

## **Megaproject 1: Management of Scarce Water Resources and Mitigation of Drought in Dry Areas**

### **Rationale**

By definition, the dry areas are regions of water scarcity. Renewable water resources are limited and rainfall is highly variable and unpredictable, both spatially and temporally, increasing the risks and uncertainty involved in agricultural production. This short-term climatic variability is likely to be exacerbated by longer-term climate change. Most climate change models predict that the dry areas of CWANA will become much hotter and drier with changes in seasonal and spatial distribution of precipitation and increasing incidence and magnitude of extreme weather events (droughts and floods). Countries with predominantly rural economies and high dependence on dryland agriculture will be at most risk as they are highly vulnerable to shifts in seasonal climatic patterns.

The dry areas' share of the world's fresh water resources is very small. The Central and West Asia and North Africa (CWANA) region, in particular, is unparalleled in the extent of its water poverty: per capita water supplies are the lowest in the world with 15 countries already below the water "poverty line" of < 1,000 m<sup>3</sup>/capita/year. Over 75% of available water in the dry areas is used for agriculture, but competition for the limited water resources in the dry areas is increasing with domestic and commercial demand reinforced by high population growth rates, improvements in living conditions, and changing expectations, depriving agriculture of substantial amounts. Inevitably, there will be new water allocation between sectors, and water currently available to agriculture is likely to decrease further. In North Africa it is estimated that by 2050 only some 50% of water will be available for agriculture.

The need to improve water use in agriculture is not only vital for agricultural productivity but also for ecosystems health in dry areas, some of which also include important wetland biodiversity reserves.

Opportunities for expanding cultivated rainfed or irrigated lands in CWANA are minimal. Sustainable increases in food supplies must come from increased productivity of both rainfed and irrigated agriculture. A limited quantity of additional water supplies is available by developing marginal quality water and through desalinization, but costs and environmental concerns limit the use of these resources. Consequently, the only option available to support agricultural production is to increase the productivity of water by, as stated by the UN Secretary General, producing "more crop per drop".

Despite the scarcity of water, current water use in agriculture in the dry areas is highly inefficient. ICARDA's research shows that in strategic crops, water productivity can be doubled if appropriate measures are taken. These include the adoption of improved technologies, modification of policies related to water allocation and use, and the establishment of enabling institutions.

Irrigated areas in CWANA constitute only 6% of the region's arable land (FAO Statistics 2005) but are of immense importance to national production. Water saving in irrigated agriculture includes two components: (i) reducing water losses at the farm level by improving irrigation efficiencies; and (ii) increasing water productivity at the farm level, field and basin levels through improved water, soil and crop management practices.

Research is also underway on developing strategies and best practices for the safe, sustainable use of marginal water (brackish water and treated effluent) in irrigation, and for the conservation and sustainable utilization of renewable groundwater resources.

Under conditions of increasing water scarcity, the key to sustaining rural livelihoods is improving the productivity and reliability of rainfed agriculture by (i) using limited rainfall more productively, through optimal on-farm soil, water and crop management practices that conserve soil moisture and increase water use efficiency, and (ii) using precipitation more effectively, for example, by conserving and augmenting water supplies through rainwater harvesting.

Through controlled concentration of runoff into target areas, water harvesting increases water availability and controls soil erosion, and can provide a buffer against drought. Water harvesting is not new — various indigenous systems of water harvesting have been developed and used for centuries throughout the CWANA region, but changing socio-economic factors have led to a decline in their

maintenance and use. Examples of water harvesting systems include small basin micro catchments, small and low-cost farm reservoirs used to store and release runoff water several times over the season. Larger structures that store run-off from a large catchment area can be used to support agricultural intensification and higher value crops. At the larger scale, methodologies have been developed for using remote sensing combined with ground information in a GIS framework to identify suitable areas and appropriate methods for water harvesting.

Rainfed production can also be enhanced through the strategic use of sources of renewable water to augment essentially rainfed production. Supplemental irrigation is the application of a limited amount of water to rainfed crops. The additional water is applied only when rainfall fails to provide the moisture essential for normal crop growth.

The water research program at ICARDA continues to evolve in response to global and regional structural and socioeconomic changes, particularly with regard to water scarcity and food security, and in light of the expressed priorities of ICARDA's NARS partners.

