Through soil health initiatives and the strategic use of genebanks, the platform will also protect the regions increasingly fragile biodiversity.

In addition, the platform boosts and emulates pillar industries such as date palm production and improves access to wind and solar power and water/energy-saving innovations, especially in greenhouse farming. Capitalizing on the new potential of information technology, artificial intelligence, and digital extension services is also a priority to inform policy and drive adoption.

Share and strengthen

The Integrated Desert Farming Innovation Platform is not a magic bullet because the needs of the region and its farming communities are complex. But its pragmatic overarching function is to share inter-country resources and capacities to better understand needs and address weak links in areas such as market access or policies that can render other efforts inoperable. Doing so will address gaps in knowledge and expertise, equipping the region's farmers, researchers, and extension agents with the skills and know-how they will need to keep pace with climate change and transition to more sustainable and resilient food systems. By definition, that makes farmer associations and regional higher education institutions priority partners, firmly putting them in the driving seat.

ICARDA's key role is to mobilize CGIAR-wide innovations and assets, along with the expertise of over 3,500 global food system scientists. CGIAR can also offer a unique and trusted network of international partners who have collaborated for decades to help the global agricultural sector adapt to a new climate reality.

As the platform takes shape throughout 2022, ICARDA and its partners will explore fundamental frameworks, including funding mechanisms to develop innovations at the required pace, ways to convince farmers to substitute conventional technologies and practices with scientifically-proven alternatives, and how farmers can better access markets and technologies.

We launched the Integrated Desert Farming Innovation Platform in early 2022 during the Khalifa International Award for Date Palm and Agricultural Innovation, attended by representatives from ICARDA and CGIAR, and ministers and officials from over 15 CWANA countries.

ICARDA and One CGIAR

An integrated unification of assets, expertise, knowledge, and operation to deliver more targeted solutions to today's integrated challenges

CGIAR, the world's largest global agricultural innovation network, has been a world leader in agri-food systems science and innovation for development for over 50 years. But as the world faces escalating climate, biodiversity, population, and food prices crises, and the landscape of research, and its funding model changes, we need to change too.

While remaining as individual research entities, CGIAR's partnership of fourteen research centers are now transitioning to a more collaborative model – One CGIAR – a new broader and integrated unification of assets, expertise, knowledge, and operation that will deliver more targeted solutions to today's integrated challenges faster, more efficiently, and more effectively.

In 2021 ICARDA's Human Resources unit continued to oversee ICARDA's transition under One CGIAR,

supporting ICARDA's capacity needs, and addressing challenges through a concerted recruitment and succession planning effort. While initially aimed at improved collaboration with other centers under One CGIAR, stronger systems and processes, and upskilling of staff across all of ICARDA's corporate functions including Human Resources, Finance, Partnerships and Grants Unit, and Communications, is also reaping benefits.

The One CGIAR global research portfolio

Working in close collaboration with its global research centers and country partners, One CGIAR has formulated a global portfolio of 33 strategic initiatives to transform the full range of land-water-crop-livestock-fish-forestry food systems into viable and adaptable approaches.

These new science and innovation-driven initiatives are designed to address country-specific challenges at systems, farm, biodiversity, and value chain levels. The initiatives draw from vital in-country knowledge and the unique scientific expertise of our global centers and partners to provide innovative and new science to address new challenges.

As of the end of 2021, ICARDA is engaging in 17 of the initiatives, and leading two:

From Fragility to Resilience in CWANA (F2R-CWANA) – led by ICARDA's Dr Michael Baum and co-led by IWMI's Maha Al-Zubi.

The F2R-CWANA Initiative works closely with countries to unlock and build on current initiatives and reduce fragility in the region, by developing key solutions that integrate with the region's diverse range of agro-ecosystems – rainfed, irrigated, agro-pastoral and desert farming. Key innovative approaches will produce more food with less water, introduce new climate-resistant staple crop varieties, build networks that connect vertical and horizontal levels of markets, and increase agricultural and business access to women and youth.

The Genebanks Initiative will support the global system for the conservation and use of plant genetic resources for food and agriculture through standardization, improved and high-quality data, and the adoption of automated approaches. It will also upscale its free supply of genetic resources from CGIAR's nine genebanks to global researchers in compliance with Plant Treaty and phytosanitary regulations.

ICARDA's Soil, Water, and Agronomy (SWA) team also collaborated with sister CGIAR centers in 2021 to support the development of the One CGIAR **Excellence in Agronomy (EiA)** and **Nexus Gains initiatives**. Leading the EiA's CWANA Region Teams, and the Nexus Gains Initiatives in Sudan and Uzbekistan, ICARDA's SWA team will support the initiatives in delivering agronomic gains for smallholder farming households in prioritized farming systems, water, energy, food, forests, and biodiversity systems, emphasizing the measurable impact of women and young farmers on food and nutrition security, income, water use, soil health, and climate resilience.

ICARDA's agrosilvopastoral research teams are also integral in developing the Sustainable Animal Productivity for Livelihoods, Nutrition and Gender Inclusion (SAPLING) Initiative which is at the core of the One CGIAR livestock portfolio. ICARDA's Mourad Rekik is Deputy Lead, while other ICARDA scientists hold roles as three work package leads and one country coordinator for Ethiopia.

ICARDA's Team Leader of Rangeland Ecology and Forages, Dr. Mounir Louhaichi, was also selected as Deputy Leader of the **Livestock, Climate and System Resilience (LCSR) Initiative**. Partnering with public and private actors, LCSR will support producers, businesses, and governments to adapt livestock agri-food systems to climate change, reduce greenhouse gas emissions, and contribute to sustainability and development goals across livestock systems.

Soil, water and agronomy:

Sustainable soil, water and agronomy management for a fertile future

Climate change, soil degradation, and limited resources – particularly water – are jeopardizing the agricultural future of the world's dry areas. In response, ICARDA's Soil, Water, and Agronomy (SWA) team, led by Dr. Vinay Nangia, conducts sustainable soil, water and agronomy management research to develop diversified and sustainable techniques for small and large-scale farming to strengthen livelihoods resilience and diversify cereal-based irrigated, rain-fed and conservation agricultural food systems. We also promote the safe use of treated wastewater to generate feed, fodder, and trees, and develop sustainable desert agriculture.

Helping to develop One CGIAR initiatives

Under the One CGIAR reformulation, ICARDA's SWA team cooperated with sister CGIAR centers in 2021 to develop new frameworks that would govern CGIAR's future agronomy, water management, and soil health initiatives throughout the world. ICARDA's SWA team supported the development of the One CGIAR Excellence in Agronomy (EiA) and Nexus Gains initiatives. EiA aims to deliver agronomic gains for smallholder farming households in prioritized farming

systems, emphasizing the measurable impact of women and young farmers on food and nutrition security, income, water use, soil health, and climate resilience.

SWA is leading its Central and West Asia and North Africa (CWANA) regional team, focusing on Egypt and Morocco. Meanwhile, the Nexus Gains initiative focuses on Sudan and Uzbekistan by generating outputs via four work packages and a cross-cutting capacity development program across water, energy, food, forests, and biodiversity systems.

ICARDA and FAO team up on evapotranspiration science

ICARDA's SWA team, led by Dr. Vinay Nangia, and the Food and Agriculture Organization of the United Nations (FAO), produced a popular six-part webinar series on state-of-the-art evapotranspiration (ET) measurement methods, which attracted over 1,700 international and regional participants. Given climate impacts of heat and water scarcity, accurately measuring the ET of crops is a vital aspect of crop planning and agronomy. The series coincided with a new regional network, initiated by ICARDA and FAO, to improve ET field measurements and enhance adaptation to climate change and freshwater scarcity in five countries: Egypt, Jordan, Lebanon, Morocco, and Tunisia.

Showcasing innovation efficiency in Egyptian agriculture

Dr. Boubaker Dhehibi from ICARDA's Social, Economy, and Policy Research (SEPR) team coauthored an important research paper on water, policy, and productivity in Egyptian agriculture, funded by the Economic Research Service, United States Department of Agriculture. Findings reveal that expanding water resources is just one way to increase or maintain agricultural output when water scarcity restricts production, and that investments in agri-research almost always improve productivity. The paper clearly demonstrates that technological innovations and efficiency gains through agri-research have contributed more to agricultural growth than the expansion of irrigated areas or increased water use.

Precision farming advances in Madhya Pradesh

Water scientists, agronomists, entomologists, GIS analysts, breeders, and economists helped establish ICARDA's first

precision farming one-stop shop at ICARDA's research station in Amlaha, India. The three-year project, funded by the Indian State Government of Madhya Pradesh and led by ICARDA's Dr. Vinay Nangia, spans irrigated and rainfed agro-ecologies and focuses on economically important crops such as cotton, wheat, and soybean. Data related to farmers' fields will be channeled to Amlaha's control room, analyzed, and delivered by SMS back to farmers to advise on irrigation and inputs. The tools chosen target low-income farmers who only adopt new technology if it is low-cost, low-maintenance, robust, easy-to-scale, stable, consistent, and simple to manage and operate.

The Moroccan Government's faith in conservation agriculture

Morocco's ground-breaking Green Generation Strategy (2020-2030) announced in February sets aside a remarkable 1 million hectares for Conservation Agriculture (CA). CA is proven by clear scientific evidence as an agronomy approach that reduces erosion and captures carbon dioxide. CA involves no (or minimal) tillage after harvest, permanent soil cover to lock in moisture and reduce evapotranspiration, and crop diversification. Widely promoted by ICARDA, in 2021 the World Bank worked with ICARDA's SWA team and the Institut National de la Recherche Agronomique (INRA-Morocco) to develop a roadmap and investment plan based on the new Morocco strategy. This is also closely linked to EiA efforts in the country.

WOCAT features ICARDA's lentil-quinoa diversification Morocco project

ICARDA efforts to diversify Morocco's standard lentil production system using quinoa, led by Dr. Mina Devkota, caught the attention of the World Overview of Conservation Approaches and Technologies (WOCAT) which included the innovation in its compendium of good land practices. ICARDA uses diversified cropping systems to rehabilitate soils across Morocco, India, Nepal and Uzbekistan, which have been degraded by decades of intensive tillage, overgrazing and damaging industrial farming practices.

More information

To read about more soil, water and agronomy projects, see:

- ICARDA participates in the 5th African Regional Conference
- ICARDA at the 2021 Arab Water Forum
- A white paper on carbon sequestration for better soil and food security
- Innovative Agriculture for Small-Holder Resilience (iNASHR)

Livestock and agro-silvopastoral systems:

Innovations for resilient and sustainable crop-livestock and agro-silvopastoral systems

ICARDA's integrated approach to more productive and sustainable crop-livestock and agro-silvopastoral systems focuses on the farmer and community-based solutions for improving sheep and goat production, sustainable rangeland management and restoration, water-efficient dryland forage production, and better crop-livestock integration in hybrid dryland systems.

Our solutions strive toward land degradation neutrality through restoration strategies that respond to climate change, reducing the environmental footprint of dryland agriculture. We also provide information and skills to rural households to ensure product safety and maximize value-added advantages. ICARDA's teams interact with other CGIAR Centers on new projects and frameworks that define future crop-livestock methods under the One CGIAR reformulation to guarantee that CGIAR uses our new science now and in the future.

This work is carried out by ICARDA's Resilient Agro-Silvo-Pastoral Systems (RASP) team led by Dr. Barbara Ann Rischkowsky, which also integrates the research teams on Rangeland Ecology and Forages (REF), the Restoration Initiative on Dryland Ecosystems (RIDE) and Small Ruminants (SR).

Community-based breeding reaches more people

Funded by the United States Department of Agriculture, ICARDA's scaling framework extended goat community-based breeding programs (CBBP) to more than 2,000 households in Konso, Ethiopia. Through the project, led by Dr. Aynalem Haile, communities gain understanding and experience that harmonize national standards, while allowing them to develop their own way forward. ICARDA offers certification to ensure quality control across the CBBP communities, covering skills such as breeding value, physical integrity, semen assessment, mating ability, and vaccination against five diseases. By engaging with 23 Ethiopian universities in 2021, CBBPs were further expanded. Over ten now incorporate CBBPs into their undergraduate programs and six have launched CBBPs in nearby villages.

Spineless cactus for people, jobs, and animal feed in degraded lands

In 2021, ICARDA introduced spineless cactus as a fodder crop in the degraded hills of Odisha, India, as part of the India-ICARDA Collaborative Program. Known as 'green gold', cactus offers a high nutritional value for people and animals alike. It is rich in carbohydrates, amino acids, vitamins, and water, and provides enormous health benefits in the reduction of cholesterol and triglyceride levels.

Some 425.26 hectares were planted with 28,442 cactus cladodes, and 16 foundation nurseries and 36 village-level multiplication nurseries were established in a work package led by Dr. Mounir Louhaichi. Funded by the Indian Council for Agricultural Research and implemented alongside the Government of Odisha and the Indian Council of Agricultural Research-Indian Grassland and Fodder Research Institute, the project has created more than 75,500 jobs and generated an additional Rs7,500 (US$100) per hectare.

Conservation agriculture expands in crop-livestock systems

The Conservation Agriculture in Crop-Livestock Systems project framework, led by Dr, Mourad Rekik and funded by the International Fund for Agricultural Development (IFAD), achieved substantial scale up of forage mixtures in Tunisia and Algeria after developing public-private partnerships for forage seed production with local companies. In both countries, forage mixtures are becoming popular with farmers, with the availability of forage seeds such as vetch (a tough grass favored by goats and sheep) increasing by 300 percent over the past five years.

Identifying climate-smart genes for sheep

Collaborating with National Agricultural Research Systems, ICARDA's RASP team made a huge breakthrough by identifying in the genomes (all genetic information of an organism) of sheep, specific genes that may be responsible for adaptation to different environments (for example drylands and highlands) and resistance to internal parasites. Such genomic locations and genes can now be used to investigate variations that can be deployed in breeding programs to increase the resistance of small ruminants to specific challenges in environments in which communities live under climate change.

