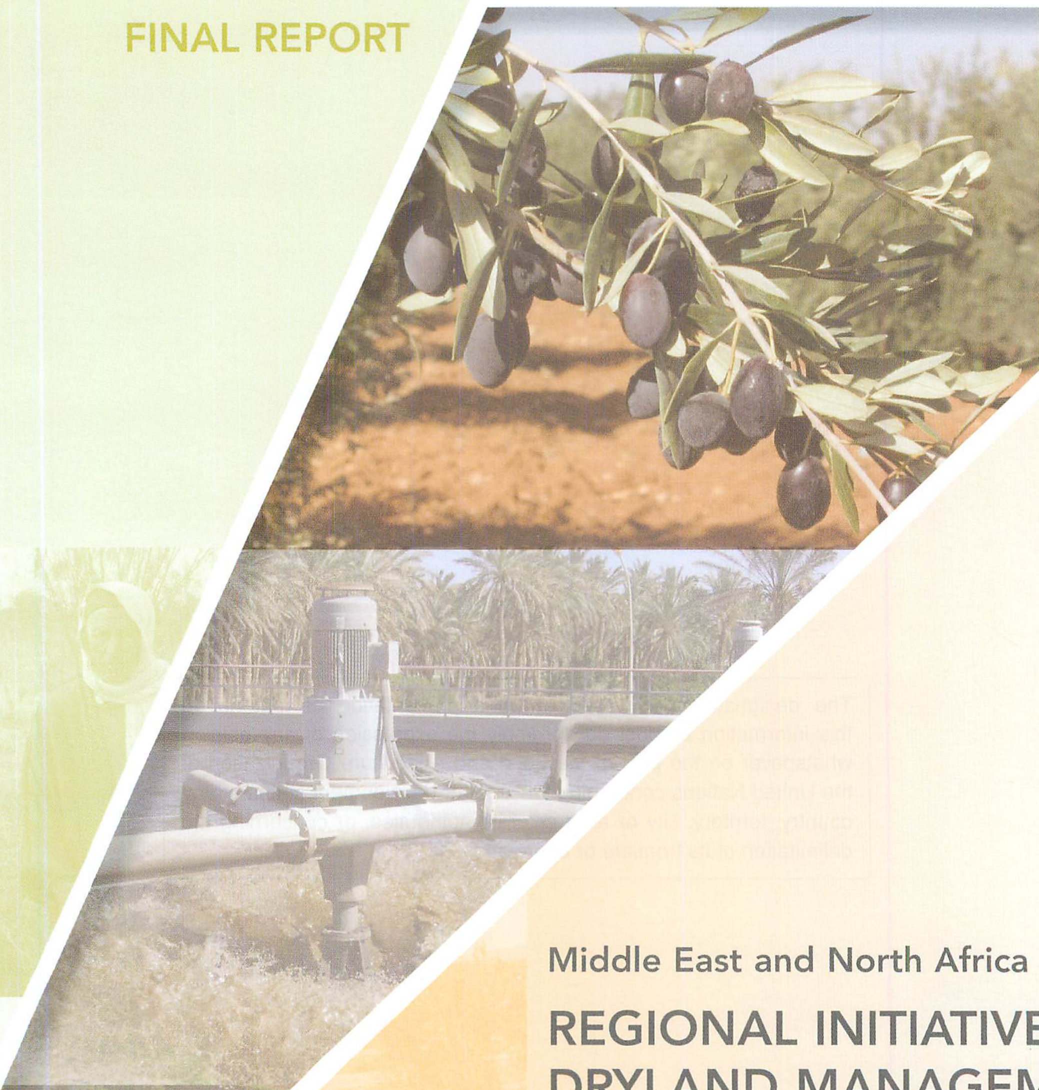
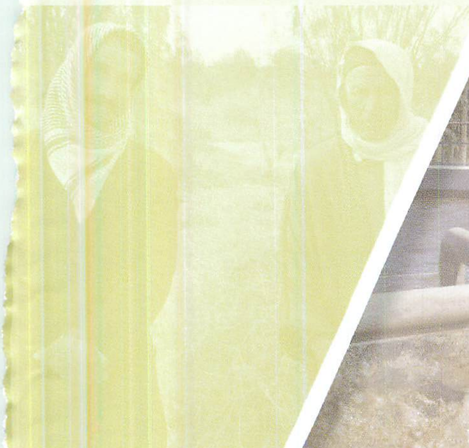
Building Bridges of Confidence

Through Technical Dialogue

FINAL REPORT





Middle East and North Africa

REGIONAL INITIATIVE FOR DRYLAND MANAGEMENT

International Center for Agricultural Research in the Dry Areas (ICARDA)

June 2007

FOREWORD

The "Initiative for Collaboration to Control Natural Resource Degradation (Desertification) of Arid Lands in the Middle East", later renamed the "Regional Initiative for Dryland Management", is a little publicized initiative designed to facilitate Arab-Israeli technical cooperation in support of the peace process of the 1990s. Conceived in the years of enthusiastic support for what appeared to be an opportunity to end a long-standing regional conflict, this 10-year program, implemented between 1996 and 2006, tells the story of political, institutional, and technical realities on the ground, constraining what enthusiastic participants, donors, and other stakeholders set out to achieve. It is the story of bold objectives, sobering experiences, continuous adaptations, and – against all odds – remarkable achievements during times of continued conflict. The story will not do justice to all the great personal efforts that made this program happen. It can only provide an indication of some of the joys and pains endured during the 10-year implementation period.

The "Regional Initiative for Dryland Management" was designed to bring together technical experts from Israel and Arab countries in an attempt to build bridges of confidence among conflicting parties, bridges that would eventually facilitate rapprochement and ultimately peace. As such, the Initiative was – by design – a "mission impossible". It was not a research program, given that the research was motivated by and aimed at Arab-Israeli dialogue. If a choice had to be made between the continuation of meetings and dialogue and the strict enforcement of technical quality objectives, Arab-Israeli dialogue was always favored. On the other hand, technical dialogue cannot – by definition – achieve peace, given that peace negotiations are conducted by political representatives, diplomatic experts, and social groups. How then does one measure the result of this program? – The Initiative's objective was simple: bringing technical experts together to discuss technical issues of mutual interest, in this case dryland management and desertification. And the Initiative did bring together Arab and Israeli technical experts throughout the entire lifetime of the program: a remarkable achievement in light of the ups and downs of the peace process.

This final report has been initiated and produced by the International Center for Agricultural Research in the Dry Areas (ICARDA) as the implementing agency of the Initiative, with support from the World Bank as the representative of the donors and Chair of the Steering Committee. The report has been written by leading participants in the program, one Arab and one Israeli, with contributions from technical teams in participating countries. The report is testimony to the dedicated efforts of both Arab and Israeli experts to start building bridges of confidence.

Inger Andersen
Director, Sustainable Development Department
Middle East and North Africa Region
The World Bank

ACKNOWLEDGEMENTS

ICARDA, as the implementing agency of the Regional Initiative for Dryland Management (RIDM) and producer of this final report, would like to acknowledge the tremendous efforts by the two authors, Drs. Uriel Safriel and Samir Abo Sliman, to review available material and to synthesize the knowledge and experience gained throughout the ten years of program implementation. the contributions from all national coordinators and partner countries in compiling information and reviewing several draft versions of the report are highly appreciated. We are most grateful to Mr. Gunnar Larson for editing the draft report and to the program facilitators, Drs. Scott Christiansen and Abelardo Rodriguez, who provided useful comments. Special thanks are also due to Dr. Rodomiro Ortiz of CIMMYT who peer-reviewed this report. We gratefully acknowledge the financial contributions of the World Bank for the production of this final report. The World Bank task team, led by Matthias Grueninger, also provided significant contributions to the structure and contents of the report itself, for which we are grateful.

Beyond the production of this report, ICARDA would like to express its gratitude to the National Coordinators and scientists of the thematic working groups in the participating countries for their dedication and collaboration during the implementation of this exceptional program with rich personal and institutional experiences. Finally, ICARDA gratefully acknowledges the generous contributions – in cash and in kind – during the lifetime of the RIDM from the following donors (listed in alphabetical order): Canada, European Union, Japan, Luxemburg, Republic of Korea, Switzerland, USA, and the World Bank.

Photo Credits

All photos were taken and kindly provided by Matthias Grueninger, with the following exceptions: Uriel Safriel: Figures 22, 52, 57, 59, 60, 61, 62; US Government/public domain: Figure 20; Abelardo Rodriguez 35, 55, 66, 67.

CONTENTS

Executive Summary 1

I. Natural Resource Degradation in The Middle East and North Africa 9

A. Geography, Demography and Economy 9

B. Land and Water Resources 11

C. Controlling Land Degradation 18

Increasing Water Availability 18

Improving Water Use Efficiency 20

Reusing Existing Water: Wastewater, Drainage Water and Biosolids 21

II. The Middle East Peace Process: The Roots and Context of the Dryland Initiative 25

A. The Middle East Peace Process and the Conception of the Initiative 25

B. Implementation of the Peace Agreements and the Birth of the Initiative 27

C. The Ups and Downs of the Peace Process during the Life of the Initiative 27

III. Evolution of the Thematic and Administrative Structures of the Initiative 31

A. Program objectives and components 31

B. The Participating Institutions 40

C. Program Management 41

D. Donors and Partners, Financing and Budgeting 43

E. Relationships with Other Regional Programs 44

IV. Communication, Knowledge Sharing, and Capacity Building 49

A. Regional Communication 49

Regional Meetings and Workshops 49

Electronic Communication and Documentation 51

B. Institutional Capacity Building 54

C. National Integration and Coordination 56

D. Community Participation, Dissemination, and Outreach 58

V. Technical Activities of the Dryland Initiative 65

A. The Watershed Management programs of the Dryland Initiative 65

Increasing Water Availability through Water Harvesting and Storage 65

Field Crop Production and Rangeland Management 69

Fruit and Non-Fruit Tree Cultivation 71

Genetic Resources and Biodiversity 74

Diversifying Farming Systems and Promoting Off-farm Activities 77

B. The Treated Wastewater and Biosolids Re-use programs of the Dryland Initiative 80

Wastewater Treatment 80

Treated Wastewater Reuse in Agriculture 81

Brackish Drainage Water Reuse in Agriculture 85

Biosolids Treatment and Use in Agriculture and Energy 86

Social, Economic, and Policy Implications of Treated Wastewater Reuse 89

VI. Implications for Future Technical Cooperation Programs 91

Annex 1: Project Sites and Areas **95**
A. Egypt 95
Marsa Matrouh Governorate, Watershed Management 95
The Sinai Peninsula, Germplasm for Arid Lands 95
The Nile Delta, Kafr El Sheikh Governorate, Treated Wastewater and Biosolids Re-use... 96
B. Israel 96
The Yatir Watershed, Watershed Management for Afforestation 96
Avdat and Mashash Experimental Runoff Farms, Watershed Management 97
Semiarid, Coastal and Valley Agriculture in Israel, Treated Wastewater 98
The Northern Negev, Biosolids Re-use 99
C. Jordan 99
Watershed Management Project sites 99
Treated Wastewater and Biosolids Re-use Sites 100
D. Palestinian National Authority 101
Watershed Management sites 101
Treated Wastewater and Biosolids Re-use 102
E. Tunisia 102
The Zammour Valley and Menzel Habib, Watershed Management 102
The Dissa Perimeter, Treated Wastewater and Biosolids Re-use 103
References 105

LIST OF TABLES

Caption		page
Table 1:	Regional Meetings of the Dryland Initiative	52
Table 2:	Overview of treated wastewater and biosolids field work under the RIDM.	88

LIST OF FIGURES

Caption		page
Figure 1:	MENA countries and their drylands.	9
Figure 2:	The RIDM countries by dryland zone	10
Figure 3:	Drylands in Northwest Egypt.	11
Figure 4:	Rainfall Variability	12
Figure 5:	The distribution of aridity in each of the RIDM countries, expressed in the percentage of land belonging to each dryland category	12
Figure 6:	Germination of annual plants – response to first rain in the arid dryland of Israel (loess soil)	12
Figure 7:	Drylands Initiative land area by aridity classification and by country	13
Figure 8:	Water resources per person and population growth rate.	13
Figure 9:	Percentage of water used for agriculture, and domestic and industry purposes, related to the percentage of rural population within each country.	14
Figure 10:	The divergent dependence of RIDM countries on the three natural water resources – surface runoff, groundwater and trans-boundary, external resources, mainly rivers and rainfall per country.	14
Figure 11:	Development Indicators.	15
Figure 12:	Primary / secondary wastewater treatment in Jordan.	17
Figure 13:	Classification of water-harvesting systems.	19
Figure 14:	Small runoff basin water-harvesting at ICARDA station, at Tel Hadya, in Aleppo, Syria.	19
Figure 15:	Harvested rainwater in depressions in Marsa Matrouh, Northern Egypt.	19
Figure 16:	Wastewater (treated): a water resource of increasing importance in dryland areas.	21
Figure 17:	Primary Wastewater Treatment.	22
Figure 18:	Secondary Wastewater Treatment.	22
Figure 19:	Tertiary Wastewater Treatment.	23
Figure 20:	Arafat and Rabin shake hands after signing the Palestinian-Israeli Peace Accord, September 13, 1993.	26
Figure 21:	Arid drylands in spring flowering; Tunisia (sandy soil).	31
Figure 22:	Gully erosion in an arid rangeland, Negev Desert, Israel.	32
Figure 23:	Support Programs of the different phases of the RIDM.	34
Figure 24:	Afforestation – saplings on large earth dykes, protected by plastic cylinders from browsing by livestock; Israel.	34
Figure 25:	A new cistern built by the Initiative in the Jordanian rangeland.	35
Figure 26:	Contour terraces in a Wadi; West Bank.	36
Figure 27:	Measuring rainfall and the resulting surface runoff generated by the forest surface; Yatir forest; Israel.	39
Figure 28:	Water collection and measurement through tipping buckets (inside box); Israel.	39
Figure 29:	Experimental production of Rye Grass; Jordan.	41
Figure 30:	Initiative funding by donor (US$ Millions equivalent). Phase I includes the "transition" period between Phase I and Phase II, and Phase II includes the Extension period.	43
Figure 31:	Phase I Funding by Recipient Country (excluding Facilitation Unit).	43
Figure 32:	Phase II Funding by Recipient Country.	44
Figure 33:	Extension Phase 2003-20005: Funding by Theme	44
Figure 34:	Regional Consultation Meeting in Sede Boqer, Israel, in October 1999: Field Tour to the northeastern Negev. An Israeli farmer explains to representatives of the five partner countries the drip-irrigation system applying treated wastewater to fruit trees.	50
Figure 35:	A Regional Thematic Workshop, Reading, England, Extension of Phase II.	51
Figure 36:	Rectangular ("diamond-shaped") micro-catchments, Hebron Region, West Bank (PNA).	56
Figure 37:	Farmers participating in the Initiative's field work; Matrouh, Egypt.	57
Figure 38:	Earthen dyke (or bank); Jordan.	58
Figure 39:	Farmers participating in the Initiative's field work inTunisia.	59
Figure 40:	Farmers discussing crops at Initiative nursery; Egypt.	60
Figure 41:	Extension brochures, produced by the Egyptian Initiative team.	61
Figure 42:	Treated wastewater reuse in Gabès; Tunisia.	63
Figure 43:	Watershed Management.	65

Figure 44:	Gullies and large-scale earthen ridges in an Egyptian watershed.	66
Figure 45:	Contours, terraces, and gullies in sloping arid drylands; Israel.	66
Figure 46:	Large-scale contours and terracing in the West Bank semiarid drylands.	66
Figure 47:	Contour "sinks" on gentle slopes in Jordan through deep ripping.	66
Figure 48:	Contour terraces in a Wadi; West Bank.	67
Figure 49:	Micro-catchments in Northwestern Egypt.	67
Figure 50:	Rectangular ("diamond-shaped") micro-catchments, Hebron Region, West Bank (PNA).	67
Figure 51:	Runoff conveyed to trench through pipe after going through a stilling pond. Mashash Experimental Farm, Israel.	68
Figure 52:	Increasing water storage by deep trenches, supporting olives at 100 mm rainfall; Mashash Experimental Farm, BIDR, Israel.	68
Figure 53:	Runnoff collection in cistern; Jordan.	69
Figure 54:	Improving cropland and rangeland productivity in Egypt.	70
Figure 55:	Rangeland rehabilitation in Henchir Senoussi and Ouled Hfaiedh, Menzel Habib region, Tunisia. Overgrazed sandy rangelands (forefront) degraded into shifting sand dunes (background, right)	71
Figure 56:	Opuntia cactus produced at eco-tourism site; Jordan.	71
Figure 57:	Run-off harvesting for tree cultivation. Almond trees on the Avdat Runoff Agriculture Demonstration Farm; Israel. Run-off generating area is the rocky slopes at the background. Small dykes (arrows) lead the runoff to the terraces.	72
Figure 58:	Drip irrigation system, using pumped groundwater from a 20-meter deep well, used in winter vegetables intercropped with figs; Egypt.	72
Figure 59:	Firewood and fodder trees. *Acacia saligna* is cultivated for perennial production of firewood. Regeneration following lopping. Runoff through a wadi bed is channeled to this run-off collecting enclosure circled by earthen dykes.	72
Figure 60:	Exploring the pros and cons for arid afforestation. Afforested and non-afforested areas of the Yatir Watershed in the spring growing season; Israel.	74
Figure 61:	Summer, non-afforested vegetation is mostly standing-dead. The Israeli WSM team harvests the annual production of the indigenous vegetation cover.	74
Figure 62:	Exploring within-species variability and trait heritability of two forage plants, *Dactylis glomerata* and *Trifolium purpureum*, collected along a rainfall gradient in Israel.	75
Figure 63:	In-situ conservation, establishing an educational protected area; West Bank.	76
Figure 64:	Gabès Nursery, Tunisia.	77
Figure 65:	Nursery Egypt.	
Figure 66:	The Jordanian Initiative team raises awareness for the production of herbal and medicinal plants among rural women.	78
Figure 67:	Jordanian lavender sold on a French market.	79
Figure 68:	Rye Grass is being fed to sheep, reducing pressure on over-exploited rangeland; on-farm trials; Jordan.	79
Figure 69:	Secondary treatment of wastewater in Gabès, Tunisia.	80
Figure 70:	Tertiary wastewater treatment funded by the Initiative; Gabès; Tunisia.	80
Figure 71:	Wastewater Treatment Plant at Al Arroub Agricultural School, West Bank.	81
Figure 72:	(Primary) Treated Wastewater. Visual appearance gives first indication of water quality and often causes social rejection of wastewater reuse, especially on food crops.	81
Figure 73:	Treated wastewater trials, Kafr El Sheikh, Egypt. Indoor experiments.	82
Figure 74:	Treated wastewater trials, Kafr El Sheikh, Egypt. Outdoor experiments.	83
Figure 75:	(Primary) Treated Wastewater Reuse in fodder and tree crop production; Jordan.	83
Figure 76:	TWW reuse in Tunisia.	84
Figure 77:	Citrus irrigation with treated wastewater; Israel.	84
Figure 78:	Tree crop production with treated wastewater; Jordan.	85
Figure 79:	Herbal and medicinal plants irrigated with treated wastewater; Jordan.	85
Figure 80:	Cut-flowers irrigated with TWW, drip-irrigation in a greenhouse; Jordan.	85
Figure 81:	Mixtures of drainage water, freshwater, and TWW used in crop production (sugar beet), on-farm trial; Kafr el Sheikh, Egypt.	86
Figure 82:	Mixtures of drainage water, freshwater, and TWW used in crop production (sugar beet), on-farm trial; Kafr el Sheikh, Egypt. Salt crust building up.	86
Figure 83:	Manure treatment, Jordan.	86
Figure 84:	Composting sludge, ONAS Plant in Gabès, Tunisia. Drying sludge before grinding.	87
Figure 85:	Experimental cereal crops with sludge application (herbizide application to separate two different treatments); Israel.	87
Figure 86:	Biogas generation, Egypt.	88
Figure 87:	Herbal and medicinal plants irrigation with treated wastewater, Jordan.	89

LIST OF ACRONYMS

ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
ARC	Agricultural Research Center
BIDR	Blaustein Institutes for Desert Research, Ben Gurion University of the Negev
BOD	Biological Oxygen Demand
CIDA	Canadian International Development Agency
CITET	Centre International des Technologies de l'Environnement de Tunis (Tunisia International Center for Environmental Technologies)
COD	Chemical Oxygen Demand
CRDA	Commissariat Régionaux au Développement Agricole (Regional Commission for Agricultural Development)
DFG	Deutsche Forschungsgemeinschaft (German Research Foundation)
DRC	Desert Research Center
EC	Electrical Conductivity
EPA	Environmental Protection Agency
ERM	External Review Mission
EWG	Environment Working Group
FAO	Food and Agricultural Organization of the United Nations
FU	Facilitation Unit
GIS	Geographic Information System
GTZ	*Gesellschaft für Technishe Zusammenarbeit* (Agency for Technical Cooperation)
ICARDA	International Center for Agricultural Research in the Dry Areas
IRA	General Institut des Régions Arides (Institute of Arid Regions)
ISNAR	International Service for National Agriculture Research
MEDRC	Middle East Desalination Research Center
MENA	Middle East and North Africa Region
MERC	Middle East Regional Cooperation program, USAID
MOA	Ministry of Agriculture
MRMP	Matrouh Resource Management Project
NCRATT	National Center for Agricultural Research and Technology Transfer
NGO	Non-Governmental Organization
ONAS	Office National de L'Assainissement (National Agency for Sanitation)
PMAT	Publications and Mail Administration Tool
PNA	Palestinian National Authority
QRDP	Quasr Rural Development Project
RIDM	Regional Initiative for Dryland Management
RSCN	Royal Society for the Conservation of Nature
RSP	Regional Support Program
SAR	Sodium Absorption Ratio
SRMP	Sustainable Range Management Project
SSC	Statistical Service Center
TFC	Total Fecal Coliform
TSS	Total Soluble Salts
UNEP	United Nations Environment Programme
USAID	United States Agency for International Development
WANA	West Asia and North Africa

EXECUTIVE SUMMARY

BACKGROUND

The Regional Initiative for Dryland Management was established in 1996 to promote technical cooperation between Egypt, Israel, Jordan, the Palestinian National Authority, and Tunisia. The Initiative was conceived by the Multilateral Working Group on the Environment (WGE) as an instrument to serve the Middle East peace process through scientific collaboration on relatively uncontroversial, apolitical issues that mutually affected the five parties concerned. The Multilateral Working Group itself had been established during the Madrid Peace Conference in October 1991. In a meeting of the Working Group held in Tokyo in May 1993, land degradation or *desertification* was identified as just such a common issue, one which would be best served through regional cooperation, including direct interaction between technical experts from Arab countries and Israel. Three months later the Oslo Accords were finalized, and catalyzed planning for the Initiative, originally named the "Initiative for Collaboration to Control Natural Resource Degradation (Desertification) of Arid Lands in the Middle East," but more widely referred to simply as the "Desertification Initiative." Later, as controversy arose over the definitions of "desertification" and drought in dryland ecosystems, its name was changed to "Regional Initiative for Dryland Management (RIDM) (for simplicity reasons, this report will use the term "Dryland Initiative"). Its program was adopted by the Working Group in 1994, and in 1995 the World Bank raised funds from donor countries facilitating the Initiative's creation the following year.