The recent restructuring of ICARDA's research program includes the following major shifts from the original water research program:

- (a) MP1 continues research on the strategic issue of sustainably increasing water productivity but has expanded its scope from the farm to the basin level. Strategic partnerships within the CP Water and Food have been established to achieve this.
- (b) Increased emphasis is given to the assessment of scarce water resources and their sustainable allocation to various uses, including both fresh and marginal quality water sources.
- (c) MP1 now incorporates research on drought preparedness and mitigation of drought through the optimal management of water resources and use of adapted crops and crop varieties and appropriate cropping patterns.
- (d) Greater emphasis is given to the dissemination of improved options through integrated and multidisciplinary research and the use of participatory research approaches at the community level at selected benchmark sites.

The new project is fully compatible with ICARDA's mission to promote productive agriculture while preserving and enhancing the resource base, the CGIAR vision developed at Lucerne and TAC's 1995 "*Priorities and Strategies for Soil and Water Aspects of Natural Resource Management Research in the CGIAR*". It is also compatible with the new 2005 CGIAR Science Council research priorities, particularly System Priority 4 on 'Sustainable and equitable management and intensification of water and land resources'.

### **Target Eco-region**

The project targets non-tropical dry areas globally, with a geographic focus on the Central and West Asia, North Africa and Nile Valley regions. Three agro-ecosystems are targeted in the dry areas: the rainfed agriculture, the marginal areas and fully irrigated systems. These are addressed through research at selected representative benchmark sites for each of the three agro-ecosystems, the results of which are then disseminated through out-scaling to agroecologically similar areas in the region.

### **Project Description**

The project goal, purpose, outputs, output targets and associated expected outcomes and impacts are provided in the attached "Project Impact Pathway" matrix. Assumptions and external conditions associated with outputs, outcomes and impacts are listed in the introduction to the Project Portfolio.

Major elements of MP1 comprise:

- Assessment of the quantity and quality of available water resources (including rain water, surface and ground water sources, and marginal water sources), and of their use at the plant, field, farm and basin levels.

- Development of options for improving the productivity of water, including supplemental irrigation, water harvesting, improved on-farm irrigation management, and agronomic management of cropping systems.
- Characterization of drought and development of strategies both socioeconomic and bio-agricultural for mitigating drought, including water resource management and drought tolerant and water-use efficient germplasm (utilizing outputs from MP2).
- Valuation of scarce water resources and policy and institutional research with a view to creating an enabling environment that supports the dissemination and adoption of water efficient technologies and drought mitigating practices.
- Institutional strengthening and capacity building.

The work on water permeates the whole ICARDA agenda, thus, in addition to the work noted above, MP1 has critical intra-Center linkages as follows:

- Research on drought mitigation is conducted in partnership with research in MP2 (integrated gene management) on developing drought tolerant germplasm.
- Agroecological characterization for out-scaling of results is undertaken with ICARDA's GIS unit.
- Research on water harvesting and watershed management in the marginal dry areas is conducted together with MP3 (combatting desertification).
- Research on cropping system management for water use efficiency links with MP4 (crop and livestock production systems).
- Research on the socio-economics of water use, policies and institutions is conducted in partnership with MP5 (poverty and livelihoods analysis)
- Results from MP1 research are up-scaled and out-scaled through MP6 (knowledge management and dissemination).

### **Users and Beneficiaries**

*Users:* The main users are national researchers, technicians, extension workers, policy-makers and others concerned with water issues. Regional and international organizations and development agencies can also benefit from the improved technological, institutional and policy options. Users also include the farm households and communities participating in pilot projects and benchmark sites who will directly use research outputs.

*Beneficiaries:* The ultimate beneficiaries are farm households and communities in rainfed and irrigated areas and in marginal lands in dry areas.

### **Collaborators**

- *National Programs:* National research and extension programs in:
  - Central Asia: Uzbekistan, Tajikistan, Turkmenistan, Kazakhstan, Kyrgyzstan and Azerbaijan;
  - West Asia: Iran, Iraq, Syria, Jordan, Pakistan, Saudi Arabia, and Yemen;
  - North Africa: Algeria, Egypt, Libya, Morocco and Tunisia;
  - Sub-Saharan Africa: Eritrea, Ethiopia and Sudan; and
  - South Asia: Pakistan.

Other national collaborators include river basin national agencies involved in the CGIAR Challenge Program on Water and Food.

- *International and Regional Organizations:* ACSAD (Arab Center for the Studies of Arid Zones and Dry Lands), ESCWA (UN Economic and Social Commission for West Asia), FAO, ICBA (International Center for Biosaline Agriculture), UNESCO, and UNEP.

- ICARDA is a member of the World Water Council and the Arab Water Council.
- *Advanced Research Institutes*: CIHEAM (International Centre for Advanced Mediterranean Agronomic Studies) in Bari, Italy, and Zaragoza, Spain; INRA (Institut National de la Recherche Agronomique), France.
- *Advanced Research Institutes — Universities*: University of California Davis, University of Delaware and Purdue University, USA; Karlsruhe University and Bonn University, Germany; Wageningen University and Research Center, Netherlands; and United Nations University.

### **System Linkages**

- ICARDA and IWMI share a joint appointment in marginal water management and are cooperating within projects in Central Asia.
- ICARDA is participating in the **Challenge Program on Water and Food**, through three projects:
  - *Improving On-farm Agricultural Water Productivity in the Karkheh River Basin* (with IWMI).
  - *Strengthening Livelihood Resilience in Upper Catchments of Dry Areas by Integrated Natural Resources Management* (with CIAT).
  - *Improving Water Productivity of Cereals and Food Legumes in the Atbara River Basin of Eritrea* (with CIAT).

The contribution of the project to the CP on Water and Food is indicated in the attached impact pathway matrix.

- **Systemwide Programmes and other CG Consortia**
  - The project is partner in the comprehensive assessment of water management, led by IWMI. ICARDA serves on the Steering Committee of the initiative and leads the implementation of the program in CWANA.
  - ICARDA participates in the Ecoregional Program for Central Asia and the Caucasus (*see separate narrative attached*).

## MTP 2006–2008: Project Impact Pathway

<b>Project</b>	<b>MP1: Management of Scarce Water Resources and Mitigation of Drought in Dry Areas</b>
<b>Goal</b>	Improved management of scarce water resources and mitigation of drought to increase sustainable agricultural production in dry areas
<b>Purpose</b>	Increased agricultural production in dry areas through efficient and sustainable use of scarce water resources and mitigation of drought

	<b>Outputs</b>	<b>Intended Users</b>	<b>Outcomes</b>	<b>Impact</b>
<b>OUTPUT 1</b>	Assessment of available water resources, including precipitation, surface water, ground water and marginal water, and the productivity, benefits and costs at different scales (plant, field, farm, and basin) of their use in agriculture in the dry areas			
<b>Output Targets 2006</b>	Potential areas for the adoption of water harvesting and supplemental irrigation practices in West Asia and North Africa (WANA), and the consequences for productivity and environment, assessed in Tunisia and Syria  Assessment methodologies provided to NARS in WANA	NARS researchers and national development agencies in WANA	NARS use the methodology and the maps for planning interventions in water harvesting and supplemental irrigation	Improved productivity of rain water results in increased farm incomes and improved livelihoods
<b>Output Targets 2007</b>	Current and future quantity and quality of water resources available for agriculture in the dry areas determined and constraints to improved allocations identified in the project benchmark sites in Morocco, Egypt, Jordan and Iran ( <i>CP Water and Food</i> )	NARS decision-makers and national and international research and development agencies in water scarce countries in the dry areas	Information used to plan water resource projects and allocation to various sectors	Improved allocation of water resources to more efficient use reduces conflicts and improves livelihoods
<b>Output Targets 2008</b>	Agricultural water productivity in the river basins of Karkheh, Euphrates and Amudaria determined and methodologies developed ( <i>CP Water and Food</i> )	NARS researchers and decision-makers; CGIAR center partners.	Methodology for water productivity assessment used in the river basins of the <i>CP Water and Food</i> and by NARS globally. Results used by NARS to overcome low water productivity	Factors affecting improved water productivity at the basin level understood by specialists and means to improve it developed and adopted by NARS  Overall water productivity in benchmark basins improved

	Outputs	Intended Users	Outcomes	Impact
<b>OUTPUT 2</b>	Options and strategies for improved water productivity of rain, irrigation and marginal quality waters in rainfed and irrigated systems through water harvesting, supplemental irrigation, agro management, and improved germplasm and cropping systems			
<b>Output Targets 2006</b>	Water use efficient packages for improved rainfed, irrigated and marginal agricultural systems developed in benchmark sites in Morocco, Egypt, Jordan and Iran ( <i>CP Water and Food</i> )	Communities and policy-makers in the water benchmark sites of Morocco, Egypt, Jordan and Iran	Adoption of improved packages in the benchmark sites	Higher water productivity and improved farm incomes
<b>Output Targets 2007</b>	Methodologies and tools developed and verified for scaling out results from project benchmark sites on improved water productivity to other countries in the dry areas	NARS researchers and development agencies	Technologies and improved packages transferred to appropriate locations and environments	Water productivity improvement outside project benchmark sites reflected in improved farm incomes and livelihoods
<b>Output Targets 2008</b>	Options for sustainable use of saline and treated sewage water in agriculture developed in dry areas of CWANA region ( <i>in collaboration with IWMI</i> )	NARS and farmers of salinity affected areas	Salinity tolerant crops, varieties and management options for the use of low quality water adopted in pilot areas in Central Asia and Egypt	Higher productivity and healthier environment in areas where low quality water is used
<b>OUTPUT 3</b>	Methods, options and strategies for drought characterization, preparedness and mitigation in the dry areas			
<b>Output Targets 2006</b>	GIS-based methodology for mapping drought and dry spells developed	CGIAR and NARS specialists	Strategies for drought preparedness and management adopted	Farmers vulnerability to drought in drought prone areas reduced
	Ten drought tolerant barley, bread and durum wheat and legumes lines identified and crop management options evaluated with NARS	NARS	Popularization of improved drought tolerant options Communities within the project benchmark sites adopt drought tolerant varieties	Livelihoods of poor farmers in drought prone areas improved
<b>Output Targets 2007</b>	Network on drought management established and functioning	National, regional and international organizations in the dry areas	Information exchange between member countries; harmonization of methodologies and approaches; strengthened human and institutional capacities	Enhanced regional cooperation in planning and implementing drought preparedness and mitigation programs

	<b>Outputs</b>	<b>Intended Users</b>	<b>Outcomes</b>	<b>Impact</b>
<b>Output Targets 2008</b>	Assessment of existing strategies, measures and policies (including indigenous knowledge and practices) for drought preparedness and mitigation	NARS and policy-makers	Constraints to improved drought management strategies identified and measures taken to alleviate them	Communities in drought affected areas are better prepared and less vulnerable to drought
	Options for drought mitigation and preparedness in selected countries developed	Policy-makers, NARS, environmental agencies and extension services in member countries of the drought network	National agencies develop mitigation plans based on these options and integrate them in national drought measures	Reduced vulnerability of the poor to drought events
<b>OUTPUT 4</b>	Policy and institutional options for improved water use and irrigation demand management			
<b>Output Targets 2006</b>	Policy and institutional constraints to the adoption of improved supplemental irrigation, water harvesting and full irrigation identified ( <i>CP Water and Food</i> )	NARS and policy-makers in Morocco, Egypt, Jordan and Iran	NARS take measures to revise water policies and build better institutions in targeted areas	More rational use of water in agriculture
<b>Output Targets 2007</b>	Methodologies for the valuation of scarce water developed and guidelines and recommendations for valuation by NARS in the project benchmark sites documented and disseminated	CGIAR and NARS researchers	Improved water valuation by NARS and CGIAR researchers in water scarce regions	Limited water is better allocated based on its value in agricultural and other sectors Improved productivity of scarce water resources
<b>Output Targets 2008</b>	Alternative policy and institutional options for improved water demand management developed and communicated to NARS and policy-makers	NARS and policy-makers	Policy and institutional options adopted in target areas	More sustainable and productive use of water in target environments
<b>OUTPUT 5</b>	Enhanced human capacity to improve water use in agriculture in dry areas			
<b>Output Targets 2006</b>	25 NARS specialists trained in improving water use efficacy in rainfed areas	NARS researchers and extensionists	NARS conduct appropriate research and transfer technologies more effectively	More productive water use by farmers in rainfed areas
	20 NARS specialists acquire skills in drought management and developing national strategies to cope with drought	NARS and environmental agency decision-makers	Greater awareness of drought mitigation requirements; development of national strategies to cope with drought	Drought management strategies implemented in participating countries
<b>Output Targets 2007</b>	25 NARS specialists trained in improving water use efficacy in marginal areas	NARS researchers and extensionists	NARS conduct appropriate research in marginal areas and transfer technologies more effectively	More productive water use by farmers in marginal areas
<b>Output Targets 2008</b>	25 NARS specialists acquire skills in drought preparedness and mitigation	NARS researchers and policy-makers	NARS conduct appropriate research and transfer technologies more effectively	Reduced vulnerability of rural communities to drought