Enhancing resilience against sand and dust storms

As part of the ICARDA-Food and Agriculture Organization of the United Nations (FAO) project, 'Catalyzing Investments and Actions to Enhance Resilience against Sand and Dust Storms in Agriculture,' ICARDA's RIDE team developed a framework and evaluation method in 2021 to assess sustainable land management (SLM) practices and their potential to mitigate sand and dust storm sources and impacts on agriculture. By adequately managing crucial land resources such as soils, water, animals and plants, SLM allows for sustainable and environmentally-sound agriculture, and the long-term survival, productive potential, and ecosystem functions of these vital resources. RIDE presented their findings at the United Nations COP26 in September 2021.

More information

To read about more livestock and agro-silvopastoral system projects, see:

- Dr. Mounir Louhaichi selected as Deputy Lead of a One CGIAR initiative
- Dr. Sawsan Hassan selected as a member of ARRI's Forgotten Foods, Neglected Crops and Underutilized Species technical committee
- Using science-based evidence to properly manage degraded arid rangelands in Tunisia
- Sulla: a native forage species for reversing degradation in Mediterranean agro-silvo-pastoral systems
- A productive year for REF publications

Genetic resources:

Collecting, conserving, and developing vital agrobiodiversity

ICARDA's Genetic Resources (GRS) team, led by Dr. Zakaria Kehel, works in Lebanon and Morocco alongside global networks, including the CGIAR Genebank Platform, the Global Crop Diversity Trust, the German Agency for International Cooperation (GIZ), the European Union (EU), and other development partners. Together, they collect, conserve, and develop the vital genetic resources needed to protect agrobiodiversity in dry regions. ICARDA's GRS team has started translating its standard operating procedures into Arabic and French for dissemination across Central and West Asia and North Africa (CWANA). An innovation in development, a subsetting tool under Genesys to mine genetic resources, was finalized in collaboration with the International Center for Tropical Agriculture (CIAT).

Improving high-throughput phenotyping

In 2021, ICARDA and partners developed two exciting innovations that improve phenotyping (the accurate measuring and recording of plant genetic traits) and enhance food security across dry areas. The futuristically named 'PhysioTron' Machine vastly speeds up phenotyping and houses up to 750 crop research plots. Its fully automated control system can design a wide range of experiments. Meanwhile, the 'Phenobuggy' was

developed as a smaller, tractor-mounted GPS-assisted multi-sensor head, and can carry out rapid and accurate measuring of a range of phenotypic traits in standard research plots.

Our genebanks' unique collections continue to grow

In 2021, the GRS team commenced regeneration of accessions (groups of plant genetic material) that were sent for safekeeping to institutions outside of the Svalbard vault in 2012 when the Syria Genebank was relocated to Lebanon and Morocco. Last year, over 6,000 chickpea accessions were retrieved from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and around 1,000 wild relatives were regenerated from accessions sent by the Millennium Seed Bank in the United Kingdom.

Building up precious agrobiodiversity

ICARDA continued its contributions to the EU-funded Activated Genebank Network (AGENT) project, led by Dr. Filippo Bassi, which was launched in 2020 to transform genebanks from passive seed libraries into advanced bio-informatics resource centers. In 2021, ICARDA scientists helped devise more straightforward tools and procedures for genomic work, and through AGENT, are working with partners to collect and standardize phenotype information from global genebank networks within a single database.

Farming with alternative pollinators promotes transformative change in agriculture

ICARDA's Farming with Alternative Pollinators (FAP), led by Dr. Stefanie Christmann and funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, enhances agricultural land by marketable habitat enhancement plants (MHEP), nesting and water support. MHEP prolong the flowering times in the fields and attract higher diversity and abundance of pollinators (enhancing productivity of many crops) and natural enemies (reducing pest abundance in the main crop and the need for chemicals). Both effects increase the net income gain for farmers significantly. A project in Morocco in four agro-ecosystems, with seven different main crops and more than 230 smallholder fields showed a net income increase of 121% and a reduction of pest abundance in the main crop by 65%.

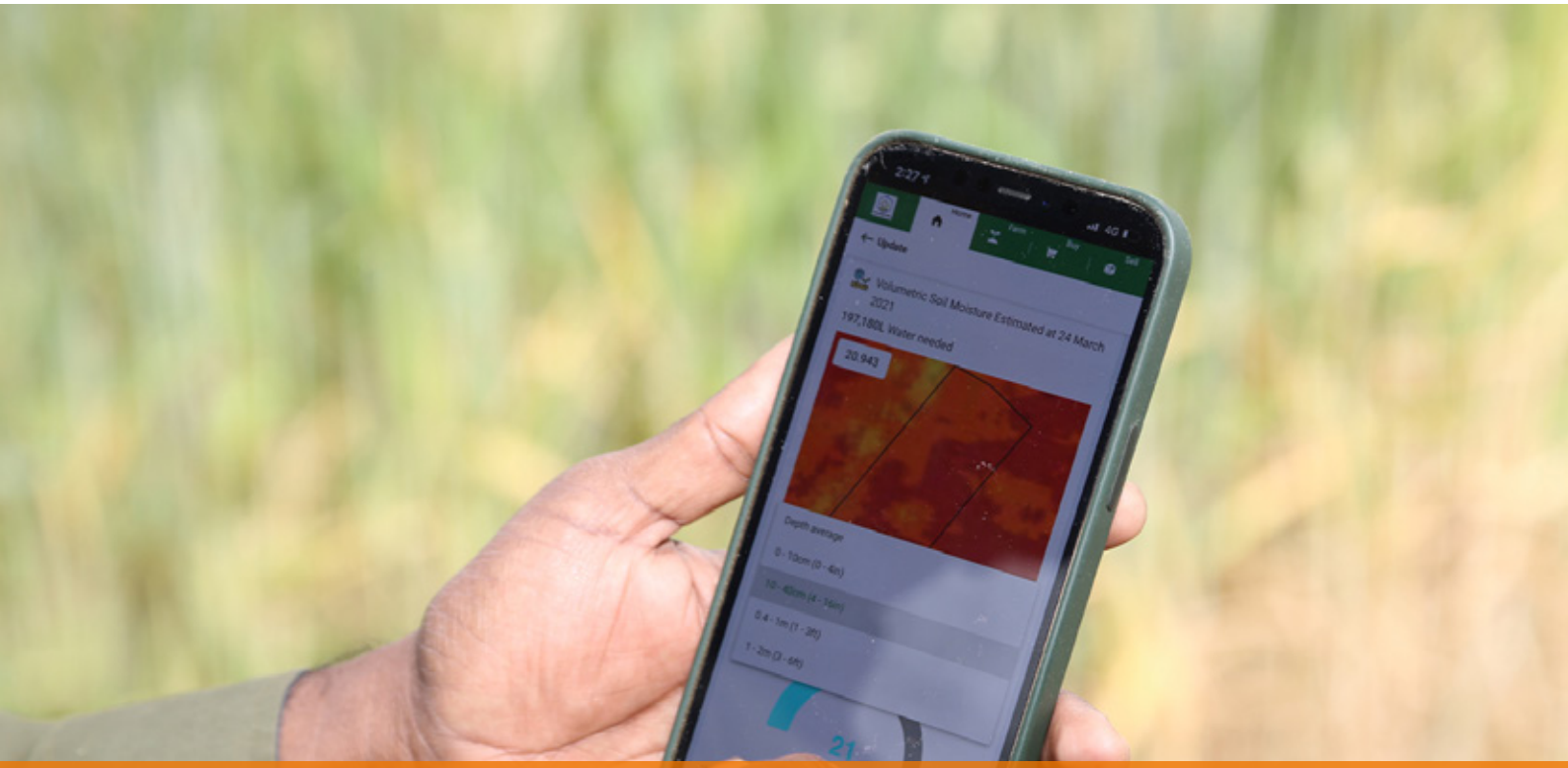
Improved grass pea crops

In 2021, a project led by Dr. Shiv Agrawal Kumar, funded by the Global Crop Diversity Trust, regenerated grass pea lines from the first successful hybridization between cultivated grass pea and five wild relatives (Lathyrus) species. This resulted in a high number of hybrids which offer various useful traits such as resistance to parasitic weed (Orobanche), low plant toxin, tolerance to drought and heat and high biomass. Additionally, new interspecific crosses were performed for barley and wheat to target disease, insect resistance, and the production of micronutrients and beta-glucans (linked to lowered cholesterol and reduce heart disease).

More information

To read about more genetic resources projects, see:

- The regeneration of non-Svalbard safety duplication
- Scaling the Focused Identification of Germplasm Strategy



Digitalization:

Optimizing new technologies for efficient and affordable research for development

ICARDA continued to digitize research in 2021 to make data collecting, information sharing, analysis, and decision-making faster, better, and more accurate. Even in the most distant and vulnerable dry places where ICARDA operates, global advances in technology, digital analytics, remote sensing, networks, and software, particularly on now-ubiquitous smartphones, make data gathering, analysis, reporting, and knowledge exchange more manageable and more efficient.

Based on four decades of drylands research, our unique and increasing pool of big data aids the modeling and analysis of novel techniques, climatic variability, evaluation of new crop varieties and livestock enhancements, socioeconomics, and decision-making at all levels. When combined with those of sister centers under the One CGIAR reformulation, our data will produce a powerful resource that will substantially contribute to the fight against global climate change.

AGROVOC – improving knowledge sharing for Arabic speakers

AGROVOC is a multilingual and controlled vocabulary tool led by the Food and Agriculture Organization of the United Nations (FAO). This valuable resource enables data to be classified homogeneously, facilitating interoperability and reuse. It offers a structured collection of agricultural concepts, terms, definitions, and relationships which are used to unambiguously identify resources. It provides a way to organize knowledge for subsequent data retrieval.

In 2021, as a part of an ongoing collaboration with FAO, ICARDA's Monitoring, Evaluation and Learning (MEL) team translated approximately 800 concepts in AGROVOC into Arabic, vastly improving knowledge sharing in Arabic-speaking countries – one of the most important regions globally for its agrobiodiversity and climate-smart agricultural approaches.

Innovation award for halting land degradation

ICARDA's MEL and Social, Economy, and Policy Research (SEPR) teams were excited to win an award for LUP4LDN (Land Use Planning for Land Degradation Neutrality) – a tool that helps inform improved land planning and restoration activities. The award, issued by the Group on Earth Observation Land Degradation Neutrality Initiative, was overseen by the United Nations Convention to Combat Desertificat. LUP4LN is a user-friendly interface that facilitates participatory land-use planning to support land restoration efforts, achieve sustainable land degradation neutrality, and prevent ongoing degradation.

WOCAT – endorsing ICARDA's work

ICARDA was thrilled when the World Overview of Conservation Approaches and Technologies (WOCAT) published information on ten ICARDA innovations. WOCAT, a global network promoting sustainable land management, is a prestigious stage on which to feature, with a wide audience of experts and decision-makers, among others. Our innovations, submitted by ICARDA's MEL team can now be referenced by agricultural experts all over the world, fulfilling ICARDA's core vision of open-source knowledge sharing.

ICT2Scale legacy lives on

The ICT2Scale project in Tunisia, funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), in collaboration with the German Agency for Inernational Cooperation (GIZ), concluded in September 2021, but its legacy lives on to support smallholder farmers and rural communities. The project, led by Dr. Udo Rudiger, introduces information and communications technology services to family farmers. ICT2Scale innovations include e-learning training modules on crop and small ruminant production, beekeeping and conservation agriculture. The project also helped develop bilingual Arabic-French smartphone apps that provide useful data such as price information on agricultural commodities in near real-time, helping farmers set prices and improve profits. Almost 1,000 farmers received a technical advisory SMS on a weekly basis.

More information

To read about more digitalization projects, see:

- GeoAgro on CGIAR's Digital Extension Services
- Enhancing the GeoAgro Pro portal
- ICARDA and the United Nations Food Systems Summit
- Monitoring, evolution, and learning supports CGIAR quality assurance
- Adding wheat and barley to global crop diagnostics app Plantix
- Dr. Chandrashekhar Biradar receives the India Agri-Extension Award

Climate-smart crops:

Crops that produce even under intensifying climate change

ICARDA's Breeding and Scaling Improved Varieties of Dryland Cereals and Pulses team, led by Dr. Michael Baum, is a crucial player in the regional and global development and dissemination of climate-resilient crops. These market-driven crop varieties protect dryland farmers from severe heat, water scarcity, new pests and diseases, and nutritional insecurity.

Over the past four decades, country partners in Asia, Africa, and beyond, have evaluated and distributed ICARDA's enhanced grain and legume varieties. Farmers have accepted our new varieties, resulting in yearly net benefits of over US$850 million.

In 2021, fourteen wheat, six chickpea, three lentil varieties, as well as one variety of each barley and faba bean were released in partnership with National Agriculture Research Systems (NARS) collaborators in Egypt, Ethiopia, India, Iran, Morocco, Turkey, and Uzbekistan.

Through the Modernization of ICARDA Breeding Programs project, supported by the Arab Fund for Economic and Social Development (AFESD) and CGIAR's

Crops to End Hunger platform, new speed breeding protocols were developed for all ICARDA-mandated crops. Through these protocols, four generations can be achieved in just one year while maintaining ICARDA's capacity to screen for the most prevalent diseases in the region, as well as for high end-use quality.

In addition, more than 4,000 entries of wheat and barley were genotyped in 2021. This will improve the capacity of breeding programs to select the best germplasm to be shared with NARS.

New big data management and analysis tools have also been developed to automatically store, curate, and analyze the field data produced by the breeding programs.

Heat-tolerant wheat varieties reach more people in Africa

The Technologies for African Agricultural Transformation (TAAT) project, implemented by ICARDA and funded by the African Development Bank, continued to scale-up heat-tolerant wheat varieties and support national wheat self-sufficiency agendas to reduce import dependence – especially relevant in today's food crisis environment. Policy advocacy, road maps for deploying agricultural innovations, and multi-stakeholder platforms contributed to productivity increases and an expansion of wheat production areas. Success stories were captured in a high-level virtual dialogue, and a short TAAT documentary beat over 3,700 nominations to win best documentary at the 2021 Stevie International Business Awards.

Collaborative research on new barley lines in Morocco, Tunisia, and Algeria

The Maghreb-ICARDA Barley Initiative – a joint venture of ICARDA's barley breeding programs in Morocco, Algeria, Tunisia and Libya – conducted its first shared trial. With the support of the CGIAR Research Program on Livestock, 24 new ICARDA elite lines targeting farmers' needs and environmental and socioeconomic conditions were tested in Algeria, Morocco and Tunisia. They demonstrated superior yield and straw production and the best lines are now being promoted to the National Variety Trials program.