The Dryland Initiative was thus born out of an expectation that regional technical cooperation could be an instrument for peace and stability in the Middle East and North Africa (MENA), and between Israel and her Arab neighbors in particular. The notion that technical cooperation could be an instrument for peace rested on an assumption of both shared concerns and open communication. Of course technical cooperation was by no means expected to lead the Middle East peace process or to assume a central role in political dialogue, but it could potentially establish channels of technical dialogue and exchange, supporting a process of rapprochement and eventually political agreements and peace.

Regional cooperation, as envisaged in the original program of the Initiative, would rely on direct exchanges of knowledge and experience between national teams, enabling project implementation in one partner country to benefit from access to the experience of projects in other partner countries. More specifically, "regional" cooperation was explicitly related to Arab-Israeli cooperation. This report will use the term "regional" with this meaning.

The concept carried an implicit principle of relative comparative advantage, such that national institutions in one country might build capacity and cultivate expertise through interaction with counterparts in other countries. Such exchanges would not only serve to build capacity, but would build a collegial culture of mutual reliance, confidence, and respect. National teams would come to rely on one another and trust one another. Regional cooperation therefore had to be based on common regional issues and priorities such as management of dryland soil and water resources, endemic biological diversity etc. This internal sense of regional community was also to be served by mutual interaction with outside entities, joint planning to be approved by external sources, and joint reporting on the products delivered and progress achieved.

PHASE I : AUGUST 1996 – JUNE 2000

The original program laid out a series of four thematic areas around which the weight of Initiative activities would be organized: *Economic Forestry and Orchards*, *Rangeland Management and Livestock*, *Germplasm for Arid Lands*, and *Marginal Water and Saline Soils.* These thematic areas would be coordinated at the regional level by four *Regional Support Programs* (RSPs), and at the national level by corresponding *National Support Activities* (NSAs). The Regional Support Programs were assigned to the participating countries based on informed estimations of their relative comparative advantages and national priorities. Egypt assumed responsibility for *Germplasm for Arid Lands*, based on the country's long experience using dryland-adapted plants irrigated with Nile river water. *Economic Forestry and Orchards* would be hosted by Israel, based on the country's extensive experience with dryland afforestation and horticulture. The *Rangeland Management and Livestock* RSP was assigned to Jordan, given the prevalence of livestock-dependent agro-pastoral livelihoods in the country, and the presence of research organizations with considerable capacity in rangeland research. Tunisia, which had pioneered the reuse of treated wastewater for agricultural production in MENA, would host the *Marginal Water and Saline Soils* program. The two year old Palestinian National Authority would not host a thematic Regional Support Program, but rather focus on building institutional capacity while benefiting from all four technical RSPs.

The original four-program thematic structure covered the initial four year period of the Initiative, generically referred to as "Phase I," which began at the Initiative's inception in August 1996 and which ended in June 2000.

PHASE II : JULY 2000 – JUNE 2003

Based on the recommendations of an external program review that evaluated the Initiative's performance during this period, the Initiative was continued into a second three year "Phase II" with a simplified programmatic structure. The simplified thematic structure saw the *Forestry*, *Germplasm*, and *Rangeland* RSPs subsumed under a broader *Watershed Management* program. The *Marginal Waters* RSP was incorporated into a similarly broader *Treated Wastewater and Biosolids Reuse* program. The "Regional Support Program" designation was dropped, based on the understanding that all activities including national field activities were actually part of the regional thematic programs. Also based on recommendations of the external review, the revised Initiative program for Phase II introduced a third thematic *Socio-Economy and Policy* program to analyze sociological and economic dimensions of dryland management, and based on its findings, to develop policy recommendations and incentive strategies to raise rural incomes and encourage sustainable resource management.

EXTENSION PHASE : JULY 2003 – APRIL 2006

Phase II itself would be extended by two years beginning in 2003, in another programmatic adaptation known as the "Extension Phase," when the Socio-Economy and Policy program would be mainstreamed into its sister Watershed Management and Treated Wastewater programs, bringing the Initiative's lifespan to ten years.

The Extension Phase program also laid out a transparent system of quarterly disbursement based on the delivery of agreed upon results, and on the satisfaction of clearly defined performance indicators. These developments made the final two years of the Initiative its most successful, although the lack of communication between workshops and meetings suggest the limitations that persisted throughout the Initiative's life.

Regional dialogue in difficult context

Within – and forming an integral part of – the regional thematic programs, participating countries conducted technical field work at the national level.

These activities were carried out at project sites and research stations where the great bulk of the technical work under the Initiative took place. The national teams responsible for the conduct of the research and demonstration were to be supported by the corresponding regional program, which was charged with providing consultation and technology transfer services during regional meetings, seminars, training courses, and demonstration site visits. But the support and coordination elements of the regional programs would remain very limited owing largely to the resurgence of Israeli-Palestinian conflict that characterized the political setting in which the Initiative was implemented.

In fact, circumstance would undermine regional cooperation—the motivating principle behind the Dryland Initiative itself—from the Initiative's very inception. While the Initiative was officially launched in 1995, it was not until August of 1996 that all national activities were fully formulated and all funding was in place. By then the peace process was unraveling. The period in which the Initiative was implemented was therefore starkly less hopeful than the period in which it was planned. The division of the Initiative's lifespan into three successive phases was the result of external reviews conducted in three-year intervals which provided important inputs for technical and institutional adjustments but which also served to adapt the program to the compromised environment for regional cooperation.

Political circumstance impinged decisively on the life of the Initiative. The transition from the 1996-2000 *Initiative for Collaboration to Control Natural Resource Degradation (Desertification) of Arid Lands in the Middle East* (Phase I) to the abridged *Regional Initiative for Dryland Management* (Phase II and Extension Phase) did away with the innovative but non-functioning structure based on a separation of regional and national support programs and activities. Based on external review recommendations, Phase II maintained regional cooperation, defined as collaboration between Israel and Arab partners, as the project purpose, but it built its technical work entirely on national development projects within which the Dryland Initiative would provide incremental and integral knowledge services based on the Initiative's applied research results. Hence the move from Phase I to Phase II was marked by refocusing the Initiative from its technical objectives (control of natural resource degradation and restoration of arid land productivity) to a dual objective structure in which regional cooperation and natural resource management appeared in parallel. This modification appeared subtle at the time but turned out to add to the difficulties in the prioritization of program activities. The Initiative, however, purposely reduced the "regionality" of its program and explicitly allowed national field activities to continue during times in which regional cooperation would be constrained by the resurgence of Israeli-Palestinian conflict. The original program of exchange visits and systematic knowledge sharing had to be relegated to periodic "regional" meetings, all of which had to take place outside the region by virtue of political tensions. Although Arab-Israeli cooperation was re-emphasized, especially during the final two years of the Initiative, cooperation would take the form of consultation and information sharing at these meetings, with little regular communication between meetings. Ironically, the success of the Initiative as an instrument for regional cooperation was constrained by the lack of this very regional cooperation in the absence of political rapprochement in the Region and was therefore contingent on factors external to the purview of the Initiative itself. The vagaries of the peace process and periodic outbreaks of violent conflict would indeed impinge heavily on the ultimate success of the Initiative in helping to create an environment of confidence.

However, throughout the 10-year lifetime of the Initiative and in parallel to the ups and downs of the Middle East Peace Process, the Initiative demonstrated a remarkable resilience to these external political factors and always – without exception – maintained a minimum level of regional dialogue and exchange. Hence it fully achieved its objective of bringing together Arab and Israeli experts to discuss common technical issues, sometimes at the cost of technical quality and program visibility. Focusing on individuals willing to sustain these partnerships was a key success factor while at the same time a key constraint to achieve even broader outreach to the scientific community and political decision-makers. Especially during the Extension Phase, the Initiative's *Regional Thematic Workshops* and *Regional Capacity Building* Workshops succeeded in bringing together Arab and Israeli counterparts in a diminished but tangible version of regional exchange. Face-to-face interactions were substantive and did afford the counterparts an opportunity to brief and be briefed by each other on the substance of recent work. For many of the participants of the capacity building workshops, this would be the first time they had encountered Arab or Israeli counterparts in person, and the proceedings of both types of workshop saw the exchange of informal advice, constructive criticism, and compared experiences.

EXTERNAL REVIEWS

The two external reviews that recommended continuation of the undertaking in 1999 and 2003 both coincided with lulls in the Israeli-Palestinian conflict, and were thus rather fortuitous in their timing. The first review was conducted in 1999, and coincided with the resumption of direct Israeli-Palestinian negotiations in September – a setting that reassured the external reviewers enough to recommend continuing the Initiative for another three years. Indeed, the development of the new program was carried out in a genuinely cooperative atmosphere, with interactive workshops, consultations, and field tours in all five countries, including Israel. The second external review, recommending the two-year Extension Phase in 2003, took place during a similar interim period of relative calm that preceded the Middle East Summit in Aqaba, during which Israel and the Palestinian National Authority both accepted the *Road Map to a Permanent Two-State Solution to the Israeli-Palestinian Conflict*. While all three review missions (including the final, post-operative review mission) observed the adverse effects of exogenous political events on regional exchange within the Initiative, all three concluded that the operation was manifestly worthwhile regardless of whether the peace process it was intended to serve was advancing or deteriorating. Indeed, the availability of such channels of communication is very arguably *more* valuable and urgent during difficult times, and is worth having readily in place for when relations improve.

AREAS OF STUDY

While the Initiative's greater objective related to regional cooperation, the actual content and subject matter of work undertaken under its auspices was of course technical and scientific. During its decade-long work, the Initiative partners explored, tested, implemented, and demonstrated practices and innovations at projects sites in rural areas of their respective countries. Most of their work related to improving and applying existing knowledge, with limited efforts to generate new or novel technical innovations. Much of the work was expository, consisting of field surveys and plant species inventories. But the work was highly pertinent to the environment-development nexus in the five countries, and in the Middle East and North Africa generally. As such, it did expand the existing knowledge base of dryland natural resource management and agricultural and rural development.

Water harvesting and soil water storage techniques, and systems for promoting sub-surface water storage, were prominent areas of study. Methods for promoting crop and livestock production to capitalize on the improved soil water storage were objects of intensive experimentation. The treatment and use of wastewater and biosolids to irrigate and fertilize crops, fodders, and trees was the focus of extensive experiments, applying various levels of differently treated wastewater and combinations of wastewater, drainage water, and fresh water to a wide range of plant varieties. Methods of soil conservation and stabilization using treated biosolids, afforestation, and improved rangeland management were explored at great length.

Research on farming system diversification and alternative non-farm rural livelihood sources would target methods to increase income levels among local communities and reduce pressure on local land resources. Biological diversity surveys and inventories on protected conservation sites and elsewhere saw the collection of plant materials for genetic resource facilities, including genebanks, greenhouses, and botanic gardens. These activities too were largely geared toward sustainable rural livelihoods, with thousands of seedlings of promising cash crops and fodders cultivated for distribution to local farmers and land users. A variety of social surveys were conducted in all five countries, profiling the needs of target communities in which Initiative-demonstrated practices would be demonstrated and hopefully adopted. Economic analyses evaluated the profitability, relative costs and benefits, and social acceptability of the practices and technologies that Initiative projects would seek to disseminate.

WORKING WITH LOCAL COMMUNITIES

All five country teams engaged local communities in their projects, and all five invested substantial effort in making the knowledge generated by the projects available to the participating communities, and in disseminating the knowledge beyond the boundaries of project sites. Evidence of the impacts of participatory activities in and around project sites would suggest that local awareness of demonstrated innovations in nearby communities was sometimes quite considerable. The teams sought permission from land owners to implement projects on their lands. When permission was granted, farmers became project participants and were often hired as project employees as well. Some community projects were identified as being complementary to Initiative projects and objectives, and therefore came to be co-financed with Initiative funding. Altogether—through demonstration sites, training courses, field days, extension services, capacity building efforts, and public awareness campaigns—the Initiative's outreach within the five participating countries was notable. The Palestinian programs in particular stressed public awareness, including the matter of public perceptions of the social acceptability of using treated wastewater and biosolids – an essential issue to the *adoptability* of applied technologies tested and demonstrated at project sites.

Much of the capacity building that took place under the Initiative was internal, designed to improve the skills and qualifications of national team members, or to qualify them to participate in some activity in which they had limited or no personal background. This was the purpose of the *Regional Capacity Building Workshops* mentioned above, in addition to a number of in-country training programs. A number of national staff were also enrolled in graduate degree programs in universities local or abroad, others were sent to short training programs conducted by schools and research institutions.

LINKING WITH NATIONAL PROGRAMS

Each national team collaborated in some way with other, ongoing programs at work on projects and activities addressing related issues and topics. These outside programs were carried out by local non-governmental organizations, government agencies, and bilateral and international organizations, and the collaboration ranged from infrequent contacts and mutual awareness to intensive engagement and coordination. Ongoing initiatives like the Egyptian Matruh Resource Management Project or the Jordanian Sustainable Range Management Project derived mutual benefits from collaboration with Initiative programs. With the exception of the Israeli Watershed Management team based at Ben Gurion University of the Negev, every country team was government-based and staffed with government employees. This made for thorough coordination with relevant government agencies and natural compatibility between government and Initiative priorities. Given the limits of regional cooperation under the Initiative, few linkages were formed with other regional programs and processes like the Middle East Desalination Research Center or the United Nations Convention to Combat Desertification. Nor did the Arab partners link to thematically relevant regional projects outside of the peace process.

NATIONAL RESEARCH

The Initiative also increased the volume of national research within each of the five party countries. The additional funding and other resources it made available to national research and development would enable the national institutions it involved to intensify their field work. Most of the wastewater treatment plants, demonstration plots, nurseries, botanic gardens, and other facilities used by national Initiative teams would have been utilized without the Initiative, but with fewer projects and activities and at a slower pace than Initiative resources and incentives made possible. Initiative resources were also used to good effect in building professional capacity among participating national experts and scientists, a result that clearly transcends the life of the ten year undertaking.

LESSONS FOR THE FUTURE

In hindsight the original program of the Dryland Initiative was exceedingly ambitious, a product of the zeal and enthusiasm of the decidedly hopeful time during which the Multilateral Peace Talks on the Environment took place. Its mandate was extraordinarily broad in purpose, and assigned its implementers with three *simultaneous* objectives: to generate high-impact technical innovations, applied knowledge products, and policy advice; to actually improve natural resource management in dryland areas; and to strategically contribute to the Arab-Israeli peace process. The Initiative's operating premise was that these three objectives were not only compatible, but mutually synergistic. This final report summarizes the extent to which and how these objectives were achieved.

The experience of the Dryland Initiative suggests a number of practical lessons for the design of future programs that focus on technical cooperation in a context of political conflict. Firstly, program design should establish a clear hierarchy of objectives and employ highly appropriate institutional structures that effectively focus and coordinate the content and flow of work. In particular the program's priorities should be clearly articulated and assigned *either* to the quality of research and knowledge generated, *or* to communication and consensus building.

Secondly, the matter of issue selection is crucial. The issues around which technical cooperation is organized should make cross-boundary collaboration not only desirable, but required. In the case of the Middle East, a number of cross-boundary issues suggest themselves as providing more genuinely shared common ground between Israel and her Arab neighbors than land degradation and rural poverty – neither of which is a particularly prominent or pressing concern in Israel. Concerns over pollution management and the protection of marine environments in the Mediterranean are clearly shared between Lebanon, Israel, the Gaza Strip, Egypt, and the countries of the Maghreb. In the Gulf of Aqaba, marine coastal zone issues are already an area of Israeli-Jordanian cooperation. The spread of pests and zoonotic diseases likewise clearly transcends national boundaries, and coordinating measures between countries is a critical and often necessary component of addressing and containing them effectively.

Identifying the most appropriate and qualified institutions to participate and collaborate in a program of technical cooperation is a crucial aspect of program design. Program planners are encouraged to undertake a broad survey of institutions and organizations that have experience and professional expertise in the technical issues that the program will address, including both governmental and non-governmental organizations and research institutes. Those organizations selected as prospective participants should be evaluated not only on the basis of their technical capacity, but their capacity to interact with counterparts within a larger framework of collaboration and exchange. With the commitment of participating institutions in place, "ownership" of the program comes to be shared by those institutions – as opposed to discrete individuals and groups of individuals who work within them. In this way the technical cooperation undertaken itself becomes institutionalized.

Should the program of technical cooperation planned include field work, suitable mechanisms to assure quality should be put into place, including a functioning peer review process, and appointment of an implementing agency that is well placed and fully qualified to provide technical support. The implementing agency appointed should necessarily be able to communicate freely and effectively with all participants. Future programs may also enjoy a wider range of options in establishing an appropriate framework of incentives, such as competitive research grants, which were not available to the Drylands Initiative. Finally, program design should provide for a broad framework of communication and information exchange, one that effectively employs state of the art information and communications technology systems.

In conclusion, it is recommended that the objective of any new confidence building program should be to place value on technical cooperation among the parties in areas that *require* this technical cooperation and to view such a goal as an end in itself. Genuine cooperation can be built and bridges of confidence constructed if non-cooperation on the subject matter is likely to create negative effects for both sides. And maybe, this cooperation will also generate personal contacts that will facilitate, in a very modest way, an enhancement of relations between the parties, thus creating one more bridge of confidence towards peace.

I. NATURAL RESOURCE DEGRADATION IN THE MIDDLE EAST AND NORTH AFRICA

The Middle East and North Africa (MENA) extends from the Atlas Mountains in northwest Africa to the Zagros Mountains in Iran (Figure 1). The region's coastlines border the Atlantic Ocean, the Mediterranean Sea, the Red Sea, and the Indian Ocean and Persian Gulf. The number of countries in the region range from 17 to 21, depending on the political and economic criteria used to define it, and regional statistics vary accordingly.

While the Initiative's five participating countries together accounted for just 11 percent of the Middle East and North Africa region's land area and 33 percent of its population, the issues to be addressed in the Dryland Initiative were characteristic of the region as a whole. High and accelerating population growth and expanding urbanization placed increasing pressure on the scant water resources and fragile soils of the region's drylands, which account for virtually its entire land area. Resource degradation led directly to reduced agricultural productivity and rural incomes across national borders. In a context of severe water scarcity, agriculture accounted for more water use than any other sector in all five countries. The RIDM project sites are shown in Figure 2.

While the Initiative's five participating countries together accounted for just 11 percent of the

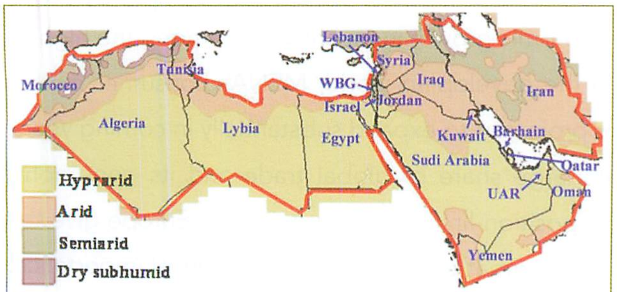


Figure 1: MENA countries and their drylands.

Source: United Nations Environment Programme. World Atlas of Desertification. Second Edition. London. 1997.

Middle East and North Africa region's land area and 33 percent of its population, the issues to be addressed in the Dryland Initiative were characteristic of the region as a whole. High and accelerating population growth and expanding urbanization placed increasing pressure on the scant water resources and fragile soils of the region's drylands, which account for virtually its entire land area. Resource degradation led directly to reduced agricultural productivity and rural incomes across national borders. In a context of severe water scarcity, agriculture accounted for more water use than any other sector in all five countries. The RIDM project sites are shown in Figure 2.

A. Geography, Demography and Economy

The region covers an area of 11.1 million square kilometers, with a population of 311.6 million by the World Bank's estimation in 2005 – including Djibouti and excluding Bahrain, Israel, Kuwait, Qatar, and the United Arab Emirates. The broader definition used by the United Nations placed the region's population at 380 million in 2000. It has the smallest population of any developing region. Yet its population increased 3.7 times over the second half of the twentieth century, the highest rate of population growth of any region in the world during that period of time. The annual population growth rate as of 2004 was 1.7 percent. The five countries that participated in the Initiative have a population density of 81 persons per square kilometer, nearly three times higher than the regional average. Among them, PNA-governed territories had the highest density with 627 persons per square kilometer, and Jordan had the lowest with 63. The PNA also has the highest rate of population growth among Initiative participants at 3.36 percent per year, while Tunisia had the lowest population

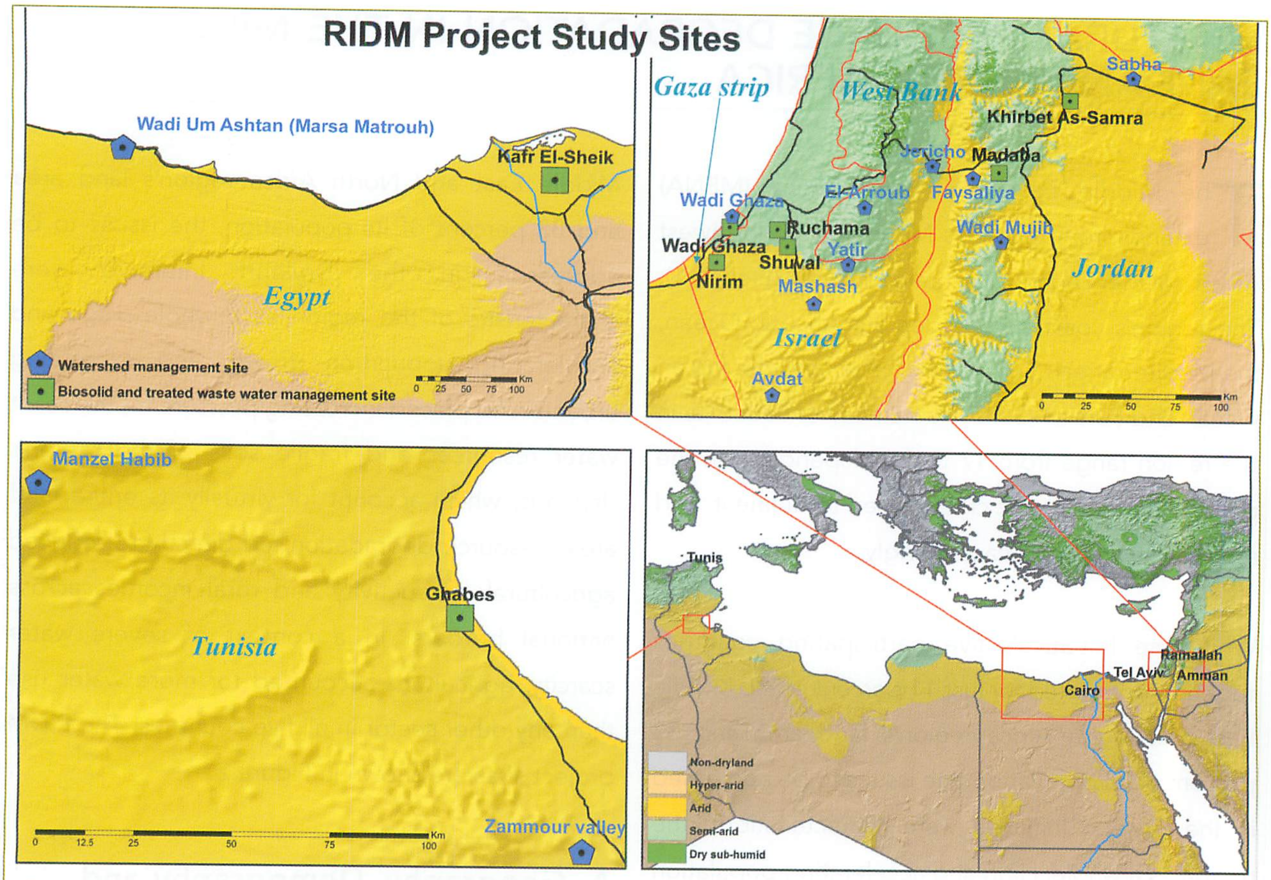


Figure 2: The RIDM countries by dryland zone

growth rate at 0.99 percent per year. The population growth rate among all five countries averages 2 per cent per year as compared to the global average of 1.14 percent, a rate of growth that suggests the great relevance of population issues to the five parties. The implications of high population growth for the natural resource bases of these countries will become clear as this report goes on to describe the climatic and agro-ecological conditions that prevail in Egypt, Israel, Jordan, the Palestinian Territories, and Tunisia.

While MENA accounts for just 5 percent of the world's population, it holds two thirds of the world's known oil reserves and provides more than 50 percent of global crude oil exports. It also accounts for 22 percent of the world's natural gas exports and 40 percent of natural phosphate exports. Its low population combined with this abundance of non-renewable resources goes far in explaining the region's relatively high per capita gross national income, which, at an estimated US$2,240 per person, is second only to Latin America and the Caribbean among developing regions.

The abundance of non-renewable resources stands in stark contrast to the region's scarcity of renewable resources, leaving it deeply dependent on international trade. Some 85 percent of its land area is covered by arid and hyper-arid drylands (Figure 3), and with few large rivers to form fertile plains. Relatively fertile semiarid and dry sub-humid areas account for the remaining 15 percent, enabling MENA to provide 11 percent of global exports of citrus fruits and 8 percent of cotton exports while importing a considerable share of global foodstuffs and manufactured luxury products. Given 5.6 percent economic growth in recent years, among the highest in the developing world, MENA's consumer market is projected to expand substantially in coming years. Its large share of global trade and its geographic disposition linking Africa, Asia, and Europe give the region great economic and geopolitical importance.

The region is socially and economically diverse, and the 5.6 percent aggregate growth rates recorded in 2003 and 2004 conceal enormous disparities. The

Figure 3: Drylands in Northwest Egypt.

highest per capita gross national incomes are heavily concentrated among the region's 10 oil exporters, for example Kuwait at US$16,340. All others, except for Israel, range from $490 (Yemen) to $1,990 (Tunisia). Nor have recent economic booms been broadly experienced within countries, and growth rates projected for MENA countries are not sufficient to address high unemployment. The particularly low overall productivity of drylands carries little or no capacity to support expanding populations, and diminishing agricultural production per capita is a direct cause of much of the region's poverty.

About 40 percent of the region's population lives in rural areas, where poverty rates are often high and acute. In 2001, some 70 million people—23 percent of the region's population—lived on an income of under US$2 a day. Seven million of these people lived on an income of under $1 a day. Rural poverty in MENA is concentrated in rainfed dryland areas, where pastoral livelihoods integrate livestock, principally sheep, with cultivated cereal fodders in seasonal migrations. These migrations may respond to rainfall variability or consist of regular seasonal transhumance. Highland agriculture, producing both rainfed and irrigated cereals and cash crops, commonly entails a vertical seasonal migration of flocks. Small scale agriculture associated with oases and boreholes likewise plays a role in livestock migrations and local trading, and provides additional sources of mainly subsistence-related production. Among Initiative participants pastoral land use patterns and livelihoods underwent significant change over the second half of the twentieth century. Transhumant livestock gave way to more intensive sedentary husbandry with a diversification of income generating livelihood sources, representing a large scale abandonment of nomadic lifestyles. This often placed increased pressure on the natural resource base in the immediate vicinity of the newly sedentary communities.

The expansive traditional rainfed agriculture of seasonal cereals and fruit trees is rapidly giving way to crops like wheat and barley, which receive supplemental irrigation. Summer cash crops like melons, sugar beets, vegetables, and cut flowers depend entirely on irrigation. Large scale irrigation is expanding, enabling intensive production of high value cash and export crops, including fruits, vegetables, cereals, and sugar. In 2001, agricultural land covered 34 percent of the region. 38 percent of this agricultural area was irrigated, the rest was rainfed. Irrigation accounts for some 87 percent of water use in MENA.

B. Land and Water Resources

Drylands are defined as continental areas of low rainfall and high evapotranspiration, with evaporation more than 1.5 times greater than precipitation. When little is precipitated and much of it evaporates, soil moisture is low and becomes the limiting resource of biological productivity. This combination also does not enable perennial rivers to form within drylands. Drylands cover some 41 percent of the earth's land surface, but nearly all of the Middle East and North Africa. They are categorized according to the degree of aridity, from hyper-arid and arid desert drylands, to semi-arid and dry sub-humid non-desert drylands, all four of which are represented in MENA.

Drylands are characterized by high between-year variability and frequent droughts (Figure 4). Water supply from rivers originating outside the region is moreover acutely vulnerable, and is subject to the use and management of river flows upstream. Storage of water to prevent evaporation requires extensive investments in infrastructure and technology. Increased rates of evapotranspiration are projected throughout the MENA region as a result of global warming.

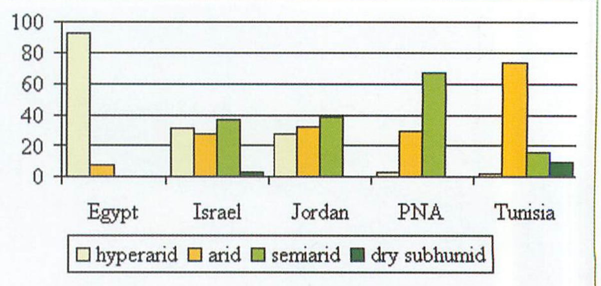


Figure 5: The distribution of aridity in each of the RIDM countries, expressed in the percentage of land belonging to each dryland category.

Among the five countries that participated in the Dryland Initiative, hyper-arid conditions cover the largest area, followed by arid and then semi-arid areas (Figure 6). The relatively fertile dry sub-humid classification applies to just 1 percent of their combined area. Hyper-arid drylands are used as rangelands and support only small populations of pastoralists. Egypt was the most arid country to participate. With 93 percent of its area classified as hyper-arid, the country's biological productivity relies heavily on the Nile River and its delta. 32 percent of Israel's territory and 29 percent of Jordan's are likewise hyper-arid, and there too agricultural cultivation was made possible only by virtue of "subsidized" non-rain water sources, such as the fossil aquifers in the Arava Valley (Figure 5).

Arid and semi-arid drylands predominate within the territories governed by the Palestinian National Authority and in Tunisia – which was the only Initiative partner with sub-humid drylands, covering about 7 percent of the country's area. Israel and Jordan are both roughly equally divided between arid and semi-arid drylands. Mixed pastoral-farming systems prevail in the arid drylands that account for 73 percent of Tunisia's territory, 33 percent of Jordan's, and 7 percent of Egypt's. Farming prevails in the arid drylands of Israel, which account for 28 percent of the country's territory, and in the Palestinian Territories, where arid drylands cover 30 percent of the area governed and semi-arid lands cover 67 percent. Farming also prevails in the semi-arid areas covering 37 percent of Israel, 39 percent of Jordan, and 16 percent of Tunisia. Figure 7 presents the relative size of the dryland categories and the overall land size by country in the five countries that participated in the Initiative.

The process of land degradation and productivity loss in dryland areas is commonly referred to as "desertification." While the rate of desertification region-wide is difficult to quantify, annual soil losses

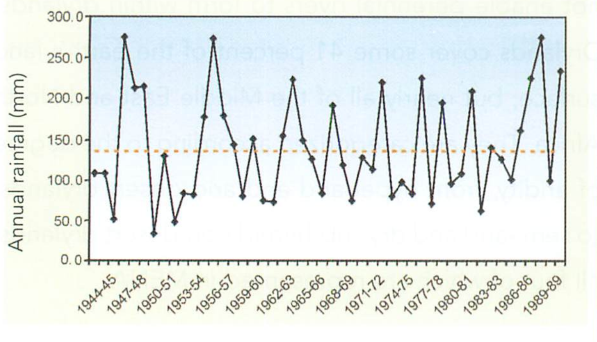
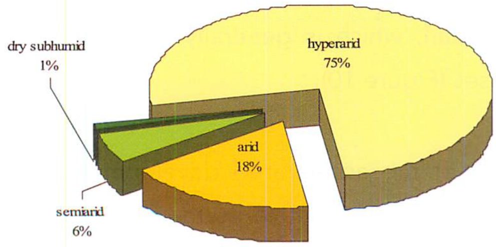


Figure 4: Rainfall Variability
Source: Oweis et al., 2001. Data for Matrouh, Northern Egypt.

Figure 6: Germination of annual plants – response to first rain in the arid dryland of Israel (loess soil).



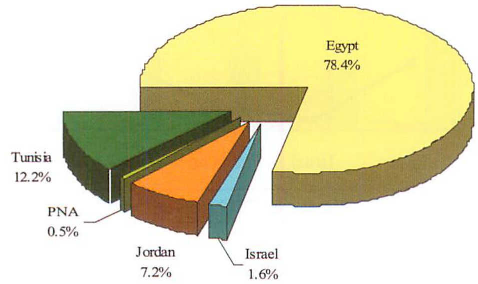


Figure 7: Drylands Initiative land area by aridity classification (left) and by country (right)

of between 5 and 50 tons per hectare, together with related forms of resource base degradation, suggest that some 35 percent of cultivated area in MENA have been affected by degradation over the last 40 to 50 years. Soil erosion is evident in all five countries that participated in the Initiative with widespread overgrazing and unsustainable fuelwood collection in Jordan, the Palestinian Territories, and Tunisia, and soil and water salinization from over-pumping in Egypt, Israel, the PNA, and Tunisia.

Given the preeminence of drylands in MENA, and the region's rapidly growing population, countries here experience the most severe water shortages on earth. The region is home to between 5 and 6 percent of the world's population, but holds only 1 to 1.4 percent of the world's accessible and renewable fresh water. Regional population growth was associated with a reduction in per capita water resources from 3,300 cubic meters per person in 1975 to 1,500 cubic meters in 2001, and is projected to decline further to around 1,000 cubic meters by 2025. Water shortages drive rates of groundwater extraction that actually double average rates of replenishment in a number of MENA countries, often leading to groundwater salinization.

Water availability per capita varies widely among the five countries that took part in the Dryland Initiative. The Gaza strip, which has the highest annual population growth rate (3.77 percent) within the five parties, also has the lowest volume of water per capita at 52 cubic meters per person. Tunisia, which has the lowest population growth rate among the five parties (0.99 percent), has 482 cubic meters of water per person – more than nine times the volume seen in Gaza (Figure 8).

Initiative partners also differ in how available water resources are allocated across sectors. The sectoral allocation of water relates naturally to geography and the role of the respective sectors within the national economy, but the relative size of a country's rural and urban sectors is also highly significant. 56 percent of Egypt's population lives in rural areas and 86 percent of the water used in the country is devoted to agriculture. While a similar proportion of the Palestinian population is rural, a variety of constraints limits the proportion of the available water that is applied to agriculture to just 64 percent (Figure 9).

Water resource utilization also differs by source. Israel, Jordan, and of course Egypt benefit from

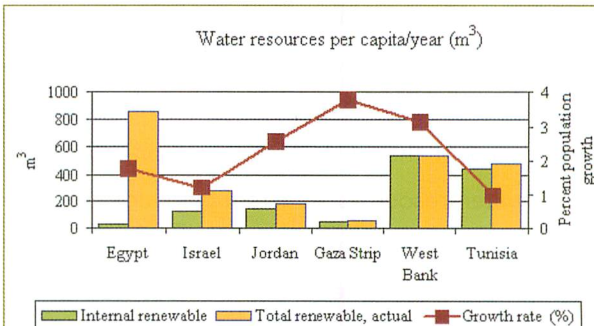


Figure 8: Water resources per person and population growth rate.

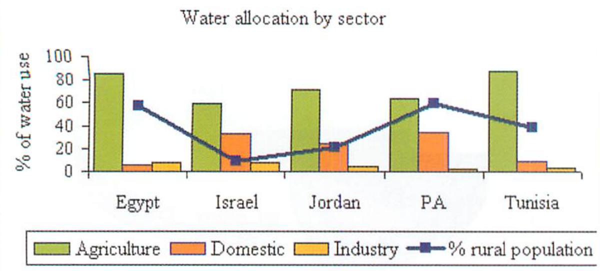


Figure 9: Percentage of water used for agriculture, and domestic and industry purposes, related to the percentage of rural population within each country.

access to water resources that originate externally, flows from the Jordan and Nile rivers. Some 98 percent of Egypt's water supply is provided by the Nile. The scarcity of water in a context of high population growth has driven a succession of historic transitions in all five countries. Pastoral livelihoods give way to farming livelihoods and rainfed agriculture gives way to irrigated agriculture. These processes represent a continuous trend toward intensification in agricultural production and to sedentary livelihoods, leading to more and more sophisticated water resource development.

Water resource development includes the management of trans-boundary rivers, the utilization of groundwater sources, the treatment and reuse of wastewater, and the desalination of brackish and sea water. All these sources have been developed among the Dryland Initiative partners. The management of river flows dates from beyond antiquity to the very dawn of history in the Nile river valley and its sister civilizations along the Tigris and Euphrates, and on a smaller scale along the Jordan River. Elsewhere, increasing dependence on groundwater resources would lead to the development of that resource by Tunisia and the PNA, including non-renewable groundwater resources in Israel and Jordan. The West Bank currently has no access to Jordan River flows and groundwater therefore constitutes 91 percent of its water supply. Increasing reuse of wastewater is now practiced in all five countries in the Initiative, generally for agricultural purposes. Finally, desalination of seawater is underway in Israel and Jordan, which is generally used for domestic purposes (Figure 10).

In spite of the accelerated development of water resources by the Initiative partners and throughout the MENA region more broadly, rapid population growth in a natural context of low biological and agricultural dryland productivity is likely to lead to further resource depletion. Overgrazing, soil erosion, and depletion of fresh water sources are all expressions of desertification, and all are likely to intensify in the face of growing human population. Water resources decline in quality as well as quantity through salinization and chemical and biological pollution, trends which may be aggravated by wastewater reuse and even by desalination. Groundwater pollution from industrial and domestic waste and fertilizer and pesticide applications is widespread in Israel, the PNA, and Tunisia. Coastal and marine pollution endangers fisheries and tourism in Egypt, Israel, and the PNA. Traditional livelihoods and the knowledge systems that sustained them lose practical relevance in the face of rural unemployment and urbanization, and traditional social structures that once sustained whole cultures are breaking down.

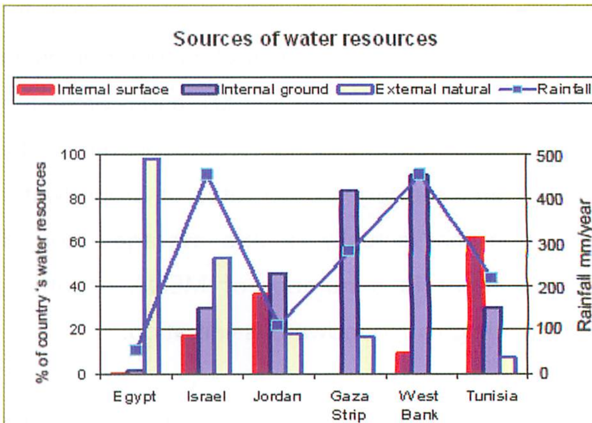


Figure 10: The divergent dependence of RIDM countries on the three natural water resources – surface runoff, groundwater and trans-boundary, external resources, mainly rivers (columns) and rainfall per country (line).

Inappropriate policies, weak governance, and limited institutional capacity among regulatory agencies also contribute to the degradation of MENA's renewable resource base. Water tariffs obscure the resource's scarcity, and together with a range of agricultural subsidies, seriously distort producer incentives – particularly incentives to use sustainable practices and technologies. Weakening of land tenure has a similar effect on incentives to use resources sustainably, and can be linked to both resource degradation and poverty.

Combinations of social, demographic, and economic dynamics have encouraged rapid urbanization, an average annual urban growth rate of 2.7 percent among the region's 25 largest cities – a rate projected to continue until 2010. Urban expansion generally takes place in fertile areas, displacing livestock and farming into less productive lands. Increasing income levels in the cities increases the demand for meat, driving unsustainable intensification of stocking rates on rangelands already approaching or exceeding their capacity to regenerate. Competition for water between urban consumers and agricultural producers becomes increasingly acute. Millennium Ecosystem Assessment projections foretell an ongoing intensification of freshwater scarcity in which the greatest stresses will be experienced in dryland areas, where if left unmitigated, will further exacerbate desertification.[1] The pressures impose critical limitations on the availability of water for either consumption or irrigation, impinging on both rural and urban development particularly in a region in which water scarcity is so endemic (Figure 11). Yet the agricultural sector is the most vulnerable, relying directly on water as the critical production input.

Urban demand—particularly in contexts of prevailing rural poverty—likewise increases pressure to intensify cultivation of crops and fuelwood in areas with inherently low productivity. Intensified cropping entails deep ploughing and irrigation using brackish waters, leading to soil erosion and salinization of croplands. Intensified fuelwood collection and

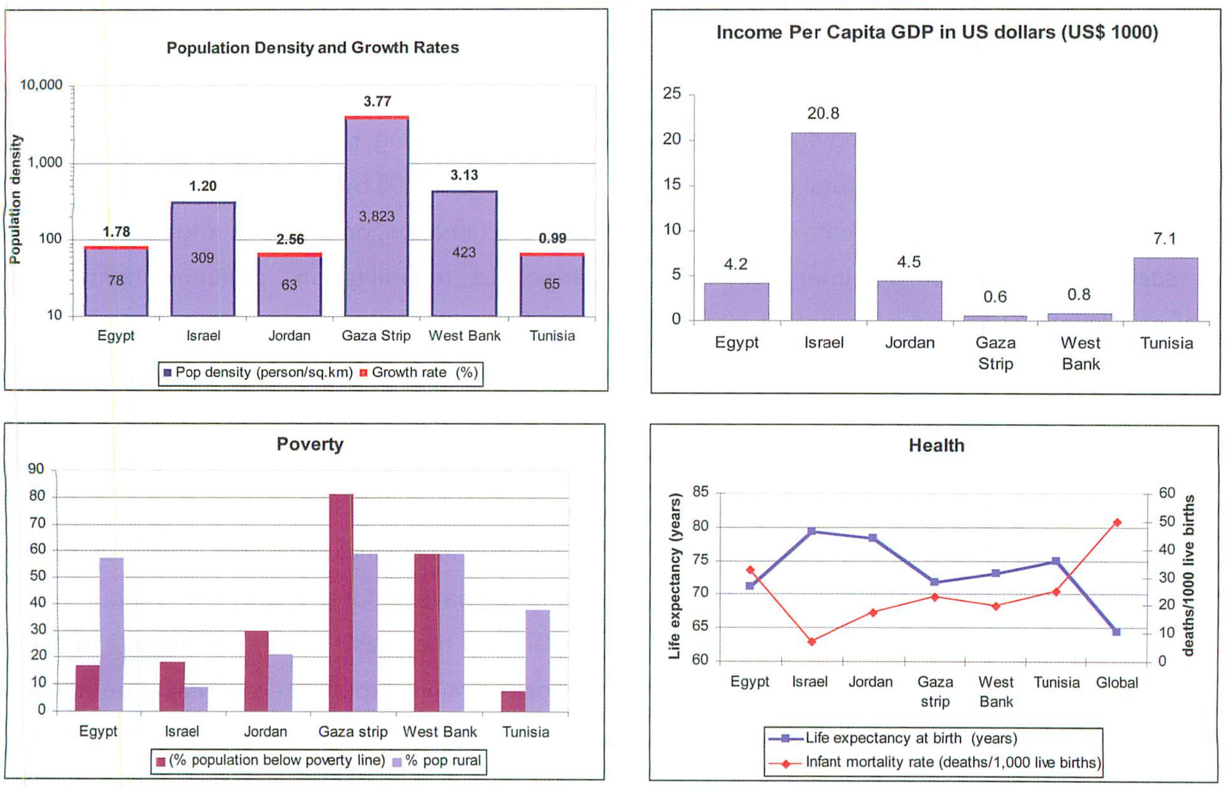


Figure 11: Development Indicators

1. *Millennium Ecosystem Assessment 2005. Ecosystems and Human Well-being: Desertification Synthesis.* World Resource Institute, Washington, DC.

grazing leads to substantial loss of vegetative cover. Forests are rare in drylands generally, and cover just 1.5 percent of MENA's land area, leaving the region with the lowest per capita forest area in the world. Rising demand for wood-based products for construction and infrastructure, as well as for non-timber forest products, brings increasing pressure to bear on the region's overall vegetation.

Recent years have however seen growing international awareness of the role forests and woodlands play in conserving soil fertility, supporting biological diversity, and in carbon sequestration. Their significance to local cultures and as a source of public goods and services is likewise increasingly recognized. Thus, while forests in MENA remain under great pressure, substantial afforestation efforts have been underway in the region, and led to a one tenth of one percent increase in total forest area between 1990 and 2000. Governmental and non-governmental organizations were actively engaged in interventions and policies addressing social and economic conditions that impinged on the environment during the life of the Initiative, and enjoyed substantial support from bilateral and multilateral sources outside the region. Much of this work focused on agriculture and rural development, and is likely to continue given Initiative participants' and supporters' attention to Intergovernmental Panel on Climate Change projections of increasing aridity throughout MENA.

Strategic planning for natural resource management among the five Initiative countries is manifest in integrative national programs that explicitly address degradation issues while establishing compliance with international commitments to sustainable development. In Jordan, national programs tend to focus on the rehabilitation of rangelands. In Tunisia, 580,000 hectares of rangelands were rehabilitated, and 320,000 hectares underwent afforestation under the National Strategy for the Development of the Forestry Sector for 2002-2011, which also includes sand dune rehabilitation. In Israel, 11 percent of the country's land area has undergone afforestation through the Israeli National Plan of Forest and Afforestation implemented by the Jewish National Fund which administers a number of other soil conservation activities as well.

Government agencies are assigned to administer water resource management in all five Initiative countries, though their coordination with land management agencies is often quite weak. The intrinsically close relationship between water and land resource issues in dryland areas makes cooperation between these agencies especially important. An opportunity for improving this cooperation was provided by the UNCCD, which encourages party countries to undertake national action programs (NAPs) to combat desertification. Two Dryland Initiative participants responded to the appeal by issuing such national action programs; Egypt and Tunisia. The Tunisian NAP was introduced in 2000 and implemented by the Ministry of Environment and Land Management. The Plan applied participatory approaches, using trees to fix dunes in restoring rangelands. The Egyptian NAP introduced in 2005 by the Ministry of Agriculture and Land Reclamation, emphasized irrigated agriculture, rangeland rehabilitation, pollution control, and population issues.

The impacts of human activity are by no means new to the Middle East and North Africa or to the areas the Dryland Initiative focused on. Demographic and social pressures, including the effects of political upheaval have a long history throughout MENA. Drylands in the coastal deserts of Egypt and Tunisia almost certainly experienced degradation following the collapse of the Roman Empire. The fall of Rome's successor, the Byzantine Empire, saw desert farming cultures in the highlands of Jordan and the Negev revert to nomadic pastoral land use. The ancient run-off cereal farming and orchard systems based on terraces and cisterns provided the principal sources of livelihoods in rocky-loessial watersheds. Bedouins continue to practice a variation of this agriculture in each Arab country that participated in the Initiative, with smaller scale production of fodders and orchard fruits for local consumption in place of the earlier cultivation of cereal crops for export to old world urban centers. Nomadic pastoral livelihoods persist in a number of areas including grazing lands in Jordan and northwest coastal Egypt. Yet with dramatically increased and still growing populations in the drylands of the Mediterranean Basin, land and water resources are now becoming acutely scarce, often exceeding their carrying capacity.

The linkages between the rural and urban sectors in MENA through rural-urban migration, urban expansion, and competition over scarce water resources require extensive reform of national and regional institutions and policies, as well as advanced technologies, to support the transition to better water conservation and higher efficiency in water use.

Among the challenges facing effective water policy in the region, two are particularly prominent. The first is widespread resistance to local water pricing policies in the most water-scarce countries. The second is a culturally-based aversion to the reuse of treated wastewater and biosolids that is prevalent throughout much of the region (Figure 12). Secure land tenure can similarly reduce pressure on water resources by improving the incentives of farmers and pastoralists to adopt more sustainable forms of cultivation and grazing and more efficient irrigation practices. Increasing farmers' and pastoralists' access to markets is another key factor that can contribute to raising income levels. In order to reach the product quality levels required by many of these markets, farmers need to adopt appropriate knowledge and

Figure 12: Primary / secondary wastewater treatment in Jordan.

technologies, acting within an improved framework of research and development, education, and certified quality assurance systems. In a region where agriculture by far uses the largest share of fresh water resources while some of the scarce water resources are left unused (non-harvested rain water draining to the Mediterranean; unused treated wastewater), adaptations of the agricultural and water policy are urgently required in order to increase available water resources at sustainable levels and to encourage more sustainable land use and increased water-use efficiency.

Poverty and vulnerability to an erratic climate restrain local decisions about how to use resources, compelling land users to focus more strictly on responding to more immediate, short term concerns. The benefits of longer term strategic investments in tree planting and soil conservation take relatively long to become apparent. And without secure tenure, land users have every reason to suspect that they would incur the full costs of any such investments while whatever benefits that eventually result will be enjoyed by others. Even assuming that tenure is reasonably secure, the financial resources required to construct and maintain water storage infrastructure is usually well beyond the means of local communities. Poverty also often rules out the purchase of external energy sources for cooking and for heating during the winter, leaving communities directly dependent on fuelwood collected from the local area. As pressure on those areas increases, the livelihoods that depend most directly on the productivity of those resources are undermined. The degradation of local resources, particularly in a context of rapid population growth, and the deepening of poverty become mutually reinforcing.

C. Controlling Land Degradation

The mechanisms that drive land and natural resource degradation in MENA are relatively well understood, and are essentially the same as those found in other regions. Methods to prevent, arrest, and reverse land degradation are generally available and comprise the subject matter of an existing knowledge base that Dryland Initiative research, experiments, and demonstrations would ultimately add to. Measures for controlling dryland degradation through improved management of water resources can best be described in terms of three concepts: (i) bringing about a net increase to water supply by adding to the water balance; (ii) increasing the efficiency with which water is used, achieving "more crop per drop" through improved technologies including genetic materials; and (iii) reusing existing water, wastewater in particular.

Increasing Water Availability

Water scarcity is the cardinal constraint limiting the biological productivity of dry areas. There are a number of technical approaches to mitigate this constraint as it impinges on the productivity of human activities that rely directly on this larger biological productivity – agriculture and livestock husbandry. The most effective such technical approach is *water transport*, widely practiced within three of the countries that participated in the Dryland Initiative. The Ghor Canal in Jordan and the National Water Carrier in Israel transport water from the semi-arid Sea of Galilee basin to arid drylands in both countries. Canals likewise transport Nile river water to desert areas of Egypt. The treatment of wastewater to be reused in irrigation also entails water transport (mainly from urban to rural areas), but represents a separate approach to water supply given that the treatment processes employed, rather than the transport of water to or from treatment facilities, are the primary focus of investment. Another option is to artificially increase rainfall by *cloud-seeding*, a practice which has been experimented with in Israel and Jordan. All three approaches—water transport, water treatment (and transport), and cloud seeding—are large scale operations that require substantial mobilization of resources nationally and sometimes regionally.

Yet given the region's agro-ecological environment, focusing on local solutions of far smaller scale is generally more appropriate. For even assuming that sufficiently massive financial resources somehow become available to increase the general availability of freshwater resources, and sufficiently detailed regional and international agreements were put in place to govern the activities – large proportions of the rural population in MENA will always rely on inherently limited locally available water resources. Nor could some hypothetical large-scale effort to raise general availability conceivably mitigate the need to reduce losses (through evaporation and runoff) and to increase the efficiency with which water is used locally. Yet in another respect, such local level solutions are not small in scale at all, but warrant substantial coordination across quite large geographic areas in which different uses of available water may come into competition, or be integrated. The most useful concept to apply to these larger water resource bases is the *watershed* – and the *watershed management* provides the most effective overarching framework for coordinating the various water uses in this larger milieu.

Water harvesting techniques (Figure 13) encompass landscape manipulation to redistribute incident

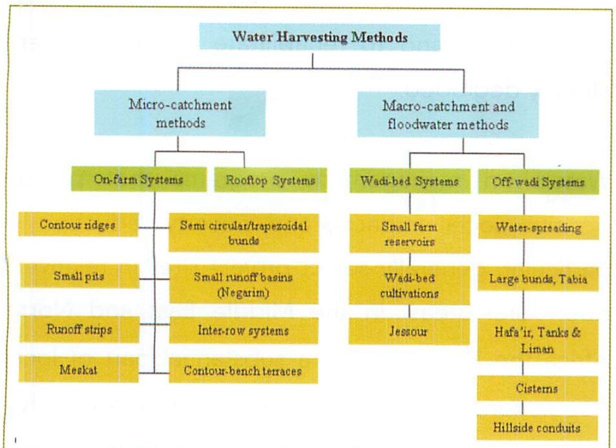


Figure 13: Classification of water-harvesting systems
(From *Indigenous Water Harvesting in West Asia and North Africa*, ICARDA, 2004).

Figure 14: Small runoff basin water-harvesting at ICARDA station, at Tel Hadya, in Aleppo, Syria.
(From Indigenous *Water Harvesting in West Asia and North Africa*, ICARDA, 2004).

rainfall. Rather than being thinly spread over the ground surface with low infiltration and high evaporation–surface rainwater runoff is channeled into *sinks* where penetration deep into the ground prevents its evaporation (Figure 15). The effectiveness with which runoff is captured from the larger contributing area can be augmented by mechanical or chemical compaction, by the use of plastic or other impermeable cover, and by protecting the surface against livestock trampling and vehicles. The water storage capacity of the sink can be increased by *ripping* its soil surface to increase infiltration. The area around the sink is planted with trees, field crops, and forages as well as simply being allowed to support indigenous vegetation. Improved vegetative cover protects surface soil from raindrop impact, preventing the development of impermeable soil crust that is characteristic of degraded drylands. The vegetative cover also provides shade, protecting the captured surface water from immediate evaporation.

The means for concentrating the runoff and directing it to the sink are diverse and depend on watershed properties – slopes and soil cover. Rocky surfaces generate runoff quite well, and where they are located in the upper parts of a slope, runoff can be directed with channels and dykes to the lower reaches of the slope, where mini-catchments of different shapes and sizes can be dug and into which the runoff can be directed. On soil-covered surfaces on generally more gently-graded slopes, contour earthen ridges can be hand- or machine-made, forming ditches on their up-slope sides. The inter-ridge areas function as contributing areas, and the ditches function as sinks. Vegetation planted at the upslope flank of the ridge helps stabilize and conserve the ditch, and can be also used as crop or forage. On a steep slope building horizontal terraces supported by stonework is preferable. On the terrace surface mini-catchments, especially for trees, can be constructed (Figure 14). Terraces are also effective in wadi tips and wide channels. The ridges and terraces not only increase soil storage but also prevent destructive runoff to develop and thus conserve soil or even rehabilitate

Figure 15: Harvested rainwater in depressions in Marsa Matrouh, Northern Egypt.
(From Water Harvesting. Indigenous Knowledge for the Future of the Drier Environments. Oweis et al., 2001.)

degraded soils. Finally, depending on local needs and conditions, runoff can also be directed to surface and subsurface reservoir or for recharging springs, in conjunction or instead of being used for promoting soil moisture storage.

Runoff is also harvested during the rainy season for storage in enclosed, sub-surface water reservoirs such as wells and cisterns, and is channeled in subsurface flows to reservoirs from which it is released as springs. The sub-surface reservoirs of harvested water are used mainly in the dry season as drinking water and for irrigating croplands, and they are critical for sustaining livelihoods during years of low rainfall. Locally harvested water is the only source of water for many of the communities and farmers in MENA and within the five countries that participated in the Initiative. Even among those rural settlements that are connected to a government-provided water grid, locally harvested water often plays an important role in production, even if a proportionately less central role in direct human consumption.

Improving Water Use Efficiency

Watershed management packages such as those which would be introduced during the Dryland Initiative must integrate two related elements: techniques for increasing the amount of runoff harvested, and techniques for increasing the efficiency with which the runoff harvested is used on farms and pastures. The two elements are mutually complementary, since the more efficient farming and rangeland management techniques and practices themselves increased water harvesting and storage. The plants used in these activities both improve runoff capture and benefit from its capture. There is moreover a direct relation between runoff harvesting and soil conservation in which improved biological productivity nourishes and stabilizes soils. *Crop production and rangeland management* techniques introduced may be used to prevent land degradation, and to rehabilitate lands that were already degraded.

Watershed management programs that pursue positive social impacts, and poverty reduction in particular, generally select project sites in relatively poor rural areas. In the Middle East and North Africa the livelihoods of a substantial part of local populations in these areas are based on agro-sylvi-pastoral production systems. The pastoral element of these systems is generally very important, and rangelands in the region are only able to serve as pasture during the brief rainy season. During the rest of the year livestock is fed on stored feeds—stubble, hays, and grains—which are produced during the rainy season. The prevailing climatic variations sometimes enable this farming to generate surpluses as well as to support vegetables and other field crops for subsistence and shorter term income generation.

Tree cultivation is another production system that is both enabled by the increased soil water storage achieved by runoff harvesting, and instrumental in soil conservation. Trees are not an annual crop cultivated only during the short rainy season, but rather must survive throughout the year, the dry season included. They cannot therefore be cultivated in drylands where soil moisture depends entirely on the incidence of rain. But where run-off water infiltrates deep into the soil horizon and is there safely stored—as is the case in the sinks of run-off harvesting systems—trees' deep root systems enable them to flourish even in the most arid drylands. Once established, trees are very effective in soil conservation and hence are recommended for rehabilitating degraded drylands. There they are used in the production of fruits (dates, almonds, figs, pistachio, and olives), gums (acacia), forages, fodders, and fuelwood.

Genetic resources and biological diversity. Loss of biological diversity or "biodiversity" is a fundamental concern in drylands that are subject to degradation, particularly when some proportion of indigenous plants and animals are unique to a particular locality. Biodiversity surveys and inventories and the use of genetic resource facilities like gene banks, botanic gardens, and nurseries are therefore essential elements of dryland resource conservation, and perhaps more urgently than in any other ecosystem. In addition to the conservation of local genetic resources, biodiversity specialists can identify exotic, non-endogenous species for introduction based on their adaptive suitability for local conditions and potential for rangeland restoration, crop improvement, and farm diversification. Experiments with the introduction of exotic species must incorporate concerns over species competition and insurance against alien invasive species. More recently, eco-tourism components have been incorporated, providing another channel of economic returns to biodiversity conservation.

Reusing Existing Water: Wastewater, Drainage Water and Biosolids

Wastewater is water that has been used and then disposed of from domestic sources, either urban or rural, as well as from industrial sources. Wastewater treatment is the process of removing pollutants from water that has been used. Treatment of waste is rooted in the early evolution of human settlements and cities, and was institutionalized by the Roman and Greek empires. As of the 19th Century, when pathogenicity was discovered, wastewater treatment focused on minimizing health risks, primarily infectious diseases. More recently, the treatment was broadened to include chronic health risks and environmental concerns. The resource consists of the water itself and the materials it contains - either pollutants to be disposed of, or solids that may serve a useful purpose. The levels of wastewater treatment and technologies used vary widely, but can be generally classified as primary, secondary, and tertiary.

Wastewater, drainage water, and biosolids are resources of particular importance in dryland areas (Figure 16). They increase the general availability of water beyond what is possible through the primary harvesting of freshwater sources, and they can be instrumental in recycling nutrients to build soil fertility. Domestic sewage is a case in point. Its sanitary removal necessarily requires investment in waste disposal facilities. This investment can be modified to serve not only the purpose of discarding materials, but of turning them into a useful resource – and in a region in which that very resource is manifestly scarce.

There are large volumes of "marginal water" within the five Initiative partner countries. Areas of Egypt, Israel, and Jordan contain large subterranean sources of fossil water as well as very slowly renewed brackish groundwater. These are used heavily for agriculture in Israel, and somewhat less so in Jordan. While fossil water is not wastewater, its use in agriculture bears a significant risk of soil salinization. Drainage is another source of marginal water, consisting of excess irrigation water that is polluted with fertilizer and pesticides and typically relatively high in salinity after it has flowed over and leached into irrigated fields. Reuse of drainage water therefore also carries significant risk of soil salinization.

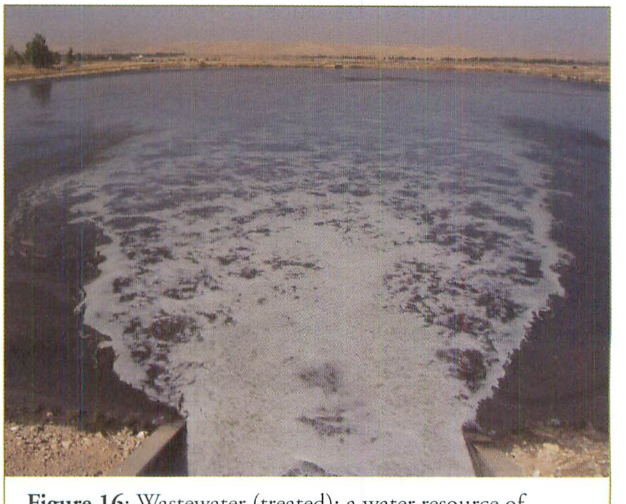


Figure 16: Wastewater (treated): a water resource of increasing importance in dryland areas.

The recycling of treated wastewater and its sludge byproduct addresses both the problem of water shortage and of waste management. These two problems are particularly serious in the Initiative countries, given their population growth, and their proximity to the Mediterranean Sea. Four of the five parties to the Dryland Initiative border the Mediterranean, and all four dump wastewater and sludge into the Sea. This impacts their own marine environment and resources, and violates the Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, to which Egypt, Israel, and Tunisia are signatories.

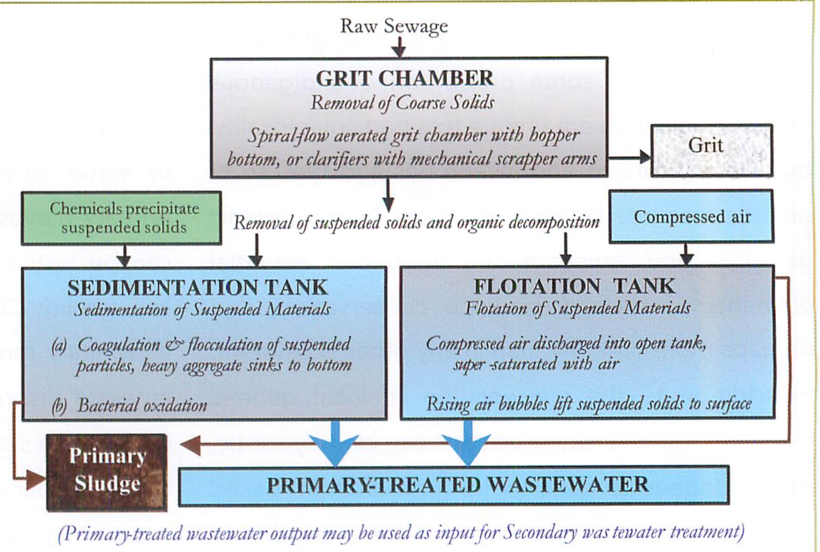


Figure 17: Primary Wastewater Treatment

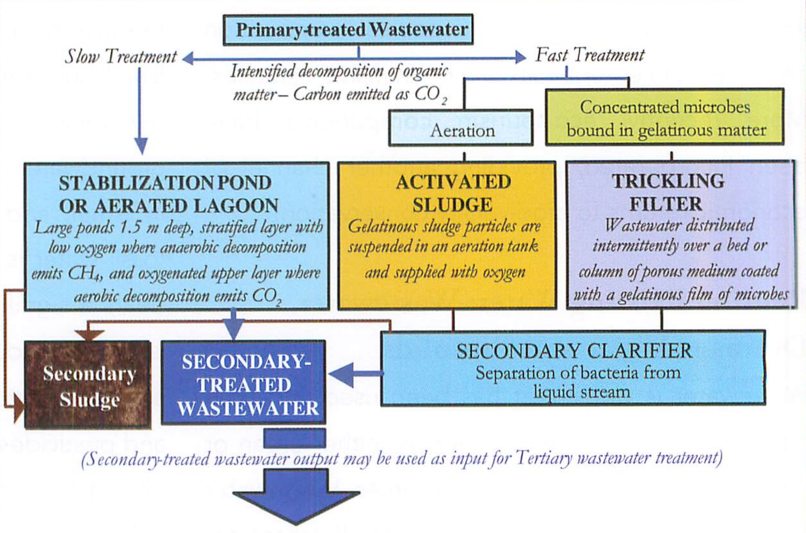


Figure 18: Secondary Wastewater Treatment

Primary treatment (Figure 17) involves removing the largest solids from wastewater and then letting the water settle in tanks so that the smaller solids and particles sink to the bottom. In this way a large proportion of the suspended solids is removed from the water. The solids can then be buried or burned, and the fluid can be released to the environment. *Secondary* wastewater treatment (Figure 18) reduces the amount of organic matter in the water by accelerating natural microbial consumption. This is achieved through aeration or by adding microbes. Bacteria that occur naturally in all moist organic wastes digest (decompose) organic molecules. During the decomposition process the bacteria absorb oxygen with which the organic molecules are oxidized. The carbon in organic matter is oxidized to carbon dioxide, which is released as gas to the atmosphere. The nitrogen and phosphorous components of the organic matter become dissolved nitrates and phosphate minerals. Since this decomposition is driven by oxygen dissolved in the water, the organic content in wastewater is measured by its *biological oxygen demand* (BOD). BOD is routinely monitored to judge the efficiency of the secondary treatment of wastewater. *Tertiary* treatment (Figure 19) removes most chemical compounds from the wastewater. These compounds are mainly nitrogenous and phosphorous. If they remain in high concentration in the released treated wastewater, they encourage growth of photosynthetic micro-organisms in aquatic and moist media. Primary treatment of wastewater typically removes between 25 and 60 percent of suspended solids, and between 60 and 80 percent of minerals and dissolved organic matter. Secondary treatment generally removes between 15 and 40 percent of dissolved organic material and minerals. Tertiary treatment leaves one percent or less of suspended and dissolved organic material, and very low mineral content.

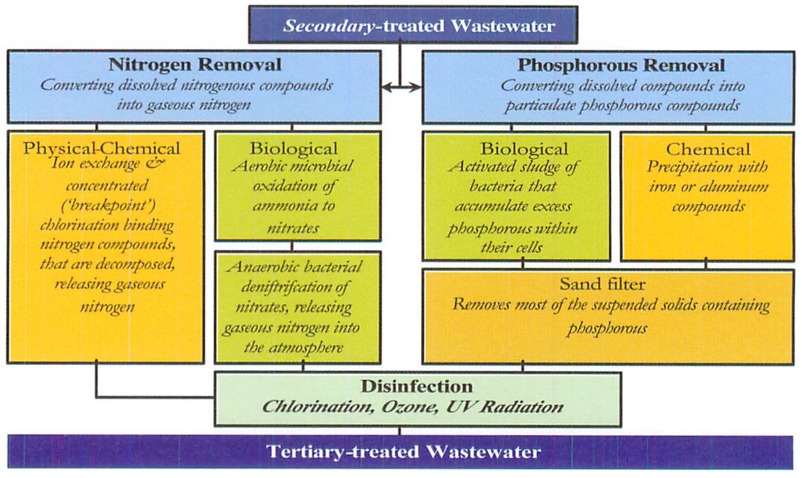


Figure 19: Tertiary Wastewater Treatment

Biosolids are waste of biological origin, and generate serious health and environmental problems. The process of wastewater treatment generates great volumes of bio-solids in the form of sludge. Whereas the water treatment process is mostly engaged with organic matter, sludge accumulates inorganic matter from industrial effluents and other chemicals carried into sewers by storm water runoff from roads and other paved surfaces. These include chemicals toxic to micro-organisms, plants, animals, or people. Sewage sludge also contains pathogenic bacteria, viruses, and protozoa along with other parasitic helminthes, which are also dangerous to humans and other organisms. On the other hand sewage sludge contains nitrogenous minerals (in different concentrations depending on the wastewater treatment level) and phosphorus minerals (usually at concentrations of 50 percent, irrespective of treatment), which are useful for plant growth, as well as organic matter that can increase the water-holding capacity of soils. The availability of the phosphorus content in the year of application is about 50 percent and is independent of any prior sludge treatment.

Sludge can be disposed of or used to improve soils in raw state. Two sludge treatment methods are composting and digestion. *Composting* is a controlled microbial decomposition, encouraged by mechanical mixing, aeration, ventilation, and controlled moisturizing, either in ventilated chambers or in the open air. The high temperature generated by the microbial activity pasteurizes the mixture, which gradually turns into a product quite similar to humus – the fraction of organic matter in the soil resulting from decomposition and mineralization of organic matter. *Digestion* too is a form of microbial decomposition, but is carried out in more anaerobic conditions, often inside of closed tanks known as "digesters." During the process the sludge is first made soluble by enzymes, and then it is fermented by bacteria that reduce it to simple organic acids. These are then microbially converted into methane and carbon dioxide. Digestion reduces organic matter by 45 to 60 percent. In both the composting and the digestion method, the treated sludge is eventually air-dried, by placing it on sand beds in the open or in a greenhouse. The treated, dried sludge can be used as a soil conditioner and crop fertilizer.

II. THE MIDDLE EAST PEACE PROCESS: THE ROOTS AND CONTEXT OF THE DRYLAND INITIATIVE

After decades of Arab-Israeli conflict, the years between 1996 and 2006 saw a variety of undertakings to resolve discord through active cooperation. For some 10 years between 1996 and 2006, the Regional Initiative for Dryland Management (RIDM) (for simplicity will be referred to in this report as the "Dryland Initiative") worked to build bridges of confidence and cooperation between Arab and Israeli technical experts, providing a venue for the creation and exchange of knowledge regarding a subject of common interest; the sustainable management of dryland resources. While the Initiative marked the beginning of technical dialogue and cooperation between Israel and four Arab countries: Egypt, Jordan, the Palestinian Authority, and Tunisia, it was perhaps the least publicized.

A. The Middle East Peace Process and the Conception of the Initiative

In 1978, after three decades of armed conflict between Israel and her Arab neighbors, including four wars, the Camp David Accords paved the way for the first peace agreement between Israel and an Arab country, the Egypt–Israel Peace Treaty the following year. The Accords provided the framework for comprehensive peace negotiations, including negotiations surrounding possible autonomy for Palestinians living in the West Bank and Gaza Strip. More broadly the success of Prime Minister Menachem Begin and Presidents Anwar Sadat and Jimmy Carter in negotiating the Accords established the possibility of normal relations between Israel and Arab countries. The preamble to the Accords expressed the hope that "the vast human and natural resources of the region can be turned to the pursuits of peace so that this area can become a model for coexistence and cooperation." [2]

In the two decades following the Camp David Accords the Arab–Israeli conflict changed substantially, essentially becoming a narrower Israeli–Palestinian conflict. Before the two parties returned to the negotiating table, two major Israeli–Palestinian confrontations would take place during the 1980s: the 1982 war in Lebanon and the first *intifada* beginning in 1987. The environment for negotiation improved following the Gulf War in 1991, with talks between the Arab states, Israel, the Soviet Union, and the United States leading to the Madrid Conference that same year. During the Conference two parallel negotiating tracks would emerge, one bilateral and one multilateral. Bilateral talks would target separate peace treaties between Israel, Jordan, Lebanon, the Palestinians, and Syria. The negotiations with Palestinians targeted interim Palestinian self government in five years, to be followed by negotiations on the permanent status of the West Bank and Gaza Strip. Multilateral negotiations would be carried out by working groups launched in 1992 and devoted to five region-wide issues: arms control, economic development, refugees, water, and the environment. It was the Multilateral Working Group on the Environment (WGE) that would go on to launch the Regional Initiative for Dryland Management.

The Role of the WGE was to identify key environmental problems common to the region and requiring joint action on the part of participating countries. Such joint action was seen as an opportunity to contribute to the peace process through normalized relations and active cooperation – a conception of

2. US Department of State. *Camp David Accords: The Framework for Peace in the Middle East*, September 17, 1978.

'peace' considerably more ambitious than simply an avoidance of war. Several areas of prospective cooperation suggested themselves to the Working Group: oil spills in the upper Gulf of Aqaba, environmentally sound uses of pesticides, and – in line with the then ongoing negotiations that would lead to the creation of the United Nations Convention to Combat Desertification (UNCCD) – dryland degradation. The Working Group was chaired by the government of Japan, and during its third meeting held in Tokyo in May 1993, began developing a proposal identifying desertification as a cross-boundary problem requiring regional cooperation. The proposal was presented and discussed at the Working Group's fourth meeting held in Cairo in November 1993, where Egyptian, Jordanian, Palestinian, and Tunisian delegations agreed to treat degradation-sensitive land management as a theme for technical cooperation with Israel. A series of meetings between technical experts from the five countries ensued between December 1993 and May 1994, and it was during these meetings that a program for the Regional Initiative was developed.

The development of the Initiative's program following the fourth meeting of the Working Group took place in the wake of the Oslo Accords of September 1993, in which Israeli and Palestinian negotiators committed themselves to the Declaration of Principles (DOP) (Figure 20). By this agreement, Israel recognized the Palestine Liberation Organization (PLO) as the representative of the Palestinian people in subsequent peace negotiations, and the PLO recognized the right of Israel to exist in peace and security. The agreement provided for a transitional five year period of Palestinian self-government in the West Bank and Gaza Strip, and for establishing a Palestinian National Authority (PNA) with an elected Palestinian Legislative Council. The completion of the Initiative program document by a joint team of the prospective Initiative's Regional Experts in May 1994 coincided with the transfer of Gaza and Jericho from Israeli to Palestinian self-rule, in compliance with the DOP-inspired Interim Agreement which set forth the future relations between Israel and the PNA.

Figure 20: Arafat and Rabin shake hands after signing the Palestinian-Israeli Peace Accord, September 13, 1993. (from left – Yitzhak Rabin, Bill Clinton, Yasser Arafat).

Additional positive developments in the peace process took place during the period between the completion of the Initiative's program and its adoption by the Working Group in October 1994, effectively stimulating international financial support for the project. A number of significant developments took place while members of the Working Group—the regional parties, the International Center for Agricultural Research in the Dry Areas (ICARDA), and the World Bank—negotiated modes of operation and funding for the Initiative. The first public meeting between King Hussein and Prime Minister Rabin took place in Washington in July 1994 and led to the Israel–Jordan peace treaty which was signed the following October. The treaty included annexes on cooperation in environmental protection, water, and agriculture. In September 1994 the Israeli-Palestinian Interim Agreement on the West Bank and the Gaza Strip was signed in Washington, setting the stage for broadening Palestinian self-government to proceed until May 1999, when a permanent status agreement was to be negotiated. This timetable was intended to provide for a period of gradual reduction in the friction between Israelis and Palestinians, while promoting channels for cooperation and peaceful coexistence. When the sixth meeting of the Working Group convened in Bahrain in October 1994 to adopt the Initiative program—the "Bahrain document"—it became clear that the Initiative was to be implemented during this period set by the Interim Agreement. Preparations for the implementation of the Initiative following the adoption of the Bahrain document benefited from the gradual implementation of the Israeli-Palestinian Interim Agreement.

B. Implementation of the Peace Agreements and the Birth of the Initiative

As preparations to launch the Initiative progressed, the peace process deteriorated ominously and the favorable political climate that had prevailed in 1995 gave way to renewed conflict. Israelis and Palestinians exchanged mutual accusations of breached agreements. These developments seriously undermined the multilateral track of negotiations, which stalled as the Arab League endorsed formal suspension of Arab participation in the Working Group on the Environment in 1997.

The Dryland Initiative itself was formally launched in August 1996, two months after the election of Israeli Prime Minister Binyamin Netanyahu and seven months after the election of Palestinian National Authority President Yasser Arafat. As these political developments unfolded the five countries participating in the Initiative, ICARDA, and the World Bank worked to define the components of the Initiative. Seed money for project preparation was provided by Japan and the World Bank. A *Facilitation Unit* was established and based at the ICARDA office in Cairo. The Unit was headed by an International Facilitator appointed by ICARDA. In two seminal meetings of the five Regional Experts held in Cairo and Amman, elements of the program were consolidated.

The first sign of the effects of the worsening political atmosphere on the Initiative, however, had became evident in the inability to convene the scheduled first technical thematic meeting of the Initiative in Israel. A series of four such technical meetings had been intended to finalize the plans for the Regional Support Programs the respective parties would be responsible for coordinating. The first such meeting was to be held in Israel to finalize the *Economic Forestry and Orchards* program that Israel had been assigned to coordinate. The meeting was cancelled when it became clear that none of the Arab experts could attend. The three other programs, to be coordinated by Egypt, Jordan, and Tunisia, were finalized in three regional workshops held in those countries in May and June 1996. Though Israeli teams actively participated in these regional workshops, the program for the *Economic Forestry* theme was prepared by Israel alone. While all four programs were subsequently approved by the Initiative's Steering Committee in Paris in July 1996, the unavoidable deviation from mutual Arab and Israeli cooperation just prior to the Initiative's kickoff in August 1996 would set the tone of interaction for years to follow.

C. The Ups and Downs of the Peace Process during the Life of the Initiative

Political upheavals severely affected the cooperation planned for the Initiative, and yet neither these upheavals nor funding problems prevented the Initiative from becoming operational in August 1996. The disagreements that would disrupt the peace process during the first four years (Phase I) of the Initiative escalated repeatedly into armed conflict and generated repercussions throughout the Arab world that would seriously impinge upon the

Initiative. In March 1997 the Arab League passed a resolution to ban Arab participation in all multilateral negotiations, and three years later announced a boycott of all international scientific conferences held in Israel. These resolutions prevented Arab partners from visiting Israel – however essential such visits were to the Initiative's own program. Between outbreaks of acute conflict, the first years of the Initiative saw several rounds of negotiations resulting in promising agreements like the 1997 Israel-PLO Protocol Concerning Redeployment in Hebron, the 1998 Israel-PLO Wye River Memorandum, and the September 1999 Sharm el-Sheikh Agreement.

The changing political environment would oblige a more cautious and pragmatic program for cooperation under Phase II, relative to the ambitious design of Phase I which had been conceived in the optimistic period following the Madrid talks and Oslo Accords. The Phase II program was purposefully less bold both with respect to its technical and its political aspirations, such as to assure greater resilience to the vicissitudes of the peace process. The transition between the two phases enjoyed a relatively peaceful and promising lull in the region's violence. Planning for Phase II took place as negotiations were reopened to determine the permanent status of the West Bank and Gaza Strip in September 2000 after a three year hiatus, and as Israel unilaterally withdrew its forces from southern Lebanon. A regional meeting held in October 1999 was the first to be held in Israel and saw nearly full attendance of the participating countries. The meeting was followed by a traveling workshop in which all Phase I sites were jointly visited by members of all five national teams. A final planning workshop in Sharm El Sheikh in February 2000 led directly to the launching of the second phase of the Initiative now shortened to "The Regional Initiative for Dryland Management" (RIDM), in June 2000. The following month saw negotiations on permanent status culminate in the July 2000 Camp David Summit between President Arafat, Prime Minister Barak, and President Clinton. Two months later however the process was derailed as the second *intifada* broke out in September, just as the first Initiative workshop to be hosted by the Palestinian team was being held in Hebron. The workshop in Hebron was attended by all teams, including the Israelis. Phase II would cover a period characterized by widespread violence in the West Bank and Gaza and a series of futile talks including the Taba negotiations in 2001. Hebron would be the only Initiative workshop to be carried out within the five countries during the life of Phase II. The final year of Phase II would see the now defunct Oslo Accords implicitly replaced with the *Roadmap* for resolving the Israeli–Palestinian conflict through a two state solution. The *Roadmap* was proposed by the EU, Russia, UN, and US in April 2003 and accepted by both sides the following month.

An extension of Phase II was recommended by an external review which assessed the Phase II experience. The recommendation was endorsed by the Initiative's Steering Committee in 2003. This "extension of Phase II" became generally referred to as the "Extension Phase" of the Initiative, given its revisions to the Phase II program – these too based on recommendations of the external review. The Extension Phase would be more demanding in its technical aspirations than either of the two preceding phases. It was also more realistic regarding cooperation, increasing the number and diversity of direct interactive activities, while allowing meetings to be held outside the region if need be to ensure the participation of all five partners. The Extension phase was launched in June 2003, coinciding with the Middle East Summit in Aqaba that was hosted by Jordanian King Abdullah II and attended by Israeli Prime Minister Ariel Sharon, Palestinian President Mahmoud Abbas, and U.S. President George Bush. The Summit took place during the *hudna* or cease-fire announced by the Fatah, Hamas, and Islamic Jihad, and once again raised hopes that cooperation within the Initiative might be reinvigorated during this, the final stage of its 10 year life. Once again however such hopes were disappointed as the *hudna* was shattered in September 2003.

In February 2005, Egyptian President Hosni Mubarak hosted a summit meeting in Sharm el-Sheikh, attended by President Abbas, King Abdullah, and Prime Minister Sharon in which measures for ending violence and implementing the *Roadmap* were elaborated. In May 2005 former World Bank President James Wolfensohn was appointed coordinator of the EU-Russia-UN-US "Quartet" for the *Disengagement Plan* by which all Israeli settlements and military personnel were evacuated from the Gaza Strip and sections of the West Bank, thus ending 38 years of occupation.

Political turmoil and periodic, often protracted conflict, impinged on the regional cooperation under the Dryland Initiative. This regional cooperation, however, was maintained at a minimum level throughout the entire 10-year lifetime of the Initiative and the ups and downs of the Middle East peace process. Regular external reviews provided the occasion and analytical substance to adjust the structure and work program of the Initiative to reflect the changing environment in which the Initiative was being implemented.

III. EVOLUTION OF THE THEMATIC AND ADMINISTRATIVE STRUCTURES OF THE INITIATIVE

A. Program objectives and components

The technical objective of the Initiative at inception was "to contribute to the control of natural resource degradation, and, where applicable, to restore productivity of arid lands in the Middle East." This objective had been similarly expressed in a series of Arab-Israeli peace agreements, in which common environmental issues were identified as targets for peaceful cooperation. Several such bilateral agreements were in place. The *Memorandum of Understanding on Agriculture* between Egypt and Israel signed in March 1980 had called for cooperation on "joint applied agricultural arid and semi-arid zone research" and the conduct of joint inventories of wild species.

The Israeli-Palestinian agreement reached at Oslo, the *Declaration of Principles on Interim Self-Government Arrangements*, signed by Mahmoud Abbas and Shimon Peres in September 1993, contained annexes prescribing similar forms of cooperation. Annex IV called for "a regional plan for agricultural development, including a coordinated regional effort for the prevention of desertification" Annex IV 3 of the agreement identified the "various multilateral working groups" as the agents of this regional coordination, working through "inter-session activities" and conducting pre-feasibility and feasibility studies. Annex VI contained a *Protocol Concerning Israeli-Palestinian Cooperation Programs*, which called for "joint effort to combat desertification and encourage the development of agricultural projects in arid and semi-arid areas" (Article V.2.f), and the "development of programs of combating desertification" (Article V.3.b.5).

The Israeli-Jordanian Peace Treaty of October 1994 similarly contained an Annex devoted to *Environment,* calling upon the two parties to "acknowledge the importance of the ecology of the region, its high environmental sensitivity" and to "recognize the need for conservation of natural resources... and the imperative of attaining economic growth based on sustainable development principles" such that "both Parties agree to co-operate in matters relating to environmental protection." The Annex further prescribed combating desertification through the exchange of information and research knowledge and the implementation of suitable technologies (Figure 21).

The multilateral Dryland Initiative therefore shared well-defined objectives and themes with individual bilateral peace agreements between Israel and her neighbors. Desertification was one of a number of closely-related thematic areas to be addressed by regional cooperation on the environment. The August 1993 regional consultative mission organized by the WGE focused on four such themes: *Marginal Water and Saline Soils, Germplasm for Arid Lands, Economic Forestry and Orchards,* and *Rangeland and Livestock Management.* The availability of

Figure 21: Arid drylands in spring flowering; Tunisia (sandy soil).

Figure 22: Gully erosion in an arid rangeland, Negev Desert, Israel.

freshwater for agriculture could be improved with technologies to make marginal water resources like brackish and waste water usable for irrigation. The high incidence of saline soils in the region pointed to the development of salt-tolerant plants through plant breeding and germplasm utilization. Plant breeding would also focus on trees and shrubs used for soil conservation and restoration while providing economic returns from the production of forages, wood products, nuts, and fruits. Management of the region's vast rangelands, the most extensive natural resource in the drylands, would promote the judicious grazing rates calculated to assure sustainable returns. Research, technology sharing, training, and identification of investment priorities were to be undertaken along the lines of these four themes.

National membership in the Working Group on the Environment and its sister multilateral working groups formed at the Madrid Peace Conference was exclusive to countries participating in the Middle East peace process, and the Dryland Initiative was inextricably related to the peace process. Three of the countries that agreed to participate in the Initiative shared borders with Israel: Egypt, Jordan, and the Palestinian National Authority. Tunisia, the only non-contiguous party, joined based on the country's pioneering efforts to resolve the Arab-Israeli conflict during the period leading to Madrid, as well as on shared concerns over dryland resources management.

Once the selection of these five countries was agreed upon, responsibility for the regional activities based on the four themes set down by the WGE would be divided among the parties. The assignment of responsibility for the themes would be determined by the respective themes' prominence in each country, and by an estimation of the expertise on the theme residing in the country. Four thematic Regional Support Programs (RSPs) would be divided among the five parties accordingly.

Egypt, given its rich agricultural experience using dryland-adapted crops irrigated with Nile River water, assumed the role of coordinator of the *Germplasm for Arid Lands* regional program. Israel, renowned for its dryland afforestation initiatives, would coordinate *Economic Afforestation and Orchards*. Jordan, where a large proportion of the population subsist or otherwise rely on livestock, would coordinate *Rangeland and Livestock Management*. Tunisia, which had grappled with problems of soil salinization and low water quality in its southern regions for centuries, would coordinate the regional program devoted to *Marginal Water and Saline Soils*. Finally the PNA, given its recent emergence and urgent need for capacity building, would seek to develop this capacity through joint interaction with experts from the four other countries, participating in all four regional thematic programs simultaneously. Within each country National Support Activities (NSAs) would be organized around all four themes.

The arrangement of thematic Regional Support Programs (RSPs) and corresponding National Support Activities represented the structure with which the Initiative would seek to build mutual trust and confidence and tighten regional cooperation. Regional Experts of the five participating countries first met at the fourth meeting of the WGE in Cairo in December 1993 and would collaborate intensively for five months to define the roles and work programs of the RSPs and NSAs. Each Regional Support Program would undertake analysis of data collected by the five Initiative partners, conduct training and joint study tours, and prepare feasibility studies based on the information collected and exchanged relating to the Program's theme. An additional program would be devoted to capacity building in the West Bank and Gaza Strip. National Support Activities would consist of pilot projects designed to identify suitable forms of investment in the four thematic areas within the particular contexts of the respective countries. The findings of these thematic national-level activities would inform and be incorporated into the formulation of larger RSP thematic strategies.

The development of the regional and national program components along these lines was facilitated by the World Bank, and also benefited from collaboration with the Arab Organization for Agricultural Development (AOAD), the European Union, the UN Food and Agriculture Organization (FAO), the International Center for Agricultural Research in the Dry Areas (ICARDA), and the government of Spain. The involvement and support of these international partners assured a high level of accountability in the overall conduct of the Initiative, and entailed regular reporting, sound management of financial resources, and responsible managerial oversight. It also encouraged the use of participatory approaches to involve local communities in the conduct of the National Support Activities. The capacities of the national institutions responsible for carrying out Regional Support Programs and their corresponding National Support Activities were carefully scrutinized by the national governments. The Regional Experts shared responsibility for implementing RSPs and NSAs with these national institutions, and were supported by a Facilitation Unit for the Initiative that ICARDA established in Cairo. ICARDA also sat on the Initiative's Steering Committee alongside participating country representatives, the Regional Experts, and donor countries and institutions – including the World Bank, which chaired the Committee.

Steering Committee meetings were held once a year, usually in the context of a larger annual meeting known as the Donor Consultation Meeting, which admitted participation by a broader range of interested institutions and countries. During these annual meetings, participants reviewed achievements and discussed and authorized the coming year's program and budget. Phase I of the Initiative was launched in August 1996 with a budget of US$7 million, contributed or pledged by the World Bank, Switzerland, Luxembourg, Japan, the US, the Republic of Korea, and Canada. These contributions and pledges were complemented by in-kind and financial inputs by the five participating countries.

The Initiative was thus served by broad international support and an innovative program purposefully designed to foster bilateral and multilateral technical cooperation between national teams of experts. In practice this scope of cooperation would not be realized. Mutual visitation between NSA and RSP teams was a fundamental guiding principle of technical cooperation set down in the Initiative's design. Thematic Regional Support Programs coordinated by one country were to support corresponding thematic National Support Activities in all five countries. Provision of this support was to take place in very large measure through RSP experts' visits to NSA sites. RSP coordinators were also charged with organizing periodic meetings of all NSA teams working on the RSP's theme, another important mechanism for cooperation. With the exception of three initial planning meetings convened in Cairo, Tunis, and Amman, no such meetings would take place. Annual Steering Committee meetings in Paris thus became the only meetings at which the Regional Experts came together to represent their national teams.

Despite the failure to fulfill the Initiative's optimistic agenda for Arab-Israeli technical cooperation, Phase I of the Initiative did see the implementation of all of

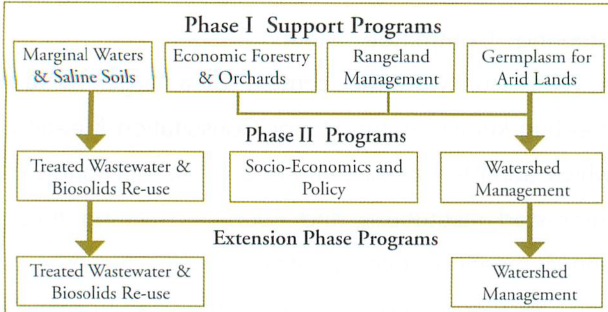


Figure 23: Support Programs of the different phases of the RIDM

the thematic NSA programs in each of the five partner countries (Figure 23).

Marginal Water and Saline Soils national activities operating within the Tunisian-led regional program tested and demonstrated the effects of irrigation using marginal waters on crops in Egypt, Israel, the PNA, and Tunisia. The effects of marginal water applications on fodder plants and fuelwood plantations were also studied by Jordanian and Tunisian NSAs. The Egyptian *Marginal Water and Saline Soils* program experimented with applications of mixed brackish, drainage, and treated wastewater, and the Tunisian NSA experimented with treated surface wastewater. Israeli national support activities used marginal waters for subsurface drip irrigation, and applied disinfected drainage water in greenhouses. PNA national activity trials experimented with wastewater treated in duckweed ponds. Jordan's NSA worked with biosolids and wastewater plantations. Saline soils were however not taken up by any of the national support activities under the Marginal Water and Saline Soils theme.

National Support Activities relating to *Germplasm for Arid Lands* took up a variety of experiments relevant to the regional program coordinated by Egypt. Egyptian and Jordanian NSAs undertook inventories of plant biodiversity in rangelands to identify indigenous forage, medicinal, herbal, and aromatic plant species. The Egyptian NSA also explored the development of techniques for propagating useful shrubs in nurseries. The Tunisian national activity treated the development of *in-situ* methods of conserving range species and endangered varieties of fruit trees within reclaimed run-off harvesting systems. The Israeli *Germplasm* team tested forage species for genetic variability along the aridity gradient.

NSAs relating to the Israeli-led *Economic Forestry and Orchards* RSP included the development of systematically monitored water harvesting systems combining livestock, fodder, and fuelwood production in Israel (Figure 24). The Jordanian NSA focused on the development of methods for regenerating natural oak forests. The Egyptian NSA experimented with water harvesting techniques for optimizing yields and increasing incomes using a variety of land use designs employing differing proportions of area allocated to the production of fruit trees, wood trees, shrubs, and fodder production.

Jordan coordinated the *Rangeland Management* RSP of the Initiative, which Egyptian and Tunisian NSAs pursued through the propagation of range shrubs and which the PNA pursued through the support of fodder, shrub, and tree species. Every party in the Initiative examined the potential roles of seed collection and sowing in improving rangelands.

Figure 24: Afforestation – saplings on large earth dykes, protected by plastic cylinders from browsing by livestock; Israel

Jordan's own activities tested and demonstrated water harvesting techniques to improve indigenous range species. The Tunisian NSA focused on planted range species.

Phase I of the Initiative suffered from a number of shortcomings. Whereas the Initiative was designed to treat desertification using integrated multi-disciplinary approaches, its actual implementation tended to address desertification as a technical problem, largely neglecting socio-economic and policy factors that contribute to land degradation. Priority was therefore generally given to the elaboration of technical solutions, with significantly less focus on the role of local populations in project areas, including their customs, needs, and tenure status. In order to quickly achieve visible results, incentives for participating farmers were often artificially and unrealistically raised, in some cases covering all investment costs for land preparation, seedlings, irrigation, and other inputs. Results in the field therefore often failed to establish whether an investment was economically feasible, self-sustainable, or socially acceptable to target groups. Most NSAs were moreover carried out on relatively small areas and involved very small target groups, making it difficult to calculate the potential for scaling the projects up spatially or among larger groups.

NSAs also tended to be carried out by practitioners of a particular specialization rather than by multidisciplinary teams. NSA teams tended to view land degradation strictly in terms of agricultural development, applying a flawed notion of dryland ecosystems' natural stability. Drylands in fact are inherently unstable, with naturally high variability between years. Several NSAs therefore attempted to reverse degradation where in reality it did not exist, but rather conditions at the time reflected a cyclical low point in the area's biological productivity. The overemphasis on agricultural solutions led NSAs to neglect alternatives to agriculture. Tourism for instance is growing in a number of areas in the five countries, and recreational uses of local ecosystems may well be less degrading to the resource base and more economically viable than agriculture or livestock production. The agricultural solutions that NSAs did arrive at tended to underutilize existing knowledge sources and the experience accumulated in earlier projects carried out in their countries.

Figure 25: A new cistern built by the Initiative in the Jordanian rangeland

Phase II saw a change in the Initiative's formal designation. The original title, the "Initiative for Collaboration to Control Natural Resource Degradation (Desertification) of Arid Lands in the Middle East," was replaced by the "Regional Initiative for Dryland Management" (RIDM). The change of orientation from *desertification* to *dryland management* reflected a broader conception of dryland resources that transcended the narrower dimension of land degradation. A new program structure was developed in the year leading up to the transition from Phase I to Phase II in 2000. This transition period saw a brief spike in regional cooperation that had been lacking during most of the life of Phase I. A series of five national planning meetings took place in the respective participating countries between November 1998 and March 1999, as Phase I was approaching completion. The five national planning meetings used a participatory workshop format based on GTZ's participatory *Oriented Project Planning* (ZOPP) model, and included national stakeholders outside of Initiative teams. In June 1999 an External Review Mission visited all Initiative sites and interviewed NSA teams and other stakeholders, submitting a comprehensive report to the Steering Committee in September 1999 recommending that planning for Phase II should begin. A planning meeting of all Initiative teams took place the following month in Israel, the first time that every Initiative party came together to meet in Israel. In January 2000 Initiative teams participated in a traveling workshop that visited Phase I sites in each partner country. The transition period culminated in February 2000 with a joint planning ZOPP-guided workshop of all country teams in Sharm el Sheikh, where a detailed Phase II plan was agreed upon. The plan was presented and endorsed at the Steering Committee meeting in Paris in June 2000. Phase II—the RIDM—was launched the following month.

Phase II was designed to shift the Initiative's emphasis away from relatively discrete, self-contained technical projects and toward more mainstream projects that were embedded or "anchored" within larger national development programs. Non-Initiative national project teams would be encouraged to design projects to produce results of greater regional significance, and more suitable for the exchange of information and technical cooperation. *National Coordinators* would replace the Regional Experts employed in Phase I and National Management Committees would bring together National Coordinators and colleagues representing national projects, within which Initiative projects would now be anchored.

The design of Phase II also reflected recognition of the fragility of the peace process and of the limits that political concerns impose on collaboration between team members of different nationalities. (Most RSP and NSA team members were after all employed by their respective governments.) While the promotion of technical cooperation between Arab and Israeli counterparts remained the *raison d'etre* of the Initiative, Phase II was designed with contingency elements to allow for possible interruptions to the peace process. Regional cooperation would be channeled into a set number of meetings held at sites of mutual convenience, including sites outside the region.

Phase II was organized into three programs: *Watershed Management* (WSM), *Treated Wastewater and Bio-Solids Use,* and *Socio-Economy and Policy* (SEP). Linking these three thematic elements together would make Phase II substantially more multidisciplinary than its precursor, and was intended to achieve greater integration of biophysical and socioeconomic work.

Watershed Management programs continued and elaborated on the work of the germplasm, forestry, and rangelands thematic programs and activities of Phase I. Watershed Management would focus on the use of water harvesting practices in cultivating a range of agricultural, horticultural, and forage plants (Figure 26). Community demonstration sites involved in the Egyptian, Jordanian, and Tunisian programs experimented with forage species, cereals, olives, and almonds. New forage species were introduced in the Jordanian and Tunisian programs,

Figure 26: Contour terraces in a Wadi; West Bank.

and the Jordanian program demonstrated the use of feeding blocks and animal sheds in curtailing overgrazing in protected areas. The PNA program worked on the regeneration of natural forages and the Israeli program focused on afforestation species. The use of nurseries for propagation of a variety of plant species for transfer to local communities was undertaken in Egypt, Jordan, the PNA, and Tunisia. The cultivation of herbal and medicinal plants was promoted in Jordan.

Treated Wastewater and Biosolids Re-use programs built on the work of the Phase I Marginal Waters NSAs and were likewise introduced in all five countries. The Israeli and Tunisian programs experimented with tertiary treatment. Egyptian, Israeli, and Jordanian programs experimented with secondary treatment, and the PNA program addressed both primary and secondary treatment. These different quality water sources were applied to an array of crops and soils.

Socio-Economy and Policy programs carried out a number of cost-benefit analyses of water harvesting techniques in Egypt, Israel, and Jordan. The Jordanian National Coordinator co-authored several governmental policy documents, and an Israeli Team Leader was a member of an inter-ministerial policy forum charged with setting standards for treated wastewater and with developing a suitable wastewater pricing policy based on these standards. The Palestinian National Coordinator attended all regional Initiative meetings accompanied by the Director General of the PNA Environment Ministry, suggesting that the meeting proceedings had the attention of a senior policy maker. Neither the cost-benefit analyses nor the participation of important officials, however, fulfilled anything close to the broad policy studies which had been planned under the program, and which were supposed to be instrumental in guiding national policy-making.

At the national level, embedding Initiative activities and projects into existing national development projects and programs created considerable confusion. Since all National Coordinators and team leaders were government officials or government appointees, it became difficult to say whether an Initiative activity was *coordinated with* or was *part of* the national project within which it was anchored. Despite the outward-looking mandate to relate Initiative activities more directly to national or bilateral projects, such integration and coordination was generally low in all five countries.

The question of whether the Dryland Initiative should itself be allowed to expire at the end of its second Phase was discussed during a second external review in December 2002 and January 2003. The weaknesses of Phase II were to some extent attributable to exogenous political events, and the external review concluded that an initiative designed to increase regional scientific collaboration within the context of the Middle East peace process is intrinsically worthwhile, regardless of whether the peace process itself is advancing or deteriorating. Indeed, the availability of such channels of communication is very arguably *more* valuable and urgent during difficult times, and is worth having readily in place for when relations improve.

On technical grounds, too, the external review found compelling justification for extending the Initiative for two years beyond the conclusion of Phase II in June 2003. Issues of dryland management had clearly lost none of their significance since the inception of the Initiative. Water management issues persisted with glaring urgency, and were shared by all five Initiative partners and by other countries in the region. The depletion of land and water resources among the five parties and in MENA clearly persisted at the end of Phase II, and issues of sustainability were by no means resolved despite the accomplishments of the Initiative. Nor had a sufficient or satisfactory picture of environmental, social, or economic policy impacts been assembled. Knowledge sharing initiatives were found to be particularly important to avoid redundancy and inefficiency in conducting national research programs.

Based on the external review recommendations, a two-year extension of Phase II was designed, approved by the Steering Committee in June 2003, and launched the following month, covering the period through December 2005 with legal closure in April 2006.

The design of the Extension mainstreamed the socio-economic and policy work into the *Watershed Management* and *Treated Wastewater and Biosolids Reuse* themes, leaving two technical programs to be carried out by regional teams that would meet twice a year. Again, meeting venues outside the region were deemed permissible if necessary to assure participation by all five Initiative parties. During these *Regional Thematic Workshops*, also attended by external thematic experts, progress reports were presented and reviewed and work programs were discussed. In addition to these Regional Thematic Workshops, a similar number of *Regional Capacity Building Workshops* were to be held in venues outside the region.

The Extension's program was less ambitious than the designs of the two preceding phases both in terms of regional cooperation and technical objectives, representing further modification to allow for political contention and confrontation. In fact all workshops convened during the Extension would take place outside the region. In the end, the eight thematic workshops and three capacity building workshops were attended by all Initiative partners despite further deterioration of the peace process. The atmosphere in the workshops was collegial and saw substantial exchange of technical advice and information. Workshop recommendations however were seldom implemented in the field by national technical teams, and projects continued to operate as independent "islands". This was surprising, given that technical activities had been clustered into "sub-projects" according to common interests shared by all five partner countries as expressed during the program planning workshop held in Geneva in April 2003.

The *Watershed Management* program saw an extensive range of projects and activities during the two year Extension Phase. Egyptian Watershed Management projects and demonstration activities applied advanced irrigation, fertilization, and seed treatment methods in a variety of farming systems. Seedlings and saplings propagated in nurseries were distributed to farmers, and training courses were carried out for local stakeholders. Botanical surveys of rangelands and studies of agro-pastoral systems were conducted in Egypt, the PNA, and Tunisia and detailed field guides were compiled. Interviews with Egyptian land users and cost-benefit analyses of farming practices were used to evaluate the socio-economic impacts of alternative interventions. Egyptian and Jordanian teams surveyed and undertook rehabilitation of wells and cisterns, and parallel activities in the PNA related to the rehabilitation of springs. Israeli Watershed Management activities continued to focus in large measure on afforestation, and experiments were conducted on different methods to reduce evaporation from surface soils. The Israelis used simulated rainfall in a number of field experiments, and worked to construct the water balance of an afforested watershed (Figures 27 and 28). Non-timber services of forests, including biodiversity conservation and carbon sequestration were also treated by fieldwork in Israel. Jordanian Watershed Management activities demonstrated the results of experiments with runoff water harvesting techniques adapted for a variety of soil types, landforms, and land uses, including rangelands. Work on restoring rangeland productivity by reducing grazing pressure continued in both Jordan and Tunisia. Other fieldwork in Jordan related to milk marketing by rangeland users. Conservation of plant materials took place in botanic gardens in the PNA, and in gene banks in Tunisia. In addition to reducing grazing pressure, Tunisian work on rangeland restoration introduced irrigated plants to stabilize sandy soils. The PNA carried out a number of Watershed Management public awareness campaigns.

The *Treatment of Wastewater and Biosolids Reuse* program saw Egyptian teams work on the reuse of treated wastewater, drainage water, and composted sludges and manures – monitoring the effects of their application to soils and a variety of cereals, vegetables, and fruit trees, including sugar beets. Egyptian experts also monitored the effects of irrigation using mixtures of freshwater and drainage water and of treated biosolids on a variety of vegetables, legumes, and medicinal plants. Different types of marginal, saline, and polluted water and fertilizers and biosolids were applied in Egyptian field, greenhouse, and lysimeter experiments.[3] Egyptian, Jordanian, Palestinian, and Tunisian activities experimented with a number of manure qualities and alternative composting methods. The Egyptian and Jordanian work in this area included series of economic evaluations and cost-benefit analyses of a variety of applications and application methods. Egyptian teams also established training centers and undertook extension activities related to this theme, similar to the training programs established under Watershed Management. Egyptian, Palestinian, and Tunisian teams all conducted studies on the public acceptability of these practices, and Palestinians made wastewater and biosolids reuse the subject of a public awareness campaign. The PNA also built and demonstrated a number of biogas units. Israelis produced guideline sheets detailing the risks of irrigation using treated wastewater. Social, economic, and political analyses undertaken by Israeli teams produced recommendations for standards and pricing policies for treated wastewater allocated to farmers. Israeli monitoring activities

Figure 27: Measuring rainfall and the resulting surface runoff generated by the forest surface; Yatir forest; Israel.

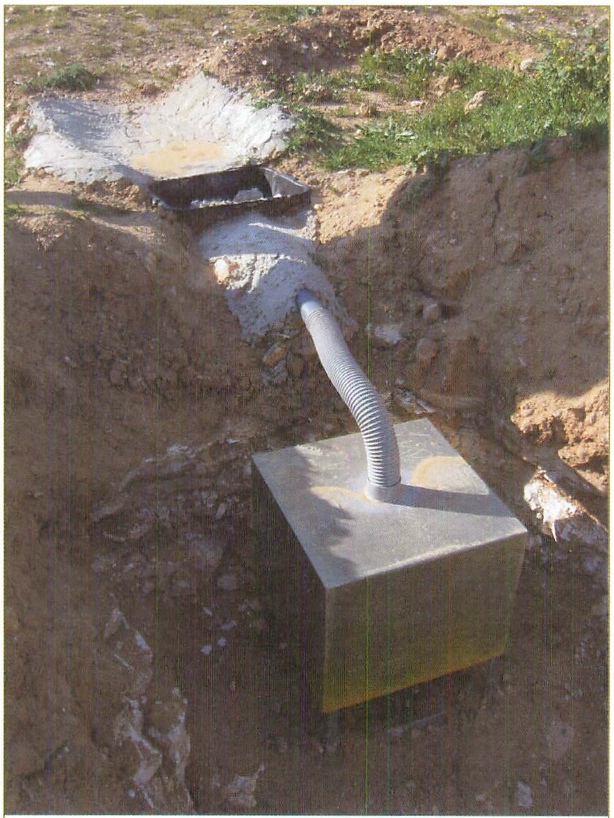


Figure 28: Water collection and measurement through tipping buckets (inside box); Israel.

3. A lysimeter is a container enclosing a column of soil, equipped with devices for sampling and monitoring the movement of water and chemicals through the soil column.

concerned longer term effects of experimental irrigation using treated wastewater and biosolids on soils in orchards and farms growing cereal crops. Jordanian monitoring activities concerned the effects of irrigation using wastewater on aromatic and medicinal plants and on trees. Tunisians monitored the effects of irrigation using tertiary-treated wastewater on cash crops, and the effects of irrigation using secondary-treated wastewater on cereals, forages, and fruit trees. A new wastewater treatment plant was also built and tested in Tunisia.

B. The Participating Institutions

The national institutions responsible for carrying out Dryland Initiative support programs, projects, and activities were appointed by the respective governments to which they belonged. This varied between the five partners according to which ministry or agency represented the country in the Multilateral Working Group on the Environment. Agriculture ministries assumed this role in Egypt and Jordan; Egypt's Ministry of Agriculture and Land Reclamation, and Jordan's Ministry of Agriculture. Environment ministries served as Initiative focal points in the PNA and Tunisia, and in both instances underwent transitions as new ministries and agencies replaced their successors. The Palestinian Environment Agency originally assumed the role of Initiative contact, before being reorganized as the Ministry of Environmental Affairs, and finally the Environmental Quality Authority. In Tunisia, the *Ministere de L'Environnement et de L'Amenagement du Territoire* first assumed responsibility for conducting Initiative activities before being replaced in this role by its successor the *Ministere de L'Environnement et du Developpement Durable*. In Israel the Ministry of Foreign Affairs was assigned responsibility for the conduct of Initiative activities. The wide range of technical issues to be addressed by Initiative field activities would require these lead ministries to rely extensively on national research institutions, and to commission or sub-contract substantial parts of the necessary field work.

In Egypt, the Agricultural Research Center (ARC) – the principal agency for technology generation under the Ministry of Agriculture and Land Reclamation – became responsible for the technical field work under the Initiative. Among the 16 research institutes attached to the ARC, the Soil, Water, and Environment Research Institute (SWERI) – charged with improving agricultural productivity and monitoring soil and water pollution and their impacts – was deeply immersed in the Marginal Water and Saline Soils and the Treated Wastewater and Biosolids Reuse themes. Its activities relate principally to the Nile Delta, though it commissioned the Desert Research Center (DRC) to undertake Initiative activities related to water and land resources in deserts away from the Nile Valley, including biodiversity. Members of the DRC were also involved in the Germplasm for Arid Lands program, and some components of the Egyptian Watershed Management program.

The Jacob Blaustein Institute for Desert Research (BIDR) at Ben Gurion University of the Negev served as the implementing agency for Initiative activities in Israel. The Institute sub-contracted the Treated Wastewater and Biosolids Reuse program to the Ministry of Agriculture's Regional Rural Extension Service for Land and Irrigation, owing to the Service's extensive involvement in that theme.

In Jordan, the Rangeland Department in the Ministry of Agriculture was responsible for Initiative-related activities and carried out much of the range management program with their own technical staff, but commissioned elements of the program to the semi-autonomous National Center for Agricultural Research and Technology Transfer (NCARTT). NCARTT was also responsible for the Germplasm for Arid Lands program, and elements of the Economic Forestry and Orchards, Treated

Wastewater and Biosolids Reuse, and Watershed Management programs. In addition, the Jordanian *Royal Society* for the Conservation of Nature was involved in biodiversity and protected areas issues addressed by the Jordanian Initiative teams.

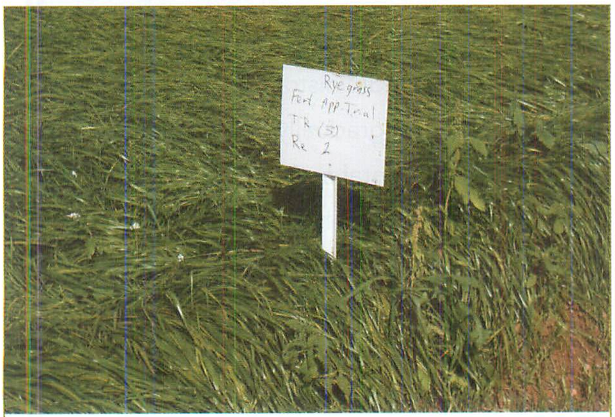


Figure 29: Experimental production of Rye Grass; Jordan.

In the Palestinian Territories, the Palestinian Institution for Arid Lands and Environmental Studies (PIALES) was responsible for program management and technical implementation. PIALES was subsequently renamed the Palestinian Environmental Authority (PEnA), and finally the Environmental Quality Authority (EQA).

In Tunisia, collaborating institutes administered under the *Ministere de l'Agriculture* included the *Centre International des Technologies de l'Environnement de Tunis* and the *Office Natinale de l'Assainissement*, the *Institut National de la Recherche en Génie Rural Eaux et Forêts* and *Direction General des Forets*. Other collaborating institutes included the *Insitut de Regions Arides* and the *Commissariat Regional de Developpement Agricole*.

The fact that the institutions participating in the Initiative were generally government institutions carried a number of drawbacks, despite the merits of government commitment implicit in the arrangements. Little if any outsourcing took place, and because government employees charged with the conduct of Initiative activities were usually not relieved of their existing duties outside the Initiative, their ability to focus on work under the Initiative was limited. When their Initiative and non-Initiative duties did not overlap or relate to each other, Initiative responsibilities tended to assume less priority. When Initiative and non-Initiative work was more closely related, greater commitment to Initiative activities was apparent, though differentiating the results and value added from Initiative and non-Initiative work became difficult. The status of technical experts as government officers clearly limited their independence and freedom from outside political constraints, from their obligation to follow official policy to formal restrictions imposed on communication with foreign counterparts. Involvement in the Initiative by independent non-governmental professionals, which would not have shown these constraints, was very limited.

C. Program Management

In response to the request by the Multilateral Working Group on the Environment and as subsequently approved by the Initiative's donors, the World Bank assumed overall responsibility for the Initiative. Based on consultations between the Bank and the five participating governments, ICARDA was selected as the implementing agency on the Bank's behalf, bearing the sole responsibility for the implementation of the work program, including procurement and financial management, and hence was the principal interlocutor for the five national partners. The World Bank administered and transferred to ICARDA the grant funds received from donors and from its own resources. The highest authority for program design, monitoring, and budgeting was the Steering Committee (SC) which was composed of the five partner countries, ICARDA (as the implementing agency), the World Bank (as Chair of the SC, Trust Fund administrator, and donor), other donors, and the two gavelholders Japan and the USA. The SC met in the context of a broader Donor Consultation Meeting, usually held annually at the Bank's office in Paris in June. The Donor Consultation Meetings served as an international forum for the technical review of the work program and achievements, with budgetary and other management decisions subsequently taken by the SC. While these annual meetings served as the principal instrument for program supervision, the World Bank advised program implementation between meetings, ensuring compliance with Grant Agreements and SC decisions.

ICARDA's Cairo office hosted the Initiative's Facilitation Unit (FU) which was headed by an International Facilitator and was staffed with administrative and financial officers. The International Facilitator was directly responsible for Initiative administration, management, technical advice, and coordination. Four such Facilitators would serve in this capacity over the life of the Initiative, each experienced in agricultural research and extension in the Middle East. ICARDA's "Facilitation" essentially consisted of technical and managerial support to the country parties, which in turn were expected to "own" and manage the Initiative within the five countries, though in practice the Facilitation Unit's coordination role went somewhat further. The FU organized the regional meetings and workshops, commissioned the parties' national technical and financial reports, disbursed funds to the parties, inspected the activities in all the countries during site visits, meetings, and in regular phone and electronic communication. The Facilitator also hosted the supervision and review missions sent to the partner countries to visit sites, institutions and governments. The Facilitator—along with the Regional Experts—reported to the Steering Committee, and was directly responsible for overseeing the implementation of all decisions taken by the Steering Committee.

The Regional Expert – later termed National Coordinators – were appointed by their respective governments and were responsible for assembling and coordinating national teams, allocating funds received from the Facilitation Unit, and monitoring the performance of the national activities. In Egypt, Israel, and Jordan, they were paid an honorarium for their work under the Initiative, which was in addition to their existing obligations, and was intended in part to offset administrative costs. In the PNA the position was gradually mainstreamed in the national environmental authority where the National Coordinator in the last phase of the Initiative became a full staff member paid by the authority. In Tunisia, the National Coordinator was a governmental employee from the start who managed the work load as long as disbursements were limited. Towards the end of the Initiative, when speed of implementation and the number of transactions increased, Tunisia decided to recruit a short-term consultant (equivalent to the payments to the NC in other countries) to support the management of the Tunisian program.

In Phase II National Coordinators were required to appoint and to chair a *National Management Committee* composed of team leaders, stakeholders, and representatives of institutions directly or indirectly involved in the Initiative. National Management Committees were responsible for facilitating cooperation between the different national teams, and promoting the involvement of local stakeholders in national activities. They were charged with monitoring the impact of these activities, and requested to minimize overlap with other, non-Initiative national programs. National Coordinators were to present the National Management Committees with reports detailing completed activities, and to submit plans for future activities for Committee approval. Information on the actual functioning of the Committees is however limited, and the ultimate significance of their roles in carrying out the Initiative remains unclear.

Review and supervision missions from outside the region monitored and evaluated performance regularly throughout the life of the Initiative. World Bank supervision missions – conducted in close collaboration with ICARDA's FU – took place at least once every year, visiting the FU, field sites, and the national institutions responsible for the Initiative's conduct in-country. The World Bank also commissioned external reviews by independent experts three times during the life of the Initiative. These reviews provided the occasion and analytical substance to adjust the structure and work program of the Initiative to reflect the changing environment in which the Initiative was being implemented, resulting in the Initiative's three "Phases".

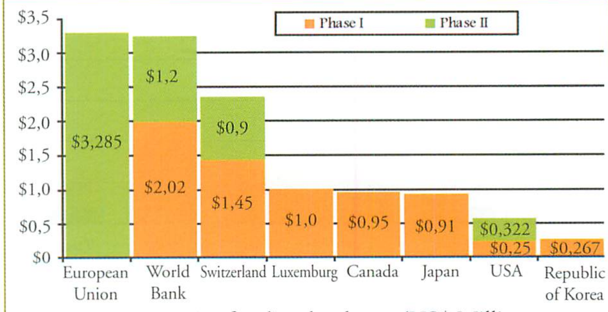


Figure 30: Initiative funding by donor (US$ Millions equivalent). Phase I includes the "transition" period between Phase I and Phase II, and Phase II includes the Extension period.

D. Donors and Partners, Financing and Budgeting

Eight donors together provided US$12.5 million grant funding to the Initiative (listed in alphabetical order): Canada, European Union, Japan, Luxemburg, Republic of Korea, Switzerland, USA, and the World Bank. Canada and Japan elected to provide support bilaterally rather than through the Facilitation Unit. Canadian investment was provided through Agrodev and CIDA, and supported Jordanian projects. Japanese funds directly supported projects in the PNA and Tunisia, in addition to providing initial seed funding for the Initiative itself. The five partner countries themselves provided in-kind support to match donor contributions.

While overall support to the Initiative during Phase II fell to US$5.7 million from the $6.8 million provided in Phase I, the composition of donors changed substantially over ten years. Only Switzerland, the US, and the World Bank supported both phases, including the Extension of Phase II. Canada, Japan, Korea, and Luxembourg contributed funds only during Phase I. EU support was exclusive to the Extension Phase (Figure 30).

The allocation of funds between countries and programs changed substantially between Phase I and Phase II. In Phase I funds allocated to the Regional Support Programs (RSPs) were clearly distinguished from those allocated to the National Support Activities (NSAs). 28 percent of multilateral funds went to RSPs, 44 percent to NSAs – the remaining 28 percent went to overall project management by the Cairo-based Facilitation Unit. The possibility of donors earmarking funds to specific countries or Initiative components led to large disparities. Most donors were reluctant to fund Israeli and Tunisian national activities based on their relatively high gross domestic product – Tunisia would ultimately receive support for its RSPs and NSAs, while Israel would receive funding only for its RSPs. Switzerland earmarked its entire contribution to RSPs (Figure 31).

Budget allocations for the three year period of Phase II were intended to bring greater balance to the distribution of international contributions. The Facilitation Unit maintained responsibility for the

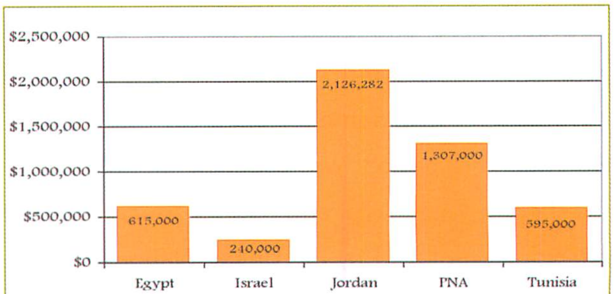


Figure 31: Phase I Funding by Recipient Country (excluding Facilitation Unit).

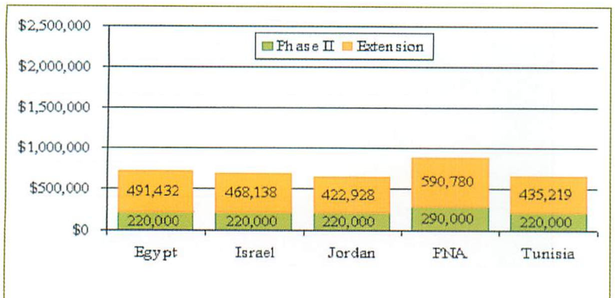


Figure 32: Phase II Funding by Recipient Country

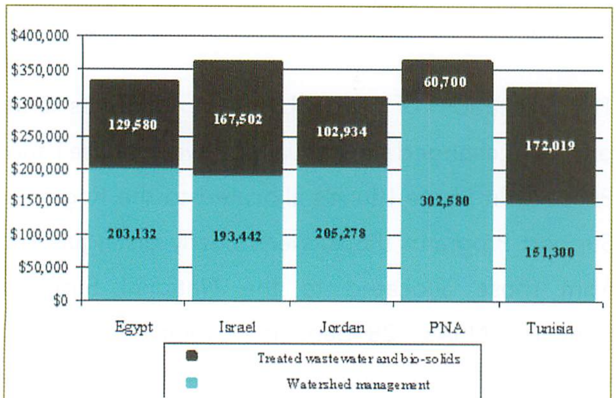


Figure 33: Extension Phase 2003-20005: Funding by Theme

regional budget. Budgeting for national Watershed Management, Treated Wastewater and Biosolids Re-use, and Socio-Economic and Policy programs was allocated fairly evenly. Palestinian national programs received higher allocations to provide for greater capacity building (Figures 32 & 33).

E. Relationships with Other Regional Programs

The Dryland Initiative was not the only multilaterally-supported, multinational program that was operational in the Middle East and North Africa between 1996 and 2006. A number of parallel programs addressed issues related to the environment-development nexus in the region, whether the region was defined as MENA or the larger West Asia and North Africa (WANA) definition employed by the United Nations and the Consultative Group on International Agricultural Research (CGIAR). Some of these programs aimed at promoting Arab-Israeli peace as well. Yet the Initiative found few opportunities to interface with other programs, which in several instances were operational in the near vicinity of Initiative activities. Comparing the Initiative with some of these different initiatives yields insights that suggest the limitations and setbacks experienced during the conduct of the Initiative were by no means exclusive to it.

The UN Convention to Combat Desertification (UNCCD) conducted a *Joint Study of Desertification Risks in the Wadi Araba Rift Valley* in 1994, a joint one-year Israeli– Jordanian–Palestinian undertaking that was substantially inspired by the Oslo Accords. The Swiss-funded study represented the first ever joint Arab-Israeli project on desertification, and was in several respects a precursor to the Initiative. The three national project leaders appointed by Israel, Jordan, and the PLO would all go on to become Initiative Regional Experts. The Wadi Araba section of the Rift Valley is shared by Israel, Jordan, and the Palestinian Territories and the study undertook a survey of the area looking for indicators of desertification risk. Joint tours of the respective parties' study areas and a number of mutual visits led to a report encompassing a package of 15 joint project proposals. The report was presented at a joint meeting in Amman, where it was considered by a number of prospective donor countries and UN organizations.

The success of the *Joint Study* was admittedly attributable in some measure to the "peace euphoria" prevailing during the project's implementation, which was completed well before the upheavals the Initiative would have to contend with. It was also of course far smaller in scope and duration than the ten-year, five-party Initiative. Yet other contrasts between it and the Initiative may be informative. The Joint Study project had no facilitator, implementing agency, task managers, or steering committee. Once the parties signed the project agreement, the project leaders and teams would not see the Swiss underwriter or the UNCCD officer who arranged the financing and negotiations again until the end of the project. It is important to qualify that this participatory element applied in no way to *Joint Study* planning. The Study's program document was prepared by the Intergovernmental Negotiating Committee that negotiated the UNCCD's establishment, with the assistance of a consultant recruited from within the MENA region – a decidedly non-participatory planning process.

This initial success of the UNCCD in masterminding a joint regional project addressing a cross-boundary shared ecosystem was very likely instrumental in prompting the UNCCD Secretariat membership in the Multilateral Working Group on the Environment, and to send representatives to most Initiative Steering Committee meetings. Initiative participation in UNCCD programs on the other hand never materialized. A meeting between the Regional Experts and UNCCD officials was held in Geneva in April 1998 to discuss opportunities for UNCCD – Initiative cooperation, but no such cooperation ever did materialize.

According to UNCCD criteria and definitions, Israel would be classified as a *developed desertification-affected country*, and would therefore be responsible for implementing its National Action Plan on desertification using its own means. This would distinguish Israel from *developing affected countries* like Egypt, Jordan, the PNA, and Tunisia, which were expected to pursue partnerships with a donor country to support them in implementing their National Action Plans. Nor was Israel accepted in either the Convention's *Regional Implementation Annex for Asia* or its *Regional Action Plan for Asia.* Israel was therefore a Party to the Convention without membership in any of the Convention's Regional Implementation Annexs. The country could therefore not be active in the Convention at the regional level, but only at its own national level. This effectively prevented the Convention Secretariat from being active in the Dryland Initiative, despite its membership in the Initiative Steering Committee.

UNCCD activities under the *Fourth Thematic Programme Network on Water Resources Management for Agriculture in the Drylands* would have provided an exceptionally strong topical interface with the Dryland Initiative. The Syria-based *Network* explored methods to rehabilitate degraded soils and to prevent soil salinization in West Asia. The *Network* functioned within the UNCCD *West Asia and North Africa Sub-Regional Program to Combat Desertification*, with overall implementation coordinated by ICARDA. Yet the opportunity lost by the absence of any Dryland Initiative interface with the Network was limited in consequence, since Network activities were limited to conferences, without funding and with no joint action on the ground.

Within the multilateral peace process itself, the Working Group on the Environment's sister *Multilateral Water Resources Working Group* established the *Middle East Desalination Research Center* (MEDRC) in Muscat in December 1996. The Center's founding members were Oman, Israel, Japan, the EU, the Republic of Korea, and the US, which were joined by Jordan, the PNA, and the Netherlands on its board of directors. The MEDRC is an international non-profit organization funded mainly by Oman, with a requirement that project funding be matched by another donor. It has been active since its establishment, irrespective of the status of the Multilateral Peace process. The Center invites researchers from around the world to compete for MEDRC grants, with a provision that all projects approved include at least one researcher from MENA. The MEDRC also invests in capacity building by organizing training courses and conferences in the MENA region. Its selection of research projects is competitive, based on scientific merit, and with little if any government intervention. Its location in an area geographically removed from the core of the Arab-Israeli conflict made the MEDRC more resilient to political circumstance. Like the Dryland Initiative, the mission of the MEDRC was conceived around technical objectives deemed to be a promising focus for regional cooperation, and hopefully instrumental in establishing channels of dialogue and exchange that would serve the peace process. While Center projects see considerable cooperation between scientists inside and outside the MENA region, cooperation between Arab and Israeli researchers is limited. Very few MEDRC projects have seen participation by Israeli scientists, although a few donors support projects that aim to promote Israeli-Arab cooperation through joint research on environmental and agricultural issues.

The Middle East Regional Cooperation (MERC) program of the US Agency for International Development (USAID) was established in the wake of the Camp David Accords and is similarly geared to support cooperative research between Arab countries and Israel. Projects under the program relate to agriculture, the environment, health, economics, and engineering. Topically the program is very closely related to the Dryland Initiative, with projects in recent years relating to watershed management, wastewater treatment, and desertification. Egypt, Israel, Jordan, Lebanon, the PNA, and Tunisia have all participated in MERC-funded projects, which are selected through a highly competitive process based both on scientific merit and evidence of effective arrangements for collaboration. Projects considered consist of at least one Arab and one Israeli institution, and those selected can be funded for between three and five years and for as much as US$3 million. The number of pre-proposals submitted has increased from 24 to 93 during MERC's last three (2003-2005) annual cycles.

While a number of Jordanian and Palestinian students conducted graduate research in Israel under the MERC program, and Israelis traveled to Arab countries to participate in MERC-sponsored projects – collaboration under the program faced a number of limitations similar to those experienced under the Dryland Initiative. Most meetings between Arabs and Israelis took place outside the region. One MERC-supported project carried out during the life of the Initiative led to the construction of a resource center for technical training on wastewater treatment technologies in the West Bank, the work of a Palestinian–Israeli–Egyptian partnership.

Despite such direct topical parallels between the MERC program and the Dryland Initiative, the Initiative would engage in just one MERC project, *Monitoring and Evaluation of Watersheds in the Middle East*. Even this engagement was limited to an Israeli Watershed Management team under the Initiative, even though the MERC project itself included Jordanian and Palestinian teams. This single instance of Initiative cooperation with a MERC project was made possible by MERC's contracting of the project to a US institution, which acted as a project coordinator rather than as a facilitator. Most members of the Initiative's Israeli Watershed Management team were moreover also members of the Israeli MERC project team, which used the Watershed Management project site in the Yatir forest. The arrangement was therefore especially cost-effective and naturally conducive to achieving a number of technical and scientific synergies. The Principal Investigator of the MERC-supported Monitoring and Evaluation of Watersheds in the Middle East project also participated in several meetings of the Dryland Initiative Steering Committee.

The Danish International Development Agency (DANIDA) supported a number of joint projects between Israelis and Arabs during the life of the

Initiative. These began with Egyptian-Israeli cooperation in agricultural training, and later expanded to engage Jordan and the PNA in agricultural research and development, including livestock husbandry and marketing of agricultural produce. The Dryland Initiative established no relationship with any of these projects.

The Hansen Institute for World Peace at San Diego State University in California contributed to two agricultural research projects of direct relevance to the Dryland Initiative. The Institute supported an initiative to support Egyptian-Israeli research collaboration, and this collaboration would lead to the establishment of the *Maryut Agro-Industrial Complex Project* in Egypt. The Hansen Institute also contributed seed money and secured additional funding sources for the development of the *Middle East and Mediterranean Desert Development Program*, a cooperative agricultural research and development project to be carried out jointly by Egypt, Israel, Jordan, Morocco, and the PNA. Collaboration between the Initiative and the Hansen Institute, however, did not go beyond a joint workshop held at San Diego State University in March 1997.

Another foundation based at a US university and active in topics of direct relevance to the Dryland Initiative was the *International Arid Lands Consortium*. The University of Arizona-based Consortium was founded by five US universities and the Jewish National Fund, and was supported by a US government grant. A member of the Consortium's board served on the Initiative Steering Committee. The Consortium supported research and demonstration projects in the Middle East that addressed a variety of environmental and development issues. Projects were selected through a competitive process and explicitly required cooperation between Israeli and Arab researchers and institutions. US researchers and research institutions were involved in all projects with components to be carried out within the United States. However, no interaction with the Dryland Initiative ever developed.

These regional programs differed from the Dryland Initiative in obvious ways. Unlike the Initiative, the human resources available to them were generally not limited to staff formally employed by government agencies. Their access to non-governmental and civil society organizations and to scientists without any implicit political obligations relieved them of many of the pressures and constraints that characterized interaction and communication under the Initiative. Project selection was in all instances notably more competitive than project selection under the Initiative. Nor did the mandates or missions of these other regional programs share the Initiative's unequivocal purpose of linking cross-boundary technical cooperation to the Middle East Peace Process.

A number of joint programs and projects in the MENA region related to activities undertaken under the Initiative, but did not involve Israel. These programs were not related to or motivated by the peace process in any way, and generally applied a definition of MENA or WANA that did not regard Israel as part of the region. They were implemented by international organizations and were principally financed with resources from outside the region. Analysis of these programs and projects may be instructive in assembling a picture of regional cooperation devoid of its preeminent stumbling block.

Between 1995 and 2002 the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Food Policy Research Institute (IFPRI) carried out the *Mashreq/Maghreb Project*, which related to the development of integrated crop-livestock production in low rainfall areas of West Asia and North Africa. The objective was to develop systems for meeting national demands for small ruminant products while conserving the natural resource base. Project activities were carried out in Algeria, Iraq, Jordan, Lebanon, Libya, Morocco, Syria, and Tunisia. Parallel activities were carried out in each member country: laboratory and field experiments, technology development and dissemination, analysis of policy and property rights, and socioeconomic and biophysical impacts of the innovations introduced. The Project was supported by the Arab Fund for Economic and Social Development (AFESD), the International Fund for Agricultural Development (IFAD), and the Canadian International Development Research Center (IDRC).

The *Conservation and Sustainable Use of Dryland Agrobiodiversity of the Fertile Crescent* project was initiated in 1997 using Global Environment Facility funds administered through the UN Development Programme. The project was also co-financed by ICARDA, the International Plant Genetic Resources Institute (IPGRI), and the Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD), as well as by the governments of Jordan, Lebanon, the Palestinian National Authority, and Syria. The project focused on agricultural biodiversity in the Levantine Uplands, which are an important center of plant diversity and genetic material, with many wild relatives of traditional crops. The project studied the conservation and sustainable use of sixteen target crops and their wild relatives, including wheat, barley, clovers, olives, pistachios, and figs. National agricultural research systems in the participating countries each established two project sites in which national level activities were carried out. ICARDA was responsible for the project's conduct at the regional level, in cooperation with IPGRI and ACSAD. Regional level coordination involves providing training and technical assistance to the national programs and integrating national activities. In Jordan the project was executed by the Ministry of Agriculture and implemented by the National Center for Agricultural Research and Technology Transfer (NCARTT). The UNDP *Programme of Assistance to the Palestinian People* is the project's executing agency in the PNA in cooperation with the Palestinian Ministry of Agriculture.

In conclusion, the evolution of the Dryland Initiative over ten years reflects adaptations to both external political circumstance and internal, systemic attributes of Initiative programs themselves, a process within which external reviews provided the critical analytical substance and opportunity for adaptations. Dropping the four National Support Activities and Regional Support Programs of Phase I, and replacing them with the more project-based Watershed Management and Treated Wastewater programs in Phase II, amounted to a more modest definition of "Arab-Israeli cooperation." Yet while the prescribed cooperation was scaled back and reduced in scope until arriving at the Regional Workshops held in Europe between 2003 and 2005, the idea of regional cooperation was never abandoned. The Workshops were still designed to fulill the original purpose of technical cooperation between Arabs and Israel that the planners of the original program had envisioned in the optimism of the mid 1990s. Much of the delay and reduction in international funding was attributable to the loss of that immediate hope - the donors had wanted their investments to serve a much greater objective than agricultural research, water resource management, or conservation of genetic resources. These areas of research and technology already had funding, and much of it by the very same donors. Yet investment in the Initiative continued despite its diminished expectations. Neither the donors nor the participating national actors gave up on the program, and as a result a substantial level of regional cooperation was ultimately achieved.

IV. COMMUNICATION, KNOWLEDGE SHARING, AND CAPACITY BUILDING

The technical cooperation around which the Dryland Initiative was conceived and designed was to take place between parties with few or no existing channels of normal communication. These channels therefore needed to be established, and to be developed through the generation and sharing of knowledge, based on the assumption that this knowledge would serve as a crystallization point for regional (Arab-Israeli) technical dialogue and cooperation. Ideally, knowledge generation would lead the five parties to jointly develop technical solutions for common problems. At a minimum, technical teams would solicit feedback and suggestions from peers in the program and consider recommendations in their field work. Capacity building for Initiative participants was a core element of the work program throughout the Initiative's three program phases, and with special attention to the capacity of the Palestinian National Authority – a purpose which required a higher-than-average budget allocation to the PNA. Commonly perceived capacity building needs would later be addressed through the Regional Capacity Building Workshops conducted during the Extension Phase.

In addition to communication and capacity building among Initiative teams themselves, the technical teams would also need to liaise with local communities, farmers, agricultural service providers (such as extension agents), policy makers, and other technical experts inside and outside of their countries and the Initiative itself, involving these partners in planning and carrying out applied research.

A. Regional Communication

Regional Meetings and Workshops

The principle of the five participating countries building a network of technical cooperation and exchange in which each party could capitalize on the partners' expertise and experience in a given thematic area rested on an ambitious agenda of visits and regular communication. The kind of substantial regional exchange and interaction envisaged in the Initiative's original program would take place at two points: during the period leading up to the first phase in 1996, and during the so-called "transition period" that preceded the second phase in 2000. These exchanges related to the development of the programs of Phase I and Phase II. The implementation of Phase I was initiated at a series of three meetings in May and June 1996 in which at least two participants from each country took part. A two-day meeting in Amman in May 1996 addressed the *Rangeland Management* theme and was attended by seven Jordanians and six Israelis, in addition to smaller delegations from the other members. The *Marginal Water and Saline Soils* program was the subject of a three day meeting in Tunis-Jerba-Gabez in June, and was immediately followed by a two day meeting in Cairo on the *Germplasm for Arid Lands* program. Each of the five delegations in these meetings made technical presentations and took part in constructive discussions.

The most productive interaction however took place during field trips to prospective project sites, where the teams found opportunity to socialize and exchange formal and informal information. Over the course of the Initiative, site visits and in-country travel (Figure 34) would afford participants the opportunity not only for productive on-site discussions, but also for meeting local people, policy makers, and technical experts in all five countries.

No regional meeting would take place in Israel until October 1999, near the end of Phase I,

Figure 34: Regional Consultation Meeting in Sede Boqer, Israel, in October 1999: Field Tour to the northeastern Negev. An Israeli farmer explains to representatives of the five partner countries the drip-irrigation system applying treated wastewater to fruit trees.

when 26 participants from the partner countries participated in an initial planning workshop on the Phase II program in Sede Boqer. In February 2000 a "roving workshop" of the five Regional Experts visited Israeli and Palestinian project sites, and this was the final and most successful fully-regional meeting of the Initiative within the region itself. The final meeting convened during Phase I was held in Jordan in May 2000, addressing the application of the *Socio-Economics and Policy* theme to Rangeland Management, and was attended by Israeli participants.

All subsequent regional meetings would be held in-doors and outside of the region. The first, held in Granada, Spain in October 2002, would serve as the model for the out-of-region Regional Thematic Workshops and Regional Capacity Building Workshops undertaken during the Extension Phase. Following up on the Granada discussions, the team leader of the Israeli Treated Wastewater and Biosolids Re-use program and the International Facilitator collaborated in preparing a Regional Concept Note for Standards in the Use of Treated Wastewater and Bio-solids. Although the Concept Note was the only attempt during the Initiative to provide guidelines for the use of treated wastewater at the regional level, it was a remarkable achievement, given the disparity in wastewater treatment levels between the participating countries. The Concept Note was an apt illustration of the potential of regional collaboration to promote strategic objectives in water resource management region-wide.

Three seminal meetings on program development for the Extension Phase took place in Europe in 2003 and were attended by representatives of all five parties. A Regional Consultation Meeting was held in Brussels in March 2003 to discuss the findings of the External Review of Phase II. The Meeting endorsed the reviewers' recommendation to extend the program, and this led to a Planning Workshop in Geneva the following month. Based on the external review recommendations, programmatic and managerial changes were introduced for the Extension Phase. The Geneva Workshop was a particularly useful exercise in participatory program development, and arrived at a consensus over the structure and financing of the Watershed Management and Treated Wastewater and Biosolids Reuse programs to be carried out under the Extension. Participants also came to an agreement over the budget allocation to each party. These arrangements were laid out in program document for the Extension Phase, presented and approved at the June 2003 Donor Consultation Meeting in Paris. The first Regional Thematic Workshop took place in Brussels in October 2003, illustrating the tight timeline along which program adaptations were prepared, agreed-upon, and implemented.

Regional Thematic Workshops were organized around the two thematic programs of the Dryland Initiative during its two-year Extension Phase: *Watershed Management* and *Treated Wastewater and Biosolids Re-use*. Virtually all regional exchange during the period would take place within these eight Regional Thematic Workshops. The three day Workshops were held in Europe, and were fully attended (with one exception due to logistical problems) by all five partner countries. Country delegations generally consisted of three members: the National Coordinator, the team leader of the country's thematic program, and a socio-economy and policy expert. Prior to each Workshop, national teams submitted semi-annual reports to the Facilitation Unit in Cairo. The reports included a technical report on the achievement of milestone indicators by each activity, and an administrative report detailing financial monitoring. Based on these reports and presentations made by partner countries and external experts, workshop participants engaged in a technical dialogue that led to the peer review of technical field work (past results and future plans) within the Initiative. These peer review sessions became the most significant means of regional exchange and knowledge sharing to take place within the Regional Thematic Workshops, and indeed within the Extension Phase of the Initiative itself. The discussions were generally lively and substantive, ending with the delivery of critical reviews and recommendations for follow-up by the national teams (Figure 35).

The first round of Regional Thematic Workshops was hosted by the Royal Flemish Academy of Belgium for Science and the Arts. The rest were hosted by the Department of Soil Science in Reading University in the UK. The full proceedings of each Workshop were produced by the Facilitation Unit, posted on the Initiative electronic library, and published on paper and on CD.

Figure 35: A Regional Thematic Workshop, Reading, England, Extension of Phase II.

In hindsight, the Regional Thematic Workshops were the most successful venue for cooperation between Arab and Israeli counterparts to be developed under the Dryland Initiative. Much of the interaction within the Workshops was informal, and considerable socializing led to the establishment of the kinds of personal ties that had been so hopefully anticipated in the original planning of the Initiative A list of all these events are summarized in Table 1.

Regional Capacity Building Workshops, which paralleled the Regional Thematic Workshops during the final two-year Extension Phase, are best described in the larger context of capacity building under the Dryland Initiative.

Electronic Communication and Documentation

Electronic communication and documentation on the internet were thought to be a useful media for circumventing political constraints, but were seldom used during the life of the Initiative. While International Facilitators communicated regularly with Regional Experts and National Coordinators by email, other trans-boundary email communication was infrequent. Many thematic team members lacked any access to email, and among those who did have access, little evidence exists that the medium was used for technical exchange between countries.

The possibility of a dedicated Initiative web resource on which to post reports and documents for dissemination among the parties suggested itself as an effective non-email means of exchange, and the development of a state-of-the-art *information* management and communication tool adapted to

Table 1: Regional Meetings of the Dryland Initiative

Date	Subject	Location
July 1995	Program development	Amman, Jordan
February 1996	Coordination with UNCCD	Geneva, Switzerland
April 1996	Program development	Cairo, Egypt
May 1996	Rangeland Management	Amman, Jordan
June-October 1996	Initiation of Phase I	Tunis, Gabes, Tunisia
June 1996	Germplasm Thematic Workshop	Cairo, Egypt
October 1996	Marginal Water Thematic Workshop	Tunis, Gabes, Tunisia
February-March 1998	Training course	Sharja, UAE
September-October 1998	Fodder training course	Rabat, Morocco
March 1999	Biodiversity workshop	Marsa Matroukh, Egypt
May 1999	Workshop	Tunis, Tunisia
October 1999 - October 2003	Regional Consultation	Sede Boqer, Israel
January 2000	Regional traveling workshop	Sites in each country
February 2000	Regional traveling workshop	Several locations, Israel and PNA
February 2000	Program development	Sharm El Sheikh, Egypt
February-March 2000	Regional accountants' training	Cairo, Egypt
April 2000 - April 2003	Rangeland policy seminar	Amman, Jordan
May 2000	Rangeland policy seminar	Amman, Jordan
May 2000	Auditor's training course	Cairo, Egypt
September 2000	Phase II initiation	Hebron, PNA
September 2001	Ecological Data Management	Bonn, Germany
September 2001	Knowledge Management	Bonn, Germany
June 2002	Sustainable agriculture	West Texas A&M University, USA
October 2002	Regional Workshop	Granada, Spain
April 2003	Program development	Geneva, Switzerland
October 2003	Watershed Management Regional Thematic Workshop	Brussels, Belgium
October 2003	Treated Wastewater Regional Thematic Workshop	Brussels, Belgium
December 2003	ISNAR - Scientific Writing	The Hague, Netherlands
March 2004	Treated Wastewater Regional Thematic Workshop	Reading, UK
April 2004	Watershed Management Regional Thematic Workshop	Reading, UK
April 2004	Socioeconomic Surveys & Data Analysis	Reading, UK
October 2004	Watershed Management Regional Thematic Workshop	Reading, UK
October 2004	Treated Wastewater Regional Thematic Workshop	Reading, UK
December 2004	Cost-benefit analysis	Reading, UK
April 2005	Treated Wastewater Regional Thematic Workshop	Reading, UK
April 2005	Watershed Management Regional Thematic Workshop	Reading, UK

the requirements of the Initiative became the focus of extensive consultation and planning. Several focus meetings with all five partner countries addressed the matter, as did the *Knowledge Management Conceptual Design Workshop* in Bonn in September 2001. World Bank knowledge management experts drafted a prototype design and terms of reference for consulting services to develop an Initiative-specific web tool, and a number of capable service providers were identified and short-listed. But the tool was never created owing to the political constraints under which ICARDA, the implementing agency, operated. Instead, a downsized, restricted-access electronic library known as the Publications and Mail Administration Tool (PMAT) was set up in December 2003, well into the Extension Phase. The Tool however had limited functions and was not user-friendly, discouraging its use from the onset.

PMAT was managed by the Facilitation Unit. Initiative partners were able to access the library and download documents using a password. Documents included thematic reports of the Watershed Management and Treated Wastewater and Biosolids Re-use programs, *Initiative Update* bulletins, training materials, and reports of country programs, the External Reviews, World Bank supervision missions, and progress reports by the International Facilitator. There were plans to expand on the PMAT, to add a photo library, solicit documents from teams, and introduce a discussion area for the two thematic programs, but the limited use of the library by Initiative partners discouraged its further development.

The Initiative partners and the Facilitation Unit produced many publications during the life of the Initiative, and these did serve the purpose of knowledge sharing and regional exchange. Documents and reports distributed at Initiative meetings and among concerned stakeholders were deposited at the ICARDA office in Cairo. Among the more important reports published under the auspices of the Initiative were *Demonstration of Sustainable Reuse of Blended Brackish Water and Treated Wastewater in Agriculture in the North Delta* (1998), *Germplasm of Natural Range Plants in the Sinai Peninsula, Egypt: Collection and Evaluation* (1997), *Wastewater Treatment and Reuse in the Middle East and North Africa Region* (2000), and the *Regional Concept Note for Standards in the Use of Treated Wastewater and Bio-solids* (2003).

Perhaps the most widely disseminated Initiative document was the monthly electronic bulletin *Initiative Update*, which was issued during the Extension Period. 30 issues were published by the Facilitation Unