How to Manage MENA Drylands in a Warning Climate:

Think Global, Act Local
Figure 1. Geographical distribution of dryland types based on the aridity index (AI). Source: within Mirzabaev, A. et al. 2019. Desertification. https://doi.org/10.1017/9781009157988.005
Why Do Dry Areas Matter?

Dry areas are inhabited by 30% of the world’s population (2.5 billion people), account for the majority of the world’s poor, with around 16% living in chronic poverty.

Dry areas lands have 8% of global renewable water resources with average per capita of less than 1,300 m³ annually.

Dry areas cover 47.2% of the world’s land surface, grow 44% of the world’s food, support 50% of the world’s livestock.

Dry areas lose 23 hectares per minute to drought and desertification.

A loss of 20 million tons of potential grain production every year costing developing countries 4.8% of gross national product each year.
The Drylands

Rainfed Farming
Water efficient & drought-resistant innovations reducing dependency on uncertain rainfall.

Irrigated Farming
All-season diversified cropping with land management, green energy, and water management

Desert Farming
More-per-drop crops/livestock approaches in a no-rain environment

Agrosilvopastoral farming
Rainwater harvesting, integrating crops, agroforestry, and livestock

NENA Agricultural Land (2.5 M km²)
17 %

More job per drop
22 %

More food per drop
58 %

Land Degradation Neutrality and Livelihood
3 %

Socio-ecological Resilience

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Dry areas expanding

Expanding Dry Areas*

- Dry areas (2000)
- Dry areas (2015)

* Including tropical and non-tropical dry areas

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Where We Work in The Non-Tropical Drylands
• Globally, over **833 million ha** area is affected by soil salinity and sodicity, which is **8.7% of the total land area**.
• This value may grow significantly in the coming years, exacerbated by climate change and unsustainable agricultural production practices.
• The map currently covers **73% of the global land area**.
Faster, widespread, intensifying

Climate change is hitting the planet faster than scientists originally thought.

A Major Report Warns Climate Change Is Accelerating And Humans Must Cut Emissions Now

August 9, 2021 - 4:00 AM ET

Climate Change Is Accelerating, Bringing World ‘Dangerously Close’ to Irreversible Change

The New York Times
Challenges in the Drylands

- Conflicts and Fragility
  - High unemployment, unrest and migration

- High Population
  - Demographic change, gender inequality

- Urbanization and heat islands

- Water Scarcity
  - High water scarcity and low efficiency

- Malnutrition
  - Food and nutrition insecurity

- Land Degradation
  - Land degradation and desertification

- Loss of Biodiversity
  - Loss of agrobiodiversity

- Climate change
  - Double impact of climate change; increasing temperature and reducing precipitation

The perfect storm

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AGRI-INNOVATION FOR RESILIENCE

Time is running out. Urgent action is needed.

Agroecosystems
Climate-smart food systems transformation
+ more sustainable production
+ more sustainable consumption
Increased conversation efforts

A powerful offer of the combined expertise, capacity and global science resources of Drylands CGIAR Research Centers

Collaborating for a systematic and collective strategic deployment of pioneering agri-science across global drylands

Prioritizing the interests and needs of our partners
The Global Dryland Strategy

- Create Climate-Optimized Farming and Diversified Agrifood Systems
- Conserve and utilize Biodiversity for Community and Ecosystem Resilience
- Manage Soil, Land, and Water Systems for Sustainable Production
- Ensure Access to Sustainable, Diverse, and Healthy Diets to Alleviate Hunger and Malnutrition.
- Translate Evidence-based Approaches into Policy for Development
1. Create Climate-Optimized Farming and Diversified Agrifood Systems

Dryland communities are on the frontline of climate change.