Improving pulse seed systems in Odisha, India

The Odisha Pulse Mission in India, which aims to strengthen village and formal pulse seed systems, reached over 13,800 farmers across 14 districts and helped 126 farmer groups manage seed hubs in project villages. A total of 4,200 hectares of rice fallows have been brought under pulse cultivation, leading to an estimated 33,000 quintals of additional production and an average annual income increase of Rs13,626 (US$172) per farmer.

Faster delivery of heat-tolerant wheat to the Senegal River Basin

The second phase of the project 'Genomic Prediction to Deliver Heat Tolerant Wheat to the Senegal River Basin' used the most advanced breeding technologies for the delivery of heat-tolerant and short-duration durum wheat varieties. The models have now been adopted by ICARDA's Durum Wheat Program for faster research, development, and delivery of heat-tolerant wheat varieties. The initiative also released three durum wheat cultivars, published ten peer-reviewed articles and received funding for a third phase.

Seed health for safer crops and better yields

ICARDA seed health labs in Lebanon and Morocco analyzed over 110,300 accessions (groups of plant

genetic material) for seed-borne pathogens and pests. The accessions were tested in 48,404 samples and the results were collected from 567,975 diagnostic reactions. Seven standard operating procedures related to seed health testing were also developed and are now standardized within ICARDA. Dr. Safaa Kumari, Head of ICARDA's Seed Health Lab, also gave lectures at universities in Abu Dhabi and Syria on seed multiplication and the importance of germplasm health in preventing the spread of pathogens and transboundary diseases.

More information

To read about more climate-smart crop projects, see:

Wheat
- Dissemination of interspecific ICARDA varieties via participatory research
- ICARDA and INRA-Morocco's barley and durum wheat pre-breeding program

Barley
- Special nurseries shared with collaborators in United Arab Emirates and Ethiopia
- Diversification of wheat-based cropping in the Ethiopia highlands

Date palm
- Delivering ecological insights with eddy covariance systems
- Participatory demonstrations promote water- and energy-saving practices
- Dr. Abdoul Aziz Niane appointed to Advisory Committee
- Date palm project wins Khalifa Award

Legumes
- Dr. Shiv Agrawal elected Chair of Scientific Program Committee
- ICARDA scientists nominated as special guest editors
- Improved food legumes for India

Seed systems, international nurseries and seed health
- Wheat seed system studies
- Rehabilitation of seed systems in Syria
- International nurseries (IN)
- Dr. Safaa Kumari's contributions

Capacity development:

Supporting farmers and communities in optimizing innovation

Whenever delivering dryland farming system innovations ICARDA's Capacity Development team, led by Dr. Charles Kleinermann, includes a vital capacity-building component of trainings, technology, and support. This supports family farmers, scientists, governments, research institutions, and private sector actors, to take full advantage of our technologies and help them overcome the critical and climate-related issues they face.

Training tomorrow's experts

ICARDA and its national and international partners held a series of interactive webinars targeting young scientists on the value of systems research in dryland agri-food systems. Over 400 participants registered for each webinar. With the support of the Arab Fund for Economic and Social Development (AFESD), ICARDA also provided training courses for over 4,100 student and professional trainees, including over 1,800 women.

Raising the visibility of research data management

Through social media campaigns, joint publications with scientists (data papers) and small working groups with scientists (data curation), ICARDA's Monitoring,

Evaluation, and Learning (MEL) team, led by Enrico Bonaiuti, promoted and improved understanding of Research Data Management (RDM). The importance of strong support and suitable tools was documented when encouraging RDM commitments – helping to address the policy conflicts and unclear data standards that often cause unexpected engagement conflicts within databases. MEL's Data Management team worked on 34 datasets, covering a range of topics and countries, and completed the curation and publication of 17.

Field days at Marchouch Crop Research Station, Morocco

In 2021, ICARDA's Genetic Resources (GRS) team organized four field days at the Marchouch Crop Research Station in Morocco, attracting over 200 attendees, including breeders, major seed multiplication companies and lead farmers. These field days offered an opportunity for attendees to select the best elite lines, view demonstration trials of new varieties of cereals, food legumes, and bread wheat, and learn about how conservation agriculture and the diversification of cropping systems improves the environment as well as yields and nutritional value.

New training course on managing date palm markets

A new e-learning course on value chain analysis, management, and market linkages of date palm, funded by the Gulf Cooperation Council (GCC), enhanced the capacity of Arabian Peninsula government officials and researchers engaged in the socioeconomic component of the project, 'Developing Sustainable Production Systems for Date Palm in GCC Countries.' Twenty-three officials and researchers participated, representing Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, as well as Egypt and Jordan.

Free e-learning courses

ICARDA's E-Learning Platform continues to offer over 85 courses aligned with various agricultural topics and the United Nations Sustainable Development Goals. Most of the courses are in English, but French, Arabic, and Spanish classes were made available in 2021. Registration for courses is free.

Promoting modern protected agricultural practices in the Arabian Peninsula

In December 2021, ICARDA and the Central Laboratory for Agriculture Climate of Egypt's Agriculture Research Center (ARC) jointly organized a workshop on modern horticulture practices for Arabian Peninsula partner countries. Funded by the AFESD and the Kuwait Fund for Arab Economic Development, the workshop covered exciting new developments in protected agriculture approaches within greenhouses and hydroponics and was attended by researchers and extension agents from five of the six GCC member countries, and Yemen.

Knowledge management communities of practice and capacity development activities

The SKiM Project, funded by the International Fund for Agricultural Development and implemented by ICARDA, raised the knowledge management capacities of 40 individuals representing national partners in Moldova, Morocco, and Sudan. The SKiM project facilitates and supports the growth of knowledge management and capacity development operations, enhancing and growing knowledge management communities-of-practice. The project helped partner institutions navigate the many disruptions caused by COVID-19 in 2021.

More information

To read about more capacity building projects, see:

- Research data management

Gender:

Prioritizing women towards equitable access to agriculutural enterprise

We prioritize research that enhances women's access to land, water, seeds, credit, knowledge, and innovation, and we empower women through capacity development that facilitates their role as leaders and active agents of change. We also help them engage in more lucrative economic activities through agricultural diversification, intensification, and value addition.

In addition, we advocate for improvements in wages and working conditions and the eradication of gender-based inequality. We also investigate promising formal and informal institutional arrangements that enhance women's voice and power in dry area communities, and we promote proven technologies that reduce agriculture-related drudgery.

An AI-driven app for women beekeepers

ICARDA's Monitoring, Evaluation and Learning (MEL) team, led by Enrico Bonaiuti, along with the Lebanese Agricultural Research Institute and the beekeeping data company HiveTracks, supported the economic activities of Lebanese beekeepers through the development of a groundbreaking hive management app aimed specifically at developing the capacity of women beekeepers. The app allows beekeeping experts and extension workers, many

of whom do not have easy access to training and peer-beekeepers, to remotely manage beekeeping practices and improve bee health. ICARDA is now working with the International Centre of Insect Physiology and Ecology, the Holeta Bee Research Centre and HiveTracks to pilot the app in Ethiopia and Uzbekistan.

The impact of migration-induced feminization of agriculture

ICARDA's Social, Economic, and Policy Research (SEPR) team contributed an important study to CGIAR's Gender Platform, discussing how male migration from rural to urban areas is creating a 'feminization' of agriculture in the region. The study examines how this affects women working in agriculture – their roles, productivity and equity – and the impact of feminization on agriculture as a whole. The study showed that feminization creates more drawbacks than benefits for women and includes recommendations on social and economic policy interventions to leverage the increasing participation of women in agriculture and improve their livelihoods.

Seed spreaders improve the livelihoods of Tunisian female farmers

A user-friendly and cost-effective seed spreader machine is helping to generate biomass yields in forage crops that are 20 percent higher than the biomass yields of forage crops cultivated with the manual sowing of seeds. The Handheld Precision Spreader (HPS), developed by ICARDA in 2021, spreads seeds and fertilizers evenly, allows farmers to spray chemical fertilizers without skin contact and slashes labor costs by 40 percent. The machine is especially important for women smallholder farmers who cannot afford larger machines and extra labor. ICARDA imported and distributed 25 HPS machines with national partners and provided technical guidance to farmers during the 2020-2021 cropping season.

Improving rural livelihoods:

Supporting the socioeconomic viability of our innovations

The Social, Economic, and Policy (SEP) research team, led by Dr. Barbara Ann Rischkowsky, at ICARDA is responsible for studying the socioeconomic feasibility, adaoption and scaling-up of ICARDA innovations, as well as their effect on poverty reduction, food security, system resilience and social inclusion. The team's methods include socioeconomic assessments, gender transformational techniques and context-sensitive targeting. Its solutions aim to achieve more equitable marketplaces and value chains, improved natural resource management and governance, and the optimization of sustainable land and livestock management alternatives.

Raised-bed technology benefits Egyptian wheat growers

Egyptian wheat growers adopting ICARDA's raised-bed technology, through the project led by Dr. Beziat Dessalegen, continued to experience benefits in 2021. These included a 937 kilogram per hectare (12.8 percent) increase in yield, a US$77.60 per hectare (9.5 percent) increase in gross margins, an 824.6 cubic meter per hectare (15.1 percent) reduction in irrigation water application and a 5.6 percent increase in water productivity. Raised bed machines can be attached

to standard tractors, and improve yields and water efficiency by creating raised soil beds, on which they simultaneously sow crops and create adequate furrows along which optimum water easily travels, rather than flooding whole fields (the traditional irrigation method).

Big lentil productivity gains in India

An economic impact assessment carried out last year found that ICARDA-improved lentil technologies have contributed to a massive productivity gain in West Bengal. When 507 sample farm households were studied, farmers adopting ICARDA's improved lentil technologies achieved a 33.36 percent increase in production over traditional lentil growers. Proper land preparation, quality seed use and better disease pest management were the prime factors behind the increase.

Seeds of resilience in fragile states

Throughout 2021, farmers affected by the reduction of available seeds due to civil unrest in Syria, received support from the Food and Agriculture Organization of the United Nations (FAO) 'Smallholder Support Program'.

The program helps key farmers become community-based seed suppliers which in turn increases access to quality seed for regional farmers in general. The supplier-farmers, based in Aleppo, Homs and Deir Azor, were supplied with quality wheat, barley, chickpea and lentil seed, and given inputs, training and assistance to produce and commercialize the seed.

Optimizing water harvesting in Palestine

In Palestine, ICARDA partnered with FAO to test and out-scale in-situ rainwater harvesting approaches that improve the storage of water where it is needed – reducing losses due to delivery issues, optimizing rainfall and improving water-use planning. ICARDA implements water productivity improvements at the watershed level and supports the scaling of in-situ water harvesting, especially for improved agroforestry and orchard agriculture. ICARDA will also support capacity building and empowerment activities through training and demonstrations for targeted communities.

Promoting permaculture for sustainable living in Jordan

ICARDA has introduced permaculture technology to Jordan's Badia, the desert and steppe region covering the country's northeast. Permaculture is an approach that encourages self-reliance through strategically planning how to use natural resources sustainably. As a low-cost development tool for managing dryland resources in agro-pastoral farming systems, permaculture promises to increase yields, reduce costs and ensure dryland resources become more efficient, diverse and multifunctional for food and nutrition-insecure agro-pastoral communities.

More information

To read about more improving rural livelihood projects, see:

- ICT2Scale offers extension services to Tunisian farmers
- Technologies for African Agricultural Transformation at work in Ethiopia
- In-situ water harvesting in Palestine
- Ultra-low-pressure drippers foster desert farming

Awards and recognition

In 2021, ICARDA staff, projects, partners, and students won several prestigious awards for their research and fieldwork. Here is a list of our 2021 highlights.

- Prof. Dr. Adel El-Beltagy, a former Director-General of ICARDA, was recognized by the 'Dr. M.S. Swaminathan Award for Leadership in Agriculture' for his "lifetime contributions in national, regional and international agricultural research that changed the lives of poor farmers of West Asia, North Africa (CWANA) and Central Asia and Caucasus (CAC) countries."
- ICARDA's story on Community-Based Breeding Programs (CBBP) won first runner-up in a 'Call for success stories of inclusive innovations for livestock-based food systems' led by the African Union (AU) – InterAfrican Bureau for Animal Resources.
- ICARDA won the Khalifa International Award for Date Palm and Agricultural Innovation (KIADPAI) in the Second Category: 'Pioneering Development and

Productive Projects' for its flagship date palm project focusing on the development of sustainable date palm production systems in the Gulf Cooperation Council (GCC) countries of the Arabian Peninsula.

- Dr. Reena Mehra, National Associate Scientist (Lentil Breeding) at ICARDA's Food Legume Research Platform (FLRP), Amlaha, India, won the Research Wizard Young Scientist Award.

- ICARDA's Monitoring, Evaluation and Learning (MEL) team and Social, Economy and Policies team received an award by The Group on Earth Observation Land Degradation Neutrality (GEO-LDN) Initiative, overseen by the United Nations Convention to Combat Desertification (UNCCD), for innovation in halting land degradation through a tool that helps better inform land planning and the undertaking of restoration activities.

- Dr. Chandrashekhar Biradar, then the Team Leader of ICARDA's GeoAgro for Sustainable Agroecosystems, was awarded the India Agri-Extension Award 2021 in Innovation in Agricultural Extension.

- Researcher Médiha Khamassi Khbou, studying for her Ph.D. in collaboration with ICARDA and lecturer at the Ecole Nationale de Médecine Vétérinaire in Tunisia, received the Best Poster Presentation award during the latest 14th International Symposium on Ticks and Tick-borne Diseases.

- ICARDA Director-General, Mr. Aly Abousabaa, was presented with the shield of the Arab Center for the Studies of Arid Zones and Dry Lands of the Arab League (ACSAD) in recognition of ICARDA's role in the important development of agricultural scientific research in the region.

- Dr. Safaa Kumari, Head of ICARDA Seed Health Lab/Plant Virologist, was selected as one of the 25 exceptional female scientists from the Mediterranean basin featured at MednightEu in Spain.

- Technologies for African Agricultural Transformation (TAAT) Wheat Compact, implemented by ICARDA continued scaling climate smart heat-tolerant wheat varieties throughout 2021. In 2021, a short documentary on TAAT won the 2021 Stevie International Business Awards among which the work on wheat is reflected. The video won the 'Best Video – Documentary' category out of over 3,700 nominations from 65 countries for the 2021 edition.

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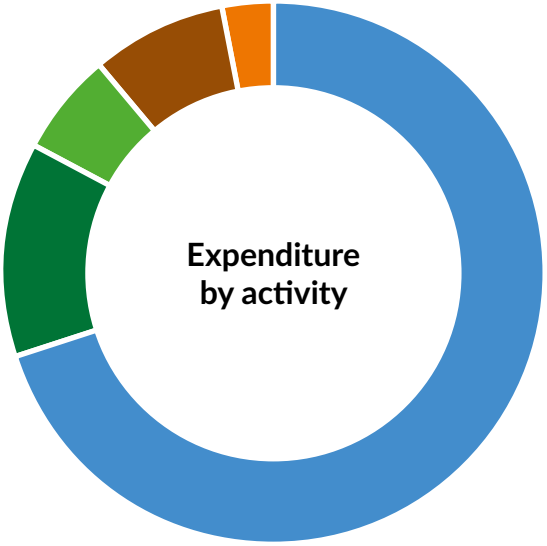
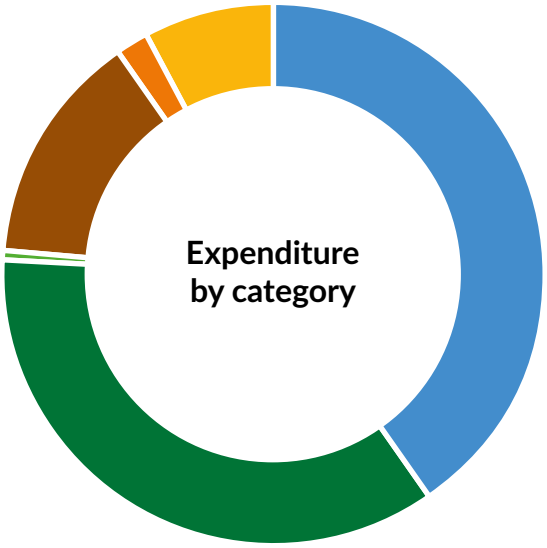
Financial information



- Research 70%
- Research Support 13%
- Management 6%
- Corporate Services 8%
- Resource Mobilization and Project Offices 3%



- Personnel Cost 40.54%
- Supplies and Services 35.31%
- Collaborators - CGIAR Centers 0.68%
- Collaborators - Partners 13.81%
- Travel 1.97%
- Depreciation 7.68%

For more detailed information, please see ICARDA's full 2021 financial statement.

Donors and partners

- African Development Bank
- Agricultural Research Center – Egypt (ARC)
- Arab Fund for Economic and Social Development (AFESD)
- Australian Centre for International Agricultural Research
- Bill & Melinda Gates Foundation
- Biotechnology and Biological Sciences Research Council
- Booz Allen Hamilton
- Caritas Switzerland
- Caussade Semences Group
- Centre de Cooperation Internationale en Recherche Agronomique pour le Developpment (CIRAD)
- CGIAR
- DCM - Shriram Ltd.
- Deutsche Gesellschaft fur Internationale Zusammenarbeit GmbH (GIZ)
- Directorate of Agriculture and Food Production, State Government of Odisha, India
- Directorate of Soil Conservation and Watershed Development DSC-O, State Government of Odisha, India
- Ethiopia Federal Ministry of Agriculture
- European Commission
- Food and Agriculture Organization of the United Nations (FAO)
- German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU)
- German Ministry of Foreign Affairs
- Global Crop Diversity Trust (GCDT)
- Government of China
- Government of Egypt
- Government of Morocco
- Government of Syria
- Government of Sudan
- Government of Turkey
- Grains Research and Development Corporation (GRDC)
- Gulf Cooperation Council (GCC)
- IHE Delft Institute for Water Education
- Indian Council for Agricultural Research (ICAR)
- International Center for Tropical Agriculture (CIAT)
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
- International Food Policy Research Institute (IFPRI)
- International Fund for Agricultural Development (IFAD)
- International Institute of Tropical Agriculture (IITA)
- International Livestock Research Institute (ILRI)
- International Maize and Wheat Improvement Center (CIMMYT)
- International Water Management Institute (IWMI)
- Japan International Cooperation Agency (JICA)
- John Innes Centre
- Khalifa International Award for Date Palm and Agricultural Innovation

- Kuwait Fund for Arab Economic Development (KFAED)
- Martin Luther University Halle-Wittenberg
- Massachusetts Institute of Technology (MIT)
- New South Wales Department of Primary Industries
- Norwegian Development Cooperation (NORAD)
- OCP Foundation
- OPEC Fund for International Development (OFID)
- PRIMA Foundation
- Regional Environmental Center for Central Asia (CAREC)
- Société des Boissons du Maroc
- Department of Farmers' Welfare and Agricultural Development, State Government of Madhya Pradesh, India
- State Government of Maharashtra, India
- State Government of West Bengal, India
- Swedish International Development Cooperation Agency (SIDA)
- Swedish Research Council (SRC)
- Swedish University of Agricultural Science
- Swiss Agency for Development and Cooperation (SDC)
- The Alliance of Bioversity International and the International Center for Tropical Agriculture (ABC)
- The University of Western Australia
- United Nations Economic and Social Commission for Western Asia (ESCWA)
- United Nations Environment Program (UNEP)
- United States Agency for International Development (USAID)
- United States Department of Agriculture (USDA)
- University of Sydney
- World Agroforestry Centre (ICRAF)
- World Bank

Appendix

SOIL, WATER AND AGRONOMY IN DETAIL

Climate change, soil degradation, and limited resources – particularly water – are jeopardizing the agricultural future of the world's dry areas. In response, ICARDA's Soil, Water, and Agronomy (SWA) team, Led by Dr Vinay Nangia, conducts sustainable soil, water, and agronomy management research to develop diversified and sustainable techniques for small and large-scale farming to strengthen livelihoods resilience and diversify cereal-based irrigated, rain-fed, and conservation agricultural food systems. We also promote the safe use of treated wastewater to generate feed, fodder, and trees and develop sustainable desert agriculture.

Moroccan Government to use ICARDA's conservation agriculture on 1 million hectares by 2030

In 2021, the Moroccan Government included a plan to have 1 million hectares under ICARDA's conservation agriculture (CA) by 2030 in its Green Generation Strategy (2020-2030). The World Bank has engaged the Soil, Water, and Agronomy (SWA) team, in partnership with the Institut National de la Recherche Agronomique (INRA-Morocco), to develop a roadmap and investment plan for achieving this target. CA is a sustainable agricultural production system that enhances soil health and, in turn, improves crop productivity and household resilience. Three core principles guide CA: no (or minimal) tillage to the soil after harvest, permanent soil cover to lock in moisture and reduce evaporation, and crop diversification replacing the traditional monocropping system. Adopting CA will half rates of soil erosion. In addition, each hectare cultivated using CA will capture around 0.5 tons of carbon dioxide, in line with the Net-Zero Carbon Emission Pledge launched at the 2021 United Nations Climate Change Conference of the Parties (COP26).

A white paper on carbon sequestration for better soil and food security

ICARDA's Soil, Water, and Agronomy (SWA) team's Agronomist Dr. Rachid Moussadek, coauthored a white paper on carbon sequestration for better soil and food security with the African Plant Nutrition Institute and Institut National de la Recherche Agronomique (INRA-Morocco) for the United Nations Food Systems Summit (UNFSS). The paper outlines challenges, such as the growing global competition for biomass, and identifies best management practices and soil fertility management for soil carbon sequestration in individual settings. It demonstrates how site-specific nutrient management using a combination of mineral and organic fertilizers, combined with other techniques, can deliver optimal results for farmers and food security.

A research paper on water, policy, and productivity in Egyptian agriculture

ICARDA's Social, Economic, and Policy Research (SEPR) Senior Economist Dr. Boubaker Dhehibi, coauthored a research paper on water, policy, and productivity in Egyptian agriculture. Findings from this paper reveal that expanding water resources is just one way to increase or maintain agricultural output when water scarcity restricts production, and that investments in research to raise productivity can also release constraints on growth. The paper underlines the fact that technological innovations and efficiency gains have contributed significantly more to agricultural growth in Egypt than the expansion of irrigated area or water use.

ICARDA signs memorandums of understanding for water management and efficiency

ICARDA signed two water-related memorandums of understanding in 2021. The first is with the International

Commission for Irrigation and Drainage (ICID) to build on the expertise and innovation of the two organizations in water management and efficiency while promoting knowledge sharing, collaborative programs, projects, and capacity development activities. The second is with Jain Irrigation Systems Limited to introduce the ICARDA-Massachusetts Institute of Technology (MIT) ultra-low-energy dripper for date palm irrigation in six Gulf Council Cooperation (GCC) countries. The dripper could result in a 22-31 percent decrease in the capital costs of a drip irrigation system due to smaller pumps and reduced operating energy costs.

ICARDA participates in the 5th African Regional Conference

Following International Commission for Irrigation and Drainage (ICID) and ICARDA's memorandum of understanding, ICARDA's Soil, Water, and Agronomy (SWA) team actively participated in the 5th African Regional Conference, organized by ICID. During the event, ICARDA hosted the first African Young Professional Workshop. ICARDA and partners from Institut National de la Recherche Agronomique (INRA-Morocco) and Massachusetts Institute of Technology (MIT) presented the challenges of drylands water scarcity and how to address them. Around 70 young professionals from 30 countries participated in a field visit to the joint ICARDA-MIT-INRA Ultra-low Energy Drip Irrigation for MENA Countries research project site on the outskirts of Marrakech, Morocco. The workshop showcased the multi-season field tests of low-energy drip irrigation emitters.

ICARDA at the 2021 Arab Water Forum

ICARDA, together with the Food and Agriculture Organization of the United Nations (FAO), participated in the Arab Water Forum 2021. ICARDA Director-General and CGIAR CWANA Regional Director, Mr. Aly Abousabaa, and ICARDA scientists Dr. Vinay Nangia, Dr. Chandrashekhar Biradar, and Dr. Ajit Govind discussed multiple topics including the climate and water security nexus, advanced technologies, and early warning systems to improve agricultural water productivity in transboundary water basins. Leveraging the untapped potential of food production under water scarcity and climate change in the Arab Region, and water for sustainable development, were also discussed.

ICARDA and FAO promote evapotranspiration measurement

The Soil, Water, and Agronomy (SWA) team organized a joint bi-weekly webinar series with the Food and Agriculture Organization of the United Nations (FAO) between September and November 2021 on state-of-the-art evapotranspiration (ET) measurement methods, which can help countries adapt to climate change and the increasing freshwater scarcity for sustainable agriculture. The webinar was led by global experts and attracted over 1,700 international and regional participants. Leading up to the series, ICARDA, in collaboration with FAO's Regional Office for Near East and North Africa, established the first regional network for field measurement of ET in five countries: Egypt, Jordan, Lebanon, Morocco and Tunisia, where National Agricultural Research Systems (NARS) use different ET measurement options. The SWA team also reviewed the FAO flagship publication, The State of the World's Land and Water Resources for Food and Agriculture (SOLAW21).

Introducing quinoa into Morocco's common lentil production system

The Soil, Water, and Agronomy (SWA) team's innovative introduction of quinoa into Morocco's standard lentil production system as a diversified cropping system caught the attention of the World Overview of Conservation Approaches and Technologies (WOCAT), which included it in their compendium of good land practices. Through diversified cropping systems such as this, ICARDA's Dr. Mina Devkota and Dr. Rajni Sinha are aiming to rehabilitate the dry regions' soils across India, Morocco, Nepal, and Uzbekistan, where soils have been broken down by decades of intensive tillage, overgrazing, overuse, and damaging industrial farming practices.

Innovative Agriculture for Small-Holder Resilience (iNASHR) 2021

Funded by the German Agency for International Cooperation (GIZ), the iNASHR project focuses on out-scaling proven agricultural technologies and agronomic practices for sustainable intensification of wheat production systems. ICARDA, together with the Egyptian Agricultural Research Center (ARC) and Access Agriculture (AA), promoted integrated technology packages on 600 on-farm

demonstration sites (20 percent owned by women) across six governorates located in the Nile Delta and Upper Egypt. These packages include seeds of improved wheat and faba bean varieties, a mechanized raised-bed machine, farmer-led seed multiplication, as well as agronomic practices including crop rotation and integrated pest management. During the year, the project transferred knowledge to 22,691 individuals (44 percent women) through farmer-field-schools, training-of-trainers, technical training, field demonstrations and farmer-to-farmer video screenings. In total, the project reached 23,291 direct and 129,335 indirect beneficiaries in 2021. Preliminary data from selected demonstration sites indicates that use of the raised-bed machine resulted in an average increase in grain yield of 23 percent in faba bean and 13 percent in wheat. Increases in water productivity were also achieved due to yield increases and a 22 percent reduction in water use.

Precision farming

Precision farming leverages advanced digital tools and breakthroughs in big data analytics, machine learning, and artificial intelligence to fast-track value creation for farmers by saving on input costs. This approach, which observes and responds to yield, moisture levels, and soil quality variations across a field, relies on analyzing data collected by sensors, drones, satellite imagery, GPS, Internet of Things (IoT) devices, and other geospatial tools that scrutinize land plots for anomalies and inefficiencies. Water scientists, agronomists, entomologists, GIS analysts, breeders, and economists pooled this precious knowledge to establish ICARDA's first precision farming one-stop shop in Amlaha, at the ICARDA research station located in the central Indian state of Madhya Pradesh. Following an official agreement with the Indian state government, ICARDA is launching a three-year pilot project funded by the State Government of Madhya Pradesh, India on irrigated and rainfed agro-ecologies focusing on the most economically-important crops in Madhya Pradesh; namely cotton, wheat, and soybean, to increase farmers' income across Madhya Pradesh, known for having the highest agricultural growth rate in India. Embracing digital technologies can help local farmers achieve ambitious targets set by Indian Prime Minister Narendra Modi to double farmers' incomes by the end of 2022.

RESILIENT LIVESTOCK AND AGRO-SILVO-PASTORAL SYSTEMS IN DETAIL

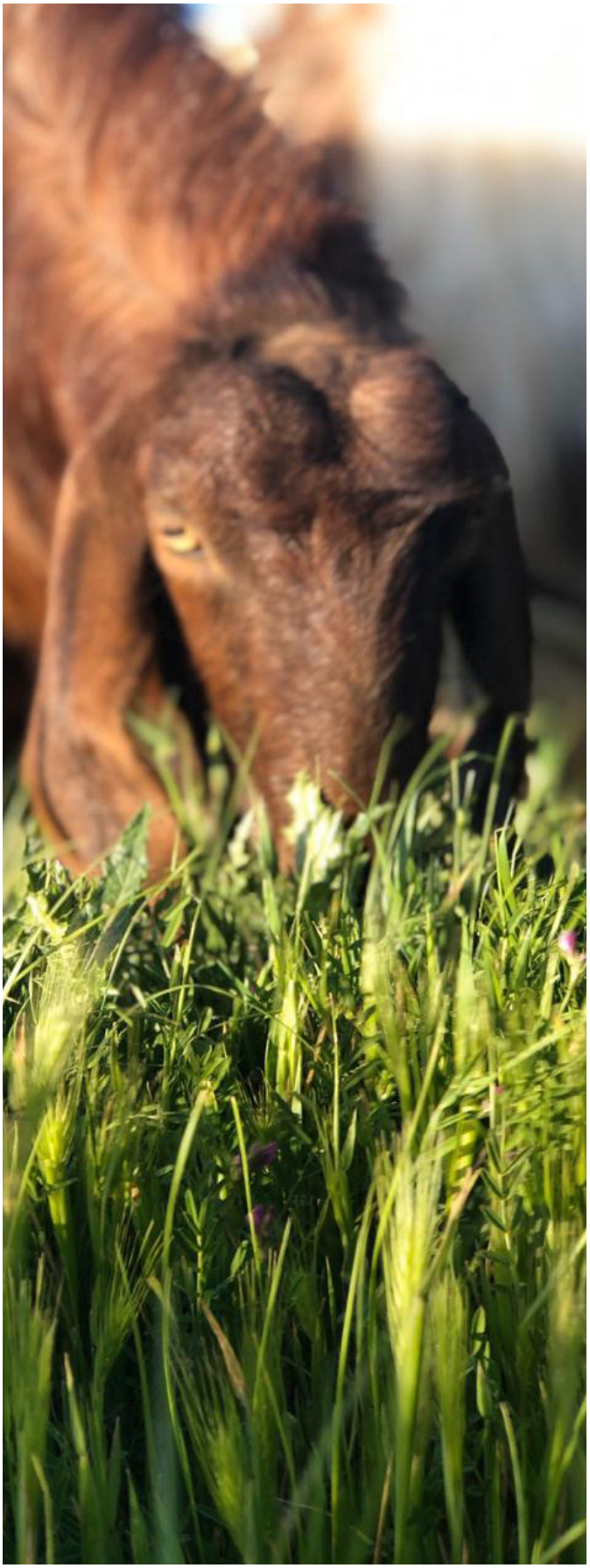
ICARDA's integrated approach to more productive and sustainable crop-livestock systems focuses on the farmer and community-based solutions for improving sheep and goat production, sustainable rangeland management and restoration, water-efficient dryland forage production, and better crop-livestock integration in hybrid dryland systems.

Our solutions strive toward land degradation neutrality through restoration strategies that respond to climate change, reducing the environmental footprint of dryland agriculture. We also provide information and skills to rural households to ensure product safety and maximize value-added advantages. ICARDA's teams interact with other CGIAR Centers on new projects and frameworks that define future crop-livestock methods under the One CGIAR reformulation to guarantee that CGIAR uses our new science now and in the future.

This work is carried out by ICARDA's Resilient Agro-Silvo-Pastoral Systems (RASP) team led by Dr. Barbara Ann Rischkowsky, which also integrates the research teams on Rangeland Ecology and Forages (REF), the Restoration Initiative on Dryland Ecosystems (RIDE), and Small Ruminants (SR).

Scaling the community-based breeding program

In 2021, the Small Ruminants (SR) team, with funds from the United States Department of Agriculture (USDA), used a scaling framework developed by ICARDA to scale the goat community-based breeding program (CBBP) with more than 2,000 households in Konso, Ethiopia. Full sire certification – covering breeding value, physical integrity, semen assessment, mating ability, and vaccination against five diseases – has been established as a pre-condition for



disseminating sires in at least four sheep and goat CBBPs in Ethiopia. To further scale CBBPs through educational systems, ICARDA engaged 23 local Ethiopian universities. Over ten universities have incorporated CBBPs in their undergraduate program, and six universities have started CBBPs in nearby villages.

Identifying important genes for climate-smart sheep

Collaborating with National Agricultural Research Systems (NARS), ICARDA's Resilient Agro-Silvo-Pastoral Systems (RASP) team made a huge breakthrough by identifying in the genomes (all genetic information of an organism) of sheep, specific genes that may be responsible for adaptation to different environments (for example drylands and highlands) and resistance to internal parasites. Such genomic locations and genes can now be used to investigate variations that can be deployed in breeding programs to increase the resistance of small ruminants to specific challenges in environments in which communities live under climate change.

Enhancing resilience against sand and dust storms in agriculture

Within the scope of the ICARDA-Food and Agriculture Organization of the United Nations (FAO) project, 'Catalyzing Investments and Actions to Enhance Resilience against Sand and Dust Storms in Agriculture,' ICARDA's Restoration Initiative on Dryland Ecosystems (RIDE) team, developed a framework and evaluation method in 2021 to assess sustainable land management (SLM) practices and their potential to mitigate sand and dust storm sources and impacts on agriculture. By adequately managing crucial land resources such as soils, water, animals, and plants, SLM allows for sustainable and environmentally sound agriculture, and ensures the long-term survival, productive potential, and ecosystem functions of vital resources. RIDE presented their findings at the United Nations pre-United Nations Climate Change Conference of the Parties (COP26) side event on 'Sand and Dust Storm and Climate Change' in September 2021.

Dr. Mounir Louhaichi selected as Deputy Lead of a One CGIAR initiative

In 2021, ICARDA's Rangeland Ecology and Forages (REF) Research Team Leader, Dr. Mounir Louhaichi, was

selected as deputy leader of the One CGIAR initiative, Livestock, Climate and System Resilience. This initiative aims to partner with public and private actors to develop and deliver actionable innovations that measurably help producers, businesses, and governments adapt livestock agri-food systems to climate change, reduce greenhouse gas emissions, and contribute to sustainability and development goals across livestock systems. Dr. Louhaichi is also a member of the Global Coordinating Group of the International Year of Rangelands and Pastoralists, which succeeded in getting the United Nations General Assembly to unanimously declare 2026 the International Year of Rangelands and Pastoralists. The REF Research Team Leader has also joined the editorial boards of the African Journal of Range & Forage Science and the Journal of the Professional Association for Cactus Development.

Dr. Sawsan Hassan selected as a member of AARINENA's Forgotten Foods, Neglected Crops and Underutilized Species technical committee

ICARDA's Forage Systems Coordinator, Dr. Sawsan Hassan, has been selected as a member of the technical committee for Forgotten Foods, Neglected Crops and Underutilized Species, managed by the Association of Agricultural Research Institutions in the Near East & North Africa (AARINENA). The committee carries out research activities and data analysis, gives presentations and discussions, holds deliberations and debates, and drafts manifestos on forgotten foods.

Spineless cactus project provides fodder from degraded lands in Odisha

Under the leadership of Dr. Nigamananda Swain, a project to introduce spineless cactus as fodder in degraded and hilly lands achieved a range of positive impacts in 2021. Implemented with the support of the Government of Odisha, and with technical support from the Resilient Agro-Silvo-Pastoral Systems (RASP) team, ICARDA and the Indian Council of Agricultural Research (ICAR)-Indian Grassland and Fodder Research Institute, 425.26 hectares of degraded and hilly community lands have been planted with 28,442 cactus cladodes to establish 16 foundation nurseries and 36 village-level multiplication nurseries. The project has created more than 75,500 job-days for local communities. By intercropping in the cactus fields, these communities also earned an additional income of Rs7,500 (US$100) per hectare, approximately 56 percent more than local communities used to earn from the same land. Positive impacts for soil and water conservation are also expected in the coming years with the establishment of spineless cactus plantations.

Using science-based evidence to properly manage degraded arid rangelands in Tunisia

Natural rangelands cover over a third of Tunisia's land. But the majority (87 percent) of these rangelands are in arid and desert areas, and erratic fluctuations in rainfall supply mean there is not always enough vegetation to sustain livestock. The main cost-effective restoration technique is *Gdel*, which consists of resting pieces of land for a fixed period, during which it cannot be grazed. However, for many years the carrying capacity of the land has been based on arbitrary visual estimates performed by a selected field crew. In recent years, under the CGIAR Research Program on Livestock, ICARDA researchers developed criteria to help land managers decide whether grazing would impede rangeland restoration efforts. Now the carrying capacity is determined based on four criteria that offer key indicators of rangeland health: (1) biomass availability, (2) percentage of desirable (edible for livestock) species, (3) vegetation cover, and (4) rainfall distribution and amount. Development agencies and local communities have expressed appreciation for the flexibility to adjust grazing strategies based on climatic conditions that differ from year to year, and ICARDA researchers hope the criteria will be widely adopted.

Sulla: a native forage species for reversing degradation in Mediterranean agro-silvo-pastoral systems

Agro-silvo-pastoral dryland landscapes are important throughout Africa and Asia for millions of rural families, who depend on them for growing the grasses, shrubs, and trees they need to feed their livestock. Yet due to worsening climate change impacts, increasing population, and mismanagement such as overgrazing, the ability of these areas to produce enough forage is fast declining. A key forage species indigenous to the Mediterranean is sulla (*Hedysarum coronarium* L.). A deep-rooted legume, sulla is also effective in the biological fixation of sloping land and improving the organo-mineral soil fertility, yields, and protein value of cereals. It is highly palatable to animals,

nutritious, and productive. The Rangeland Ecology and Forages (REF) team has demonstrated that planting sulla can help halt degradation, significantly reduce soil and water erosion, increase productivity, and provide more forage to sustainably meet the demands of increasing livestock production while lowering import costs of feed. The REF team has used these findings to develop an integrated package for agropastoral restoration.

Scaling conservation agriculture in crop-livestock systems

ICARDA has enabled public-private partnerships for forage seed production in the Conservation Agriculture in Crop-Livestock Systems project framework, funded by the International Fund for Agricultural Development (IFAD). As a result, 2021 witnessed substantial achievements in scaling forage mixtures in crop-livestock-based systems in Tunisia and Algeria. For example, the quantities of vetch seeds available in the market increased by 300 percent in the past five years. Similar growth has been observed for forage mixtures, which are increasingly demanded by farmers.

A productive year for REF publications

Rangeland Ecology and Forages (REF) scientists published a total of 13 papers in International Scientific Indexing publications in 2021, covering topics ranging from the sustainable restoration of agro-silvo-pastoral systems to the impact of rangeland biodiversity and climate variability. The REF team has also reinforced the Sustainable Rangeland Management toolkit, which will be adopted by the International Union for Conservation of Nature (IUCN) in their training programs, with the publication of an outcome impact case report, an innovation brief, and a guide for rangeland inventorying, monitoring, and assessment. Other publications include an International Livestock Research Institute (ILRI)-ICARDA policy brief summarizing key insights on rangeland restoration, a study on native, drought-tolerant forage species for enhanced dryland pasture restoration in Tunisia, and more than ten factsheets characterizing forage and range species.

Spineless cactus

ICARDA's work on spineless cactus was selected as one of International Fund for Agricultural Development's (IFAD) Panorama Solutions, and a case study about a cactus fruit plantation in arid drylands was uploaded to the World Overview of Conservation Approaches and Technologies (WOCAT) Global Database on Sustainable Land Management. Activities related to strengthening cactus pear development and adaptation also led to a brief, an outcome impact case report, a newsletter, four educational videos, and, in collaboration with the Food and Agriculture Organization of the United Nations (FAO), an event to launch the Arabic edition of Crop Ecology, Cultivation and Uses of Cactus Pear.

GENETIC RESOURCES IN DETAIL

ICARDA's Genetic Resources (GRS) team, led by Dr. Zakaria Kehel, works in Lebanon and Morocco alongside global networks including the CGIAR Genebank Platform, the Global Crop Diversity Trust, the German Agency for International Cooperation (GIZ), the European Union (EU), and other development partners. Together, they collect, conserve, and develop the vital genetic resources needed to protect agrobiodiversity in dry regions. ICARDA's GRS team has started translating its standard operating procedures into Arabic and French for dissemination across Central and West Asia and North Africa.

ICARDA's genebanks accessions in 2021

As of September 2021, ICARDA's genebanks contain 151,889 accessions of cereals, food legumes, forage, and rangeland species. Some 15,926 and 5,557 accessions were regenerated in Morocco and Lebanon, respectively. In addition, a total of 17,896 accessions for import, 35,251 accessions for export, and 21,759 accessions for conservation were analyzed for seed health.

The regeneration of non-Svalbard safety duplication

In 2021, the Genetic Resources (GRS) team started the regeneration of non-Svalbard safety duplication with over 6,000 chickpea accessions retrieved from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). Additionally, ICARDA-Lebanon has successfully regenerated around 1,000 wild relatives sent by the Millennium Seed Bank in the United Kingdom.

Scaling the Focused Identification of Germplasm Strategy

The Focused Identification of Germplasm Strategy (FIGS) methodology is a scientifically-proven tool that helps crop breeding programs identify valuable traits in plant genetics more accurately and efficiently, improving on the limitations of more traditional approaches. To scale the FIGS methodology, ICARDA launched an open-source FIGS analytical tool for broader use and developed a Genesys sub-setting tool with the International Center for Tropical Agriculture (CIAT). ICARDA further collaborated with CIAT to create a dashboard to summarize outputs from a gap analysis of 22 CGIAR crops. This collection mission planning tool can be used by genebanks from both CGIAR and national programs.

Improved grass pea crop

2021 witnessed the regeneration of lines from the first successful interspecific crosses between grass pea and five *Lathyrus* species. This resulted in a total of 110 F3 families from interspecific crosses using *Lathyrus cicera*. F2 and

F3 BC2 and BC3 seeds from crosses with *L. articulatus*, *L. cicera*, *L. heirosolymitanus*, *L. inconspicuous*, *L. marmoratus*, and *L. ochrus* were also successfully produced. Additionally, new interspecific crosses were performed for barley and wheat to target disease and insect resistance and the production of micronutrients and beta-glucans.

Introducing PhysioTron and PhenoBuggy: ICARDA's new approach to high-throughput phenotyping

In 2021, ICARDA, with the support and collaboration of the CGIAR WHEAT Research Program and co-investing national agricultural research institutes, the International Maize and Wheat Improvement Center (CIMMYT), and the Institut National de la Recherche Agronomique (INRA-Morocco), developed the innovative PhysioTron, a machine that speeds up the accurate measuring and recording of plant genetic traits, allowing for more advanced research toward achieving food security in the dry areas. The PhysioTron can house up to 750 plots, each 1.5 meters deep and filled with soil according to soil profiles specified by the station. Its fully automated control system offers flexibility for designing a wide range of experiments that allow for the application of various and controlled water regimes in each plot. A mobile gantry also enables researchers access to middle plots without disturbing the earth of side plots.

Further innovation relates to the field-based high-throughput phenotyping (HTP) system, as phenotyping remains one of the main bottlenecks in plant breeding. In response, with the support of the Arab Fund for Economic and Social Development (AFESD), Dr. Andrea Visioni and the manufacturer Hiphen developed the PhenoBuggy: a tractor-mounted, GPS-assisted multi-sensor head. The PhenoBuggy allows for rapid and accurate measuring of phenotypic traits, such as green fraction, senescence, vegetation indices, leaf area index, biomass, spike number, and plant height.

Greater agrobiodiversity with the Activated Genebank Network

ICARDA continued its contributions to the European Union (EU)-funded Activated Genebank Network (AGENT) project, launched in 2020 to transform genebanks from passive seed libraries into advanced bio-informatics resource centers. In 2021, ICARDA scientists helped devise more straightforward tools and procedures for genomic work that would typically involve a lot of complex statistics to improve breeders' ability to define valuable germplasm. Through AGENT, ICARDA and partners are working to collect and standardize phenotype information from global genebank networks within a single database. This will revolutionize plant genetic resources information sharing.

Farming with alternative pollinators promotes transformative change in agriculture

ICARDA's Farming with Alternative Pollinators (FAP), led by Dr. Stefanie Christmann and funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, enhances agricultural land by marketable habitat enhancement plants (MHEP), nesting and water support. MHEP prolong the flowering times in the fields and attract higher diversity and abundance of pollinators (enhancing productivity of many crops) and natural enemies (reducing pest abundance in the main crop and the need for chemicals). Both effects increase the net income gain for farmers significantly. A project in Morocco in four agro-ecosystems, with seven different main crops and more than 230 smallholder fields showed a net income increase of 121% and a reduction of pest abundance in the main crop by 65%.

DIGITALIZATION OF RESEARCH IN DETAIL

ICARDA continued to digitize research in 2021 to make data collecting, information sharing, analysis, and decision-making faster, better, and more accurate. Even in the most distant and vulnerable dry places where ICARDA operates, global advances in technology, digital analytics, remote sensing, networks, and software, particularly on now-ubiquitous smartphones, make data gathering, analysis, reporting, and knowledge exchange more manageable and more efficient.

Based on four decades of drylands research, our unique and increasing pool of big data aids in the modeling and analysis of novel techniques, climatic variability, evaluation of new crop varieties and livestock enhancements, socioeconomics, and decision-making at all levels. When combined with those of sister centers under the One CGIAR reformulation, our data will produce a powerful resource that will substantially contribute to the fight against global climate change.

GeoAgro on CGIAR's Digital Extension Services

The objectives of ICARDA's GeoAgro for sustainable agroecosystems team are fully aligned with the CGIAR Platform for Big Data: harnessing big data and information technology to accelerate and enhance the impact of international agricultural research to drive equitable rural development. In 2021, the GeoAgro team led by Dr. Ajit Govind, coauthored CGIAR's Digital Extension Services, bridging the gap between developing and adopting new climate change adaptation strategies and developing geotagging and agro-tagging tools to digitize agriculture research and outreach.

Enhancing the GeoAgro Pro portal

In 2021, ICARDA's GeoAgro team introduced an atlas of real-time mapping of crop fallow dynamics and corresponding legume suitability for the sustainable intensification of legumes in cereal systems. To achieve this, the GeoAgro team developed new algorithms for mapping yield gaps at farm level – one of the first yield gap decomposition models and applications for data-limited regions – and produced the revamped GeoAgro Pro portal with enhanced features. This work, achieved in partnership with the Indian Council of Agricultural Research (ICAR) and with support from the International Fund for Agricultural Development (IFAD), makes precision agriculture possible through real-time advisories with site-specific packages of practices, within the framework of the One CGIAR Excellence in Agronomy initiative.

Dr. Chandrashekhar Biradar receives the India Agri-Extension Award

In 2021, Dr. Chandrashekhar Biradar, then serving as the GeoAgro Team Leader, was awarded the India Agri-Extension Award 2021 in Innovation in Agricultural Extension. The award recognized the GeoAgro team's digital innovation that advises small family farmers on input saving techniques, carbon sequestration, and yield improvement to increase their income, resilience, and sustainability.

ICT2Scale legacy lives on

Led by Mr. Udo Rudiger, ICARDA's Agricultural Innovation Specialist, and Dr. Boubaker Dhehibi, ICARDA's Agricultural Economist and ICT2Scale Co-Leader, the ICT2Scale project launched in Tunisia in 2019 to introduce information and communications technology (ICT) services to family farmers using cellphones to offer e-learning and extension services for crop and small ruminant production, beekeeping, and conservation agriculture. Although the project concluded in December 2021, its legacy will live on as the project's ICT innovations, such as the e-learning training modules that were developed to be promoted by extension services and mobile apps, continue to support small landholders in Tunisia in the future. One example is 'Kolfa', a bilingual Arabic-French smartphone app that provides price information on agricultural commodities to Tunisian farmers in near real time. Introduced in August 2021, Kolfa has been downloaded over 1,000 times and is widely promoted online. ICT2Scale was funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and in collaboration with Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

ICARDA and the United Nations Food Systems Summit

In 2021, ICARDA became a founding partner of the Indigenous Knowledge and Research Infrastructure, a digital infrastructure that supports the implementation of the United Nations Food Systems Summit (UNFSS). In this role, ICARDA co-developed global dialogue and co-organized the UNFSS pre-summit on the Integration of Frontier Technologies and Indigenous Knowledge for Food Systems Transformation and its Summit Dialogues, addressing emerging science and technology-based solutions for integrating indigenous knowledge and experiences for food security. GeoAgro also co-organized the UNFSS Independent Dialogue in Egypt on the role of water security for food systems transformation. Additionally, the GeoAgro team organized and co-chaired the joint technical session with the International Center for Biosaline Agriculture and the International Commission on Irrigation and Drainage on advanced technologies and early warning systems to improve agricultural water productivity in transboundary water basins, and presented digital dynamism for agriculture water management in drylands at the 5th Arab Water Forum.

Monitoring, evolution, and learning supports CGIAR quality assurance

In 2021, ICARDA's Monitoring, Evaluation, and Learning (MEL) team, led by Enrico Bonaiuti, supported the evaluation of scientific credibility within the CGIAR Quality of Research for Development (Qo4RD) framework by developing a tool that validates peer-reviewed publications in an automated and efficient way. The MEL team also supported the development of CGIAR's repository for grant-level agricultural research for development indicators by processing data on performance indicators used by ICARDA projects. The data is used in Graphileon, visual data analysis, and inference. In support of the One CGIAR initiatives, the MEL team created in partnership with Royal Roads University (Canada) and Codeobia (Jordan) an online board to visualize and monitor their theories of change, integrated within the Online Submission Tool.

Adding wheat and barley to global crop diagnostics app Plantix

Also in 2021, ICARDA included barley and wheat in the world-renowned Plantix agricultural smart-device app. Plantix offers automated diagnostics for over 350 globally-identified plant diseases, pests and nutrient deficiencies on more than 65 agricultural crops through real-time updates.

Making AGROVOC accessible to Arabic speakers

In 2021, as a part of an ongoing collaboration with the Food and Agriculture Organization of The United Nations (FAO), ICARDA's Monitoring, Evaluation, and Learning (MEL) team translated about 800 concepts in AGROVOC, FAO's agricultural data tool, into Arabic.

Publishing and disseminating ICARDA's work

In 2021, the World Overview of Conservation Approaches and Technologies (WOCAT), developed in 2020, published ten ICARDA innovations on three digital resources to help support wider dissemination on the ICARDA website and social media platforms. ICARDA also uploaded 93 publications to the Monitoring, Evaluation, and Learning (MEL) website in 2021. Of these, 58 are open access, thereby continuing ICARDA's practice of ensuring that at least 60 percent of its resources are open access.

ICARDA teams awarded for their innovation in halting land degradation

ICARDA's Monitoring, Evaluation, and Learning (MEL) and Social, Economy and Policy Research (SEPR) teams received an award for a tool that helps better inform land planning and restoration activities. The award, issued by the Group on Earth Observation Land Degradation Neutrality Initiative, was overseen by the United Nations Convention to Combat Desertification. The tool will allow participatory land-use planning efforts to more precisely target areas requiring land restoration, sustainable land degradation neutrality, and protection from ongoing degradation.

CLIMATE SMART CROPS IN DETAIL

ICARDA's Breeding and Scaling Improved Varieties of Dryland Cereals and Pulses team, led by Dr. Michael Baum, is a crucial player in the regional and global development and dissemination of climate-resilient crops. These market-driven crop varieties protect dryland farmers from severe heat, water scarcity, the appearance of new pests and diseases, and nutritional insecurity.

Over the past four decades, country partners in Asia, Africa, and beyond have evaluated and distributed ICARDA's enhanced grain and legume varieties. Farmers have accepted our new varieties, resulting in yearly net benefits of over US$850 million.

In 2021, seven wheat varieties and one variety each of barley, chickpea, and lentil were released in partnership with National Agriculture Research Systems (NARS) collaborators in Ethiopia and Turkey.

Also in 2021, ICARDA's Crop Breeding teams made groundbreaking progress through the Modernization of ICARDA Breeding Programs project, supported by the Arab Fund for Economic and Social Development (AFESD) and CGIAR's Crops to End Hunger platform. New speed breeding protocols were developed for all ICARDA-mandated crops, allowing four generations to be achieved in just one year while maintaining ICARDA's capacity to screen for the most prevalent diseases in the region as well as for high end-use quality. In addition, more than 4,000 entries of wheat and barley were genotyped in 2021. This will improve the capacity of breeding programs to select the best germplasm to be shared with NARS. In addition, new big-data-management and analysis tools have been developed to automatically store, curate, and analyze the field data produced by the breeding programs.

Seed systems, international nurseries, and seed health

Wheat seed system studies

Two major studies on wheat seed systems, varietal adoption and impacts in Turkey were published in 2021 and another for Uzbekistan was completed. The Turkish studies cover variety development, release, licensing, and protection; seed production, quality assurance, and marketing; and the policies, institutions, laws, and regulatory frameworks governing them. The studies also estimate the level and determinants of varietal adoption and the associated livelihood impacts. Each chapter provides detailed analyses of the different topics and identifies major challenges and opportunities within the limits of their individual thematic focus. The studies make several recommendations for improving Turkey's wheat sector, including strengthening formal academic education in seed sciences, tailoring policies and interventions to meet specific regional needs, and aligning domestic biodiversity practices with international conventions. The authors presented their findings and recommendations at two international webinars in November 2021.

On a mission to improve pulse seed systems in Odisha, India

The Odisha Pulse Mission aims to enhance nutritional security by strengthening village and informal seed systems for farmers' preferred varieties of pulses in Odisha. The project was funded by the Government of Odisha and supported by the Indian Council of Agricultural Research (ICAR) and was successfully led by Dr. Nigamananda Swain and the ICARDA Odisha project team in coordination with Dr. Zewdie Bishaw and other stakeholders. By the end of July 2021, it reached 13,832 farmers across 14 districts, helped 126 farmer groups to manage seed hubs in project villages, and demonstrated technologies for the intensification of pulses, especially in rice fallows. A total of 4,200 hectares of rice fallows have been brought under pulse cultivation, leading to an estimated 33,000 quintals of additional production with an average incremental income of Rs13,626 per farmer.

Rehabilitation of seed systems in Syria

Through its Food and Agriculture Organization of the United Nations (FAO)-funded project, 'Services to Support the Seed Multiplication Sector in Syria for the Season 2020/21,' ICARDA supported smallholder farmers by providing seeds of improved wheat, barley, chickpea, and lentil varieties; establishing seed producers' groups for sustainable local seed business; and strengthening the capacity of partners and farmers. In 2021, a total of 9.7 tons of wheat, barley, chickpea, and lentil seed was provided to 53 smallholder farmers (12 percent female) in three seed producers' groups, together with agricultural inputs and operational costs for weed control, irrigation, harvesting, and processing. A total of 184 tons of wheat, barley, chickpea, and lentil was produced, representing a net profit of US$301.60, or 119.5 percent.

In addition to technical backstopping, a train-the-trainer course on community-based seed production and marketing was organized. The course included field days, a cross-learning tour, and formal training covering quality and healthy seed production, crop inspection, certification, and seed processing operations. A total of 250 participants attended, including development partners and high-level delegates from FAO and ICARDA.

Scaling of heat-tolerant wheat varieties in Africa

Wheat is one of the key crop commodities of the African Development Bank's Feed Africa Flagship, part of its Technologies for African Agricultural Transformation (TAAT) initiative. Implemented by ICARDA, the TAAT Wheat Compact (TWC) continued to provide technical support in scaling heat-tolerant wheat varieties in target African countries. TWC focused on creating awareness and a sense of urgency for wheat transformation through policy advocacy and the development of road maps for deploying agricultural innovations in target countries. Multi-stakeholder platforms, consisting of high-level inter-ministerial steering committees and technical committees, have been established to lead national wheat self-sufficiency agendas in target countries. As a result, wheat area expansion and increased wheat production have been observed in almost all project target countries. Ethiopia and Sudan are driving wheat self-sufficiency and other countries are making wheat a priority crop through national decrees. TWC success stories were featured in the 2021 high-level virtual dialogue, Feeding Africa: Leadership to Scale Up Successful Innovations. Also in 2021, a short documentary on TAAT beat over 3,700 nominations from 65 countries to win the 'Best Video – Documentary' award at the 2021 Stevie International Business Awards.

International nurseries (IN)

In 2021, ICARDA's International Nurseries (IN) team led by Dr Abdoul Aziz Niane, carried out seed production and distribution of about 575 sets, containing 11 trials of seven mandate crops, and 1,619 elite lines to 103 cooperatives in 44 countries. Total cost recovery was through CGIAR Research Programs, projects, and country contributions.

ICARDA IN continues to benefit from its partnership with National Agriculture Research Systems (NARS) through the release of improved cereal and legume varieties. These are preferred by farmers, because of their adaptation and agronomic traits, and by industry and consumers, because of their grain quality traits. In 2021, a total of 24 improved cereal and legume varieties were released in eight countries. These varieties included five spring bread, one durum and seven winter wheat, one barley, one faba bean, six chickpea, and three lentil varieties. It is anticipated that these varieties will contribute to food and nutritional security for smallholder farmers and support effective and efficient scaling.

Maintaining and promoting seed health

During 2021, ICARDA seed health labs in Terbol, Lebanon, and Rabat, Morocco, analyzed 110,390 accessions for seed-borne pathogens and pests, including viruses, bacteria, fungi, nematodes, weeds, and storage insects. These accessions were tested in 48,404 samples and the results were collected from 567,975 diagnostic reactions. Also in 2021, seven standard operating procedures related to seed health testing at ICARDA were developed, covering legumes, wheat, and barley, as well as seed cleaning and disinfection, field and quarantine inspection, information management and certification, and capacity building.

Dr. Safaa Kumari, Head of ICARDA's Seed Health Laboratory, actively promoted seed health in 2021. In November, she presented two lectures as part of a wheat management course for scientists in the Syrian General Organization of Seed Multiplication. She also presented a virtual lecture, 'Safe movement of food and forage crops germplasm at ICARDA,' to more than 60 participants at an event organized by the Abu Dhabi Agriculture and Food Safety Authority (ADAFSA). Another virtual lecture, on the importance of germplasm health in preventing the spread of pathogens and transboundary diseases, was given to around 120 experts and specialists, representing 19 countries, at an event led by the Khalifa International Date Palm Award and Agricultural Innovation.

Wheat

ICARDA's durum and bread wheat breeding efforts employ wild relatives extensively to generate elite germplasm that is well-suited to the severe and frequent droughts that plague the drylands where the organization operates.

High yielding, rust-resistant, and heat-tolerant spring bread wheat varieties of ICARDA origin, including 'Abay' and 'Hachalu' in Ethiopia, were released in 2021, and others have passed the distinctiveness, uniformity, and stability test for registration in Morocco. Similarly, there are many high yielding and drought-tolerant elite spring bread wheat genotypes which survived an extremely severe drought at Marchouch station, Morocco, in 2021/2022, much better than other cultivars, without irrigation. These elite spring bread wheat genotypes will be distributed to the national programs of countries in Central and West Asia and North Africa and sub-Saharan Africa in August 2022.

Furthermore, a total of 12 high yielding, drought tolerant, and yellow resistant Winter Facultative Wheat varieties – originating from Turkey-International Maize and Wheat Improvement Center (CIMMYT)-ICARDA (TCI), International Winter Wheat Improvement Program (IWWIP) – were released in four different countries, six in Turkey, four in Azerbaijan, one in Iran, and one in Uzbekistan.

Dissemination of interspecific ICARDA varieties via participatory research

ICARDA's Dissemination of Interspecific ICARDA Varieties via Participatory Research (DIIVA-PR) project, supported by the Crop Trust's Crop Wild Relatives (CWR) Project, developed new climate smart crop varieties derived from CWR crosses. Through a participatory varietal selection strategy, DIIVA-PR introduced these varieties to farmers in dry regions critically affected by climate change and climate variability. The project concluded successfully in July 2021. Building on its success, a second phase, 'BOLD-DIIVA,' launched shortly after DIIVA-PR's conclusion. The project focused on areas in Ethiopia, Lebanon, Morocco

and Senegal that are heavily affected by drought and with a high concentration of rural poor. Using crop wild relatives, DIIVA-PR aimed to improve the climate change adaptation of three staple crops: durum wheat, barley, and lentil. Some 40 on-station trials were conducted to confirm the value of CWR-derived germplasm. In addition, a total of 22 on-farm demonstrations were set up to engage some 12 rural communities. The ultimate outcome was that the CWR-derived germplasm outperformed the best local varieties for adaptation to climate extremes, including a very severe drought in Morocco during 2019-20 season and temperatures exceeding 38 degrees Celsius in Senegal. Farmers also showed clear appreciation for several of the CWR-derived entries because of their adaptation and rusticity. Four varieties have been released by the project thus far based on farmers preferences, five more should be released soon, and over 50 partners around the world have benefitted from this unique germplasm.

Genomic prediction to deliver heat-tolerant wheat to the Senegal River Basin

The 'Genomic Prediction to Deliver Heat Tolerant Wheat to the Senegal River Basin' project, funded by the Swedish Research Council and led by ICARDA's Dr. Filippo Bassi, reached a successful conclusion in December 2021. The project successfully used advanced genomic models to increase the rate of genetic gain for the delivery of heat-tolerant and short-duration varieties of durum wheat that were adapted to the pedo-climatic conditions of the Senegal River valley. The major outcomes of these four years were the publication of ten ISI research articles in high impact factor journals.

Further, the genomic selection model was improved using different training populations tested across three years for different traits of varying complexity levels. The use of kinship split to improve accuracy was confirmed and fully adopted by ICARDA. Due to the high impact within Senegal River communities, a third phase, under the project name 'Delivering heat-tolerant alleles to raise farm income along the Senegal River,' has now received funding until December 2024. The project aims to double the area of cultivation, integrate female cooperatives to operate as community-based seed enterprises, and attempt the fine mapping and possible cloning of the major locus identified as controlling heat tolerance.

Overall, this project represented a major milestone in the deployment of genomic selection as a breeding tool. ICARDA's Durum Wheat Program has now shifted to this technology and will use it for achieving higher rates of genetic gain under the Accelerated Breeding Initiative (ABI) for all targeted product profiles.

ICARDA and INRA-Morocco's barley and durum wheat pre-breeding program

In 2021, more than 1,000 accessions of barley and 1,800 lines of wheat were selected from ICARDA genebanks and shared with the Institut National de la Recherche Agronomique (INRA-Morocco)'s barley and durum wheat program. More than 1,400 wheat pre-breeding lines are being genotyped for alleles and gene detection and for further integration into wheat breeding programs.

Food legumes

Our elite food legume lines are available to National Agricultural Research System (NARS) partners through ICARDA's international nurseries. ICARDA's food legumes team is also working alongside other CGIAR centers to develop the One CGIAR initiatives that seek to unify efforts in crop improvement globally and across CWANA.

ICARDA's food legumes projects receive funding from the Indian Council of Agricultural Research (ICAR), the Government of Odisha, the International Fund for Agricultural Development (IFAD), the European Union (EU), the CGIAR Research Program on Grain Legumes and Dryland Cereals, the Grains Research and Development Corporation, the Global Crop Diversity Trust, the Arab Fund for Economic and Social Development (AFESD), the Organization of the Petroleum Exporting Countries (OPEC) Fund for International Development, and the Templeton World Charity Foundation, among others.

Dr. Shiv Agrawal elected Chair of Scientific Program Committee

ICARDA's Lentil Breeder, Dr. Shiv Kumar Agrawal, was elected as Chair of the Scientific Program Committee of International Food Legume Research Conference. The conference and its committee aim to build global communication linkages to promote research collaboration and the interchange of scientific and technical information covering all aspects of research and development of cool-season food legumes.

ICARDA scientists nominated as special guest editors

In 2021, ICARDA's Legume Breeder, Dr. Fouad Maalouf, was nominated as a Special Guest Editor for the Multidisciplinary Digital Publishing Institute's special issue of Plants – an international, scientific, peer-reviewed, open access journal published semimonthly online – on legume genomics and breeding. The same year, Dr. Shiv Kumar Agrawal and Dr. Michael Baum were Special Guest Editors for a special issue of Frontiers in Plant Sciences titled 'Accelerating Genetic Gains in Pulses'.

Improved food legumes for India

Improved pulse technologies are being promoted in rice fallows and traditional areas in 14 districts of Odisha under the Odisha Pulse Mission Phase II. Incentivization of non-paddy crops such as red gram is also being promoted in 2,847 hectares of farmland in Odisha. In Madhya Pradesh, lentil technologies were upscaled in partnership with Jawaharlal Nehru Agricultural University and its six Agricultural Science Centers. Two varieties of lentil performed excellently for seed yield and disease resistance. Furthermore, a new cropping pattern, which includes the super-early lentil variety, Barimasur-9, in the new rice-lentil-rice pattern, is being recommended to intensify the rice system in Bangladesh, eastern India, and Nepal.

Date palm

ICARDA works across the Arabian Peninsula to improve date palm, an essential crop for the region, which produces 90 percent of the world's dates. Funded by the six member countries through the Secretariat General of the Gulf Cooperation Council (GCC), the project entitled 'Development of sustainable production systems for date palms in the Gulf Cooperation Council countries' aims to improve date palm production systems in GCC countries, employing modern technology to increase crop management, post-harvest date management, and market and value chain development.

Delivering ecological insights with eddy covariance systems

A major project milestone in 2021 was the introduction of eddy covariance systems for measurements of gas exchange between ecosystems and the atmosphere in the Kingdom of Saudi Arabia through the date palm project. These systems combine precision instruments, on-site flux computation, and powerful post-processing software into a single package to deliver ecosystem insights faster than ever before. The systems streamline the research process, empowering researchers of all experience levels. The systems are also linked to ultra-low drip irrigation to facilitate smart and water- and energy-saving irrigation for date palm and associated crops.

Participatory demonstrations promote water- and energy-saving practices

Another major aim of ICARDA in the Arabian Peninsula is to improve agricultural production systems and conserve natural resources affected by climate change through the development and demonstration of climate-smart technological packages. In 2021, ICARDA held participatory demonstrations of water- and energy-saving practices for smallholder farmers across six target countries. These practices included the use of solar energy, net houses, hydroponic irrigation, ultra-low-dripper pressure, and root zone cooling. The project is funded by the Arab Fund for Economic and Social Development (AFESD) and the Kuwait Fund for Arab Economic Development (KFAED).

Dr. Abdoul Aziz Niane appointed to Advisory Committee

Dr. Abdoul Aziz Niane was appointed as a member of the Advisory Committee for Research of the Abu Dhabi Food Safety Agency. The Agency is responsible for agriculture, food safety, food security, and biosecurity in the Emirate of Abu Dhabi.

Date palm project wins Khalifa Award

An ICARDA project, 'Development of Date Palm Production Systems in the Gulf Cooperation Council (GCC)

Countries,' won the prestigious 2021 Khalifa International Award for Date Palm and Agricultural Innovation. The project, funded by GCC, won in the second category, 'Pioneering Development and Productive Projects.'

Barley

Barley promotes food and feed security by increasing animal and crop output per unit area and providing food, feed, forage, and malt. It is the ultimate multipurpose crop in the Middle East and North Africa's drylands, with 3.3 million hectares planted primarily in Algeria, Morocco, and Tunisia. Barley is the sole and often the last choice for many traditional subsistence farmers to feed their cattle, especially during dry years. Even when conditions are ideal, turning a profit on barley is difficult. By the end of the century, climate change is anticipated to cut rainfall by up to 50 percent and raise temperatures by up to 4 degrees Celsius in the region. As a result, new technologies must be developed and deployed to boost production per unit area in the face of climate change.

The ICARDA Global Barley Breeding program led by Dr. Miguel Sanchez-Garcia has developed new barley genotypes, producing at least 10 percent more grain and straw under severe drought conditions than conventional varieties. New wild relative-derived genotypes with consistently higher beta-glucan content for increased nutritional value have also been developed, with new genotypes producing 30 percent more forage production than conventional varieties. A total of 180 new elite barley genotypes have been distributed to 36 collaborators in 19 countries upon demand. The program receives funds from the CGIAR Research Program on Livestock, the Arab Fund for Economic and Social Development (AFESD), the Crop Diversity Trust, and the Chinese Academy of Agricultural Sciences.

Special nurseries shared with collaborators in Ethiopia and United Arab Emirates

Two special nurseries targeting feed barley were shared with collaborators in United Arab Emirates in 2021. The first consisted of 100 new elite genotypes to be tested as an observation nursery under local conditions. The best lines from this will be selected and promoted for further testing. The second nursery consisted of 1 kilogram of seven elite feed genotypes and has been tested in farmer fields.

2021 also saw two new special nurseries, one targeting food and fodder barley and another one targeting malt

and fodder barley, shared with barley breeders from the Ethiopian Institute of Agricultural Research. The 300 elite lines in these nurseries were tested in the field and more than 100 were promoted to be tested at larger scale.

Shared trials of new barley lines in Algeria, Morocco, and Tunisia

2021 saw the first shared trial of the Maghreb-ICARDA Barley Initiative, a joint venture between ICARDA's barley breeding programs in Algeria, Libya, Morocco, and Tunisia, to assemble, share, and test one common yield trial representing a shared product profile. With the support of the CGIAR Research Program on Livestock, 24 new ICARDA elite lines from the Feed for Arid and Semi-Arid Areas Mega Product Line – targeting the environmental and socioeconomic conditions as well as the local farmers' needs of the arid areas of the Maghreb – were tested in nine locations in Algeria, Morocco, and Tunisia. The results showed superior yield and straw production in the new tested lines compared to the commercial checks. Breeders in the target countries have already started promoting the best lines to the National Variety Trials program.

Diversification of wheat-based cropping in the Ethiopia highlands

Due to the low productivity of major cool-season cereals and food legumes, smallholder farmers in Ethiopia are increasingly abandoning traditional practices of high crop diversity in favor of growing more bread wheat. Increased wheat monocropping lowers soil fertility, increases the risk of disease epidemics, and reduces the dietary diversity of farmers. ICARDA, in partnership with the Africa RISING project, funded by the United States Agency for International Development (USAID), has diversified the wheat-based system in four intervention zones, releasing wheat, barley, and food legume varieties. Once validated, the seeds of these farmer-selected cultivars have been produced through community seed production schemes involving individual farmers and seed producing unions. In the 2020/2021 cropping season, 161 male and female farmers and seed growers in nine districts produced 349 tons of wheat, barley and faba bean seeds. The certified seeds will be exchanged and sold to other farmers and will contribute to alleviating seed shortages in the intervention areas.

CAPACITY DEVELOPMENT IN DETAIL

When delivering dryland farming system innovations, ICARDA's Capacity Development team, led by Dr. Charles Kleinermann, ensures the inclusion of vital capacity-building component of training, technology, and support. Family farmers, scientists, governments, research institutions, and private sector actors, among others, can then take full advantage of our technologies to help overcome the critical issues they face, especially under a climate crisis.

Training tomorrow's experts

In 2021, ICARDA held a series of interactive webinars in collaboration with the International Center for Advanced Agronomic Studies and other institutions such as the Food and Agriculture Organization of the United Nations (FAO), the Arab Fund for Economic and Social Development (AFESD), World Bank, Friends of Europe, Mo Foundation, Agropolis Foundation, as well as national partners to engage young scientists in the value and function of systems research to support the transformation of dryland agri-food systems. Over 400 participants registered for each webinar.

Additionally, through the continued annual funding support of AFESD, ICARDA was able to offer multiple series of training courses and PhD and MSc opportunities, and individual non-degree training for mid-career professionals targeting Arab nationals. A total of 4,168 trainees attended. Of 3,248 trainees enrolled in group courses, 1,849 were women (60%). Eighty-three students (43 PhD and 40 MSc) were enrolled in degree training, of which 60 were women (72%). A total of 16 scientists were enrolled in non-degree individual training, of which ten were women (62.5%).

Research data management

The Monitoring, Evaluation and Learning (MEL) team led by Enrico Bonaiuti, supported learning around Research Data Management (RDM) and documented the importance of strong support and suitable tools to help develop RDM commitments. Without such knowledge and understanding, policy conflicts, unclear data standards, and multi-platform sharing can lead instead to unexpected engagement conflicts within databases.

Our Data Management team worked on 34 datasets, completing the curation and publication of 17 of them by the end of 2021. The datasets relate to Egypt, Jordan, Kazakhstan, Kyrgyzstan, Syria, Tajikistan, Tunisia, and Uzbekistan. They cover a range of topics, such as crop and livestock improvement, genomic data, capacity development, and the impact of COVID-19 on agricultural activities.

Field days at Marchouch station, Morocco

In 2021, ICARDA's Genetic Resources (GRS) team organized four field days at Marchouch station in Morocco that attracted over 200 attendees, including breeders, major seed multiplication companies, and lead farmers. These field days gave attendees the opportunity to select the best elite lines, view demonstration trials of new lines of cereals, food legumes, and bread wheat, and to learn about conservation agriculture and the diversification of cropping systems.

New training course on date palm value chain analysis, management, and market linkages

A new e-learning course, 'Date Palm Value Chain Analysis, Management, and Market Linkages in the Gulf Cooperation Council (GCC) Countries,' was produced in 2021. Funded by the GCC, the course is designed to enhance capacity development of the Arabian Peninsula government officials and researchers who are engaged in the socioeconomic component of the date palm project, 'Developing Sustainable Production Systems for Date Palm in GCC Countries.' Twenty-three professionally-trained National Agriculture Research Systems partners from Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and United Arab Emirates, including five women, took part in the course, together with two participants from Egypt and Jordan.

Other free e-learning courses

ICARDA's E-Learning Platform continues to offer over 85 courses addressing various agricultural topics and the United Nations Sustainable Development Goals (SDGs). Most of the courses are in English, but French, Arabic, and Spanish classes have also been made available. Registration for these courses is free.

Training in modern protected agricultural practices in the Arabian Peninsula

In December 2021, ICARDA and the Central Laboratory for Agriculture Climate of Egypt's Agricultural Research Center (ARC) jointly organized a workshop on modern horticulture practices for the Arabian Peninsula partner countries in Egypt. The workshop took place within the framework of the Arabian Peninsula Regional Program and was funded by the Arab Fund for Economic and Social Development (AFESD) and the Kuwait Fund for Arab Economic Development (KFAED). The workshop was led by several experts and researchers from ICARDA and ARC and was attended by researchers and extension agents from five of the six Gulf Cooperation Council (GCC) member countries, and Yemen. The discussions involved protected agriculture practices, such as greenhouses and hydroponics, which substantially reduce water usage and provide a better and higher yield.

Knowledge management communities of practice and capacity development activities

The International Fund for Agricultural Development (IFAD) SKiM Project, implemented by ICARDA, strengthened the capacity of 40 (25 male and 15 female) representatives from national institutions in Moldova, Morocco, and Sudan in 2021. In line with needs identified in a consultative Capacity Needs Assessment and Innovation Plans, 29 participants benefited from the Republic of Moldova Learning Route (19 male and ten female), and 15 benefited from the Knowledge and Innovation Transfer through Technology Transfer Offices (TTOs) (ten male and five female) participants, in line with their knowledge management needs identified through the project. In this regard, the communities of practice on knowledge management established by SKiM in Moldova, Morocco, and Sudan strengthened resilience throughout the COVID-19 pandemic, with stakeholders engaged in knowledge sharing activities at the national and international levels.

GENDER IN DETAIL

Together with other CGIAR Centers, ICARDA is increasing its support for women as more men relocate to cities and more studies are conducted on gender inequalities and the potential of women in agriculture. We emphasize research that improves women's access to land, water, seeds, credit, knowledge, and innovation. Our work empowers women via capacity building that allows them to be more effective leaders and change agents. Through agricultural diversification, intensification, and value addition, we also help them engage in more lucrative economic pursuits. We push for better pay and working conditions and the elimination of gender inequity. We also look at potential formal and informal institutional structures that strengthen women's voices and influence in dryland communities and promote proven agricultural technology.

AI-driven beekeeping for women

The Monitoring, Evaluation and Learning (MEL) team led by Enrico Bonaiuti nurtured a partnership between ICARDA, the Lebanese Agricultural Research Institute, and the beekeeping data company HiveTracks, under the project 'AI-Driven Climate-Smart Beekeeping for Women Advisory and Extension' led by Laura Becker and funded by the German Agency for International Cooperation (GIZ). The initiative aims to improve beekeeper hive monitoring and management, increase the economic activities of women beekeepers, and allow beekeeping experts and extension workers to remotely manage beekeeping practices and bee health. This project will adapt and launch a hive management app for beekeepers in Lebanon, focusing on women, and will develop a new web application for extension workers and researchers that enables improved engagement with

beekeepers and monitoring of bee health. To localize and pilot this app in Ethiopia and Uzbekistan, ICARDA has received funds from the German Federal Foreign Office and is partnering with the International Centre of Insect Physiology and Ecology, the Holeta Bee Research Centre, and HiveTracks.

Migration-induced feminization in the dry areas

In 2021, ICARDA's Dr. Dina Najjar from the Social, Economic, and Policy Research (SEPR) team contributed an evidence explainer to the CGIAR Gender Platform. The explainer discusses how the increasing migration of people out of the world's dryland areas affects women's roles in agriculture and related activities, in particular their productivity and gender equity. It also encourages social and economic policy interventions to leverage the increasing participation of women in dryland agriculture and improve women's livelihoods.

User-friendly seed spreaders for Tunisian female farmers

To help Tunisian female farmers, three ICARDA scientists – Drs. Mina Devkota, Zied Idoudi, and Dina Najjar – introduced a user-friendly and cost-effective innovation that saves time and reduces the number of seeds needed. The Handheld Precision Spreader (HPS) spreads seeds and fertilizers evenly, resulting in 20 percent higher biomass yields in forage crops than manual broadcasting. The HPS also allows farmers to spray chemical fertilizers without their skin being in contact with the product, reducing health concerns. ICARDA has imported and distributed 25 of the low-cost spreaders with national partners and provided technical guidance to farmers during the 2020-2021 cropping season. Farmers reported that the machine is easy to handle, reduces labor, and slashes costs by 40 percent – saving time spent on broadcasting. The development of the HPS was supported by the International Fund for Agricultural Development (IFAD), the Institut National de la Recherche Agronomique de Tunisie, and the Office d'Elevage et des Paturages Tunisie.

IMPROVING RURAL LIVELIHOODS IN DETAIL

ICARDA's Social, Economic, and Policy Research (SEPR) team, led by Dr. Barbara Ann Rischkowsky, is responsible for studying our innovations' socioeconomic feasibility, adoption, and scaling up, as well as their effect on poverty reduction, food security, system resilience, and social inclusion. The team's methods include socioeconomic assessments, gender transformational techniques, and context-sensitive targeting. Its solutions aim to achieve more equitable marketplaces and value chains, improved natural resource management and governance, and the optimization of sustainable land and livestock management alternatives.

ICT2Scale offers extension services to Tunisian farmers

ICARDA's ICT2Scale project, funded by the German Agency for International Cooperation (GIZ) and led by Mr. Udo Rudiger and Dr. Boubaker Dhehibi, uses cell phone-based services to offer extension services to smallholder farmers in Tunisia. In 2021, 50 percent of participating farmers learned new technologies and received further information, and 40 percent stated that they were willing to pay to receive technical information via SMS. ICARDA's national partners are now building on this work and making it their own.

Raised-bed technology benefits Egyptian wheat growers

In 2021, Egyptian wheat growers who adopted ICARDA's raised-bed technology through a project led by Dr. Beziat Dessalegn, benefited from a 937 kilogram per hectare (12.8 percent) increase in yield, a US$77.60 per hectare (9.5 percent) increase in gross margins, an 824.6 cubic meters per hectare (15.1 percent) reduction in irrigation water application, a 16.7 percent reduction in seeding rate, a 5.6 percent increase in water productivity, and an 11.8 percent reduction in downside yield risk.

Promoting permaculture for sustainable livelihoods in Jordan

The Jordanian Badia is the region of desert and steppe covering the country's northeast. In this challenging environment, Dr. Boubaker Dhehibi, in collaboration with Jordan's National Agricultural Research Center, implemented permaculture technology as a new low-cost development tool for managing dryland resources in ago-pastoral farming systems. The benefits associated with permaculture include high yields and increased savings from reduced inputs. Investing in permaculture could make dryland resources more efficient, diverse, and multifunctional for food and nutrition-insecure agro-pastoral communities.

Increased resilience for fragile states

Under a project entitled 'Services to support the seed multiplication sector in Syria for the season 2020/2021,' under the 'Food and Agriculture Organization of the United Nations (FAO) Syria Smallholder Support Programme (SSP) for Agriculture Transformation', smallholder farmers in areas affected by civil unrest were supported to become community-based seed suppliers. The farmers, from Aleppo, Homs, and Deir Azor were given quality wheat, barley, chickpea, and lentil seed to engage in farmer-based seed production. They were also provided with inputs, extension services, and training on community-based seed production and commercialization business management. They produced and commercialized a total of 244.4 tons of seed. They generated an income of SYP300,344,906 (US$240,280) under an Arab Fund for Economics and Social Development (AFESD)-funded project, 12.8 tons of seed of 47 crop varieties, and five seed cleaners were provided to support the seed sector in Lebanon.

In-situ water harvesting in Palestine

In Palestine, ICARDA partnered with the Food and Agriculture Organization of the United Nations (FAO) to test and out-scale in-situ water harvesting approaches. ICARDA will implement water productivity improvements at the watershed level and support the scaling of in-situ water harvesting for improved agroforestry and orchard agriculture. ICARDA will also support capacity building and empowerment activities for targeted communities.

Ultra-low-pressure drippers foster desert farming

In 2021, within the framework of the Arabian Peninsula Regional Program (APRP), led by Dr. Abdoul Aziz Niane and funded by the Arab Fund for Economic and Social Development (AFESD) and the Kuwait Fund for Arab Economic Development (KFAED), ICARDA distributed 10,000 ultra-low-pressure dripper units to six APRP member countries. The energy-saving, solar-power-compatible dripper technology fosters desert farming.

Technologies for African Agricultural Transformation at work in Ethiopia

In Ethiopia, the ICARDA-coordinated 'Technologies for African Agricultural Transformation (TAAT) Wheat Compact' produced a total of 27,543 tons of basic seed, certified seed, and quality declared seed in the 2020/2021 growing season. The seed was produced in partnership with the Ethiopian National Agriculture Research System, public/private seed companies, and cooperatives. TAAT Wheat Compact was funded by the African Development Bank.

Improved technology adopted by lentil growers in West Bengal, India

An economic impact assessment has found that ICARDA-improved lentil technologies have contributed significantly to a massive productivity gain in West Bengal, with a registered lentil yield of over 1 ton per hectare in the state, a 33.36 percent increase over traditional lentil growers. Overall livelihood status of the lentil farm-family has increased, and ICARDA has established long-term sustainability of food legumes in West Bengal.

ICARDA

ICARDA is a non-profit international organization undertaking research-for-development for innovative, science-based solutions that improve livelihoods in rural communities across dry regions. ICARDA's long history as the only CGIAR center headquartered in the non-tropical drylands means we possess a unique understanding of regional critical issues, and the scientific knowledge, country agreements, and research networks required to deliver resilient livelihoods to rural dryland farmers.
www.icarda.org

CGIAR

CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources and ecosystem services. Its research is carried out in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector.
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