Our focus:
• Design climate-smart dryland farming systems for productivity and resilience.
• Diversify crops and livestock to bolster farm-level resilience.
• Prioritize breeding of crucial dryland crops and forages.
• Support optimal climate adaptation in livestock and aquaculture.
• Develop climate-resilient livestock feed technologies.
2. Conserve and Use Biodiversity for Community and Ecosystem Resilience

Dryland biodiversity for ecosystem health, resilience in agrifood systems, and combatting desertification.

Focus areas:
- Promote diverse and resilient forage and crop varieties tailored to local needs.
- Incentivize biodiversity conservation via value chain investments and supportive policies.
- Encourage agroforestry practices for soil stabilization, water regulation, and other benefits.
Managing natural capital sustainably for dryland agrifood systems' resilience

Focus areas:
• Promote conservation agriculture (CA) with diversified crops, drought-tolerant varieties, and water-efficient techniques, tailored to local conditions.
• Enhance sustainable water management for increased productivity, especially during scarcity.
• Improve soil health through conservation and regenerative practices, including land restoration.
4. Ensure Access to Sustainable, Diverse and Healthy Diets to Alleviate Hunger and Malnutrition

Access to nutritious food in drylands is crucial for children's development, particularly during the critical first 1,000 days of life. Focus areas:

• Promote diverse, nutrient-dense crops and animal-sourced foods.
• Encourage dietary shifts through education, market interventions, and policy incentives, with a focus on pregnant and lactating women and infants.
• Support agribusiness entrepreneurship in the private sector to develop healthy food products for both rural and urban consumers.
• Partner with humanitarian agencies to promote nutrient-rich foods and genetic innovations for resilience against climate change and other risks.
Drive transformation in drylands, translating research into policy is key at all levels.

Focus areas:
- Co-design inclusive policies and innovations with partners for sustainable development, including land tenure and resource governance.
- Conduct local policy dialogues to mitigate resource conflicts.
- Generate evidence for informed decision-making, enhancing technology adoption.
- Establish equitable agrifood systems for all stakeholders, prioritizing marginalized groups.
ICARDA plays a critical role in the conservation, development, improvement, and dissemination of climate-resilient, market-driven crop varieties that provide a crucial defence against extreme temperatures, water scarcity, the emergence of new pests and diseases, and nutritional insecurity.

Over the past four decades, ICARDA’s improved cereal and legume varieties have been tested and released by national programs in partnership with ICARDA and adopted by farmers worldwide, generating net benefits of approximately US$850 million each year.
Improving crops adapted to Target environment - Dry areas

- 35% of world agricultural land
- 2 billion People (27% world population)

<table>
<thead>
<tr>
<th>Agro-ecosystems</th>
<th>Area (m ha)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigated systems</td>
<td>312</td>
<td>17</td>
</tr>
<tr>
<td>Rainfed systems</td>
<td>512</td>
<td>22</td>
</tr>
<tr>
<td>Agropastoral systems</td>
<td>873</td>
<td>58</td>
</tr>
<tr>
<td>Desert farming</td>
<td>342</td>
<td>03</td>
</tr>
</tbody>
</table>

Rainfall:
- Faba bean: 450 mm
- Chickpea: 250 mm
- Lentils: 250 mm
- Grass pea: 100 mm
- Date Palm: 100 mm

Crops:
- Bread Wheat
- Durum Wheat
- Barley
- Chickpea
- Faba bean
- Lentils
- Grass pea
- Date Palm
- Cactus
ICARDA’s genebank system works alongside global networks to collect, conserve, and develop vital genetic resources to protect agrobiodiversity in dry regions.

ICARDA’s dry region genebank system was established in 1985 in Syria. It now rests in two genebanks in Morocco and Lebanon and contains around 150,000 samples of major winter cereals, food legumes, forage, and rangeland species drawn from four major Vavilovian centers of plant diversity.

The collection is safety duplicated in genebanks around the world including the Svalbard Vault in Norway.
ICARDA’s Genebank Collection

January 2012: ICARDA’s Collection in Aleppo ~142,000 accs.

Safe duplication of the Collection at the SGSV

September 2015: Retrieval of the Collection

29th September 2016: Inauguration of ICARDA’s Genebank facilities at Lebanon

September 2016: first samples deposited in ICARDA’s Genebank facilities at Morocco

18th May 2022: Inauguration of new ICARDA’s Genebank facilities at Morocco
Modernization of breeding

Use of speed breeding, genomic selection, data tools, and physiology

- It is widening the gap between CGIAR and NARES
- Need to train for success
Sustainable intensification (CWANA)

Established: G x E x M Experimentation in all countries

Crop Diversification: resilience and diversify the farm income

Climate smart mechanization & its value chain

- Supported soybean - mission of Egypt government
- Explored crop diversification option: Morocco Egypt: Crops: Sorghum, millet, mungbean, maize, soybean, quinoa, forages
- One supplemental irrigation: over 1 M ha Morocco can reduce wheat imports by 35% in drought year

1. Raised bed planters: >100,000 ha under mechanized raised beds in Egypt & expanding other countries, Sudan, Syria
2. Low-cost No-till seeder: supporting for 1 M hectare CA in Morocco

"The machine is amazing! It’s so easy to use and works really well. As a farmer, it’s a game-changer for me. Not only does it make my work more efficient, but it also helps me save on seeds and fertilizers."

- Tharwat Mohamed AbelAziz, Farmer
Integrated food, land, water and energy systems for climate resilient landscapes

Water Reuse Cost Benefit Analysis Methodology / MA

Water Accounting + Dashboard
MA – Sous Masa Watershed
LEBANON Terbol Research

Collection and Conservation & exchange of plant genetic resources (Gene Bank)

Plant breeding & crop improvement

Seed Health Testing & Field Inspection

Seed multiplication and dispatch of international nurseries to partners

Capacity Development & Training
MOU with MoA in Jordan signed on October 27th 1977. In 1989, ICARDA initiated the West Asia Regional Program Office in Amman to coordinate bilateral and regional activities. Major research activities:

- Conservation of genetic resources and crop improvement
- Small ruminants’ production and introduction of spineless cactus as a feed and food crop.
- Natural resource management: rangelands rehabilitation, grazing management, irrigation, water management and harvesting, dairy value chains and pollinators diversity
- Social and economic policy, capacity development, big data, and ICT tools.

**Recently Completed Projects (Donor)**
- Food Security Project (AFESD)
- Pollinator Diversity Project (BMU)
- ET Project (SIDA/FAO)
- WFP Feasibility Study

**ON-Going & NEW Projects (Donor)**
- Watershed Rehab in Badia (USFS/USDA)
- SOILS4MED Project (PRIMA)
- Water Scarcity Project (FAO/NL)
• **Long-standing Partnership** (began in 1979 through the Nile Valley Project, in conjunction with Sudan to deliver solutions for enhancing livelihoods and food security)

• **Strategic Hub in Regional Program** (Egypt plays a pivotal role in ICARDA’s decentralization strategy and serves as a thematic research location for sustainable intensification in irrigated systems).

• **Financial Collaboration** (Egypt is a contributing member of CGIAR due to its collaboration with ICARDA)
Major Objectives

- Represent ICARDA in South Asia and China to promote research for development activities
- Accelerating the development of climate-resilient germplasm of legumes and cereals
- Application of precision agriculture and climate-smart approaches for site-specific advisories
- Promoting spineless cactus as 5F crop for improving livelihood of small-scale farmers
- Delivering genetic gain in farmers' fields through demonstration and informal seed systems in rice-fallows
- Capacity development to strengthen research and human capacities

• 2014 – MP Govt allocated 71 ha land for 30 years on token-lease
• 2016 – Inauguration FLRP, Amlaha
• 2017 – UN Organization status
ICARDA-APRP Office was established in 1997. It is managed by a regional coordinator with a specialized team
(i) on-farm water use and irrigation management;
(ii) rangeland, irrigated forages, and livestock; and
(iii) protected agriculture

Program Partners

Bahrain: Ministry of Municipal Affairs and Agriculture
United Arab Emirates: Ministry of Climate Change and Environment
Kuwait: Public Authority for Agriculture Affairs and Fish Resources
Oman: Ministry of Agriculture, Fisheries & Water Resources
Qatar: Ministry of Municipal Affairs and Agriculture
Saudi Arabia: Ministry of Environment, Water, and Agriculture
Yemen: Ministry of Agriculture and Irrigation
Current donors: The Arab Fund for Economic and Social development (AFESD), The Kuwait Fund for Arab Economic Development (KFAED), & the Gulf Cooperation Council
Important research and technologies developed, implemented & transferred by the ICARDA-GCC DP project

- Successfully promoted the subsurface irrigation technology showed high potential in water saving and productivity. Successfully tested low-pressure drip irrigation & ultra-low pressure, solar-powered drippers.
- Introduced the Eddy Covariance tech for calculating real water requirements & rationing date palm irrigation in KSA, Oman and UAE.
- Optimized date Palm Liquid pollination technology and use of drones for pollination of date palms.
- Integrated Pest Management against major date palm pests particularly the Red Palm Weevil.
- Introduced artificial intelligence for monitoring & managing date palm pests (GeoAgro Mpro App).
- Developed the polycarbonate date drying chambers; widely adopted by date farmers in the GCC.
- Developed multi-purpose polycarbonate chambers for drying dates and raising vegetable seedlings.
- Developed the solar operated mobile date dryer.
- Studied the diversity of 190 date palm cultivars collected from the GCC countries using 19 SSR primers.
- Atlas of the popular date palm varieties in the GCC based on a genetic fingerprint and morphological studies.
- Developed and launched an application for calculating the economic feasibility of date palm cultivation projects in the GCC region.

In 2021, ICARDA won the prestigious Khalifa International Award for Date Palm and Agricultural Innovation, in the category ‘Pioneering Development and Productive Projects.’
Thermal Imaging-based Irrigation Scheduling

- This approach is based on leaves/air temperature difference ($\Delta T$).
- In Egypt, thermal imaging proved reliability for detecting water stress, instant measurement of leaf relative/soil water content, and precision irrigation in new reclaimed lands.

$\Delta T$ threshold to start irrigation: for leaves, a threshold is recommended by Shahin & Farghali, 2015, $T_{water} = 0.5$ °C.
PATHWAY FOR SCALING APPROPRIATE MECHANIZATION (AM) FOR CWANA

Morocco Use case:
Promote CA for 1 Million Ha
Under national plan 2021-2030
TUNISIA – ICARDA’S APPROACH FOR CROP-LIVESTOCK INTEGRATION AT FARM AND LANDSCAPE LEVELS IN TUNISIA

1. Mulching
   - To increase soil water reserves and an entry point for smart agricultural practices

2. Herd-Health Management
   - Improving animal health, reproductive and herd management for profitable livestock

3. Household Promotion of Forage Production
   - (Strategic forage mixtures, legumes inclusion) and their use at critical stages of the physiology of small ruminants (precision feeding)

4. Sustainable Communal Grazing Systems
   - Enriching the communal grazing land through minimum soil disturbance and locally adapted pastoral plants

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Small-Scale Mechanization for Better Crop-Livestock Integration
Seed system support: Sudan

Technologies for African Agricultural Transformation (TAAT)
• 60,000 tons of new heat tolerant bread wheat cultivars seeds produced
• Yield has increased from 2.1 t/ha in 2014 to 3.5 in 2020
Objectives of the site:

- Former HQ of ICARDA for 35 years
- Tel Hadya farm is the largest ICARDA operated farm
- Activities in the country financed mainly by Syrian contribution due to sanction by US and EU.
- Rehabilitation of the farm and buildings under way with limited resources by Syrian Government, and it is managed now to re-establish the crop rotation and some seed multiplications.
INTEGRATED DESERT FARMING INNOVATION PROGRAM

A cross center program to address a cross sector issues in transformative and resilient agriculture circularity-based food system
“The Integrated Desert Farming Innovation Platform will improve the use of natural resources such as wind and solar power for a food and nutrition secure region. This event is crucial to discuss and expand on these aspects.”

H.E. Mariam bint Mohammed Saeed Hareb Almheiri, Minister of Climate Change and Environment, UAE.
Economic losses

Annual cost of RPW control programs in 2022 (in million USD$)

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost (in million USD$)</th>
</tr>
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<tbody>
<tr>
<td>Saudi Arabia</td>
<td>34.4</td>
</tr>
<tr>
<td>Egypt</td>
<td>5.7</td>
</tr>
</tbody>
</table>

The value of lost date palm trees and forgone revenues in 2022 (in million USD$)

<table>
<thead>
<tr>
<th>Country</th>
<th>Value (in million USD$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>213</td>
</tr>
<tr>
<td>Saudi Arabia</td>
<td>401</td>
</tr>
</tbody>
</table>

Source: (FAO, 2023)
(Modified from Boubaker et al. 2024)
Synchronized evapotranspiration and water discharge through solar energy-powered ultra-low-pressure drippers in date palm plantation compared to conventional irrigation.

Eddy Covariance

ENHANCING DATE PALM IRRIGATION EFFICIENCY
Solar Energy Powered Net-House with Root Zone Cooling Hydroponic System

Benefits

• Extending production until mid-June without quantitative and qualitative yield penalties
• Water productivity reached 37kg/m³ compared to 8 kg/m³ in a cooled greenhouse.
• 14% increase in net return and a 28% reduction in the cost of production
• Saving 6650-kWh electricity, equivalent to 4.7 metric tons of CO₂ sequestration.
Ultra-Low Energy drippers have an activation pressure of 0.15 bar, which require 85% less pressure, 50% less overall system pumping power than existing products and lowers the GHG emissions by 64% compared to diesel pumps and capital cost of a solar-powered drip irrigation system by 42%.
NEXT GENERATION: INTEGRATED DESERT FARMING SYSTEMS

- Transform desert agriculture in the global drylands into highly productive food systems
- Accelerate agricultural innovations along field-to-fork value chains
- Handheld devices for on-the-spot diagnostics of agriculture heath
- Carbon farming
- Plant-based alternative proteins
- Green energy solutions
  - Agrivoltaics
  - Solar desalination using electrodialysis technology
  - Solar drip irrigation using ULE drip technology
  - Solar hydroponics and root zone cooling
ICARDA’s flagship GeoAgro Platform can:

- Forecast weather
- Do yield gap analysis
- Forecast probability of disease outbreaks
- Improve modeling and climate change patterns
Integrated Aquaponics Systems

Image modified from source: https://ag.purdue.edu
Smart Farming and technologies

More accuracy monitoring by sensors technology and fast-tracking

Machine learning technology and robots

Databases and professional analysis

Phone – customer services

TV channel for expertise

Disease early alarming and prediction

Social media for knowledge sharing

Extension and advisory

Satellite imagining, weather

Agricultural market, crop selection
Grain yield of wheat under different management system

- Rainfed potential: long-term situation (1985-2022);
- Average yield under conservation agriculture & conventional tillage systems 7 years average (2015-2022)
- National average yield (1985 – 2022) FAOSTAT

1. Rainfed potential yield: 5.4 t/ha
2. Yield with best management practices with CA: 4.32 t/ha
4. Yield with best management practices with CT: 3.4 t ha\(^{-1}\)
5. Average yield under farmer condition: 1.45 t/ha

Attainable yield gaps: 1.95 t/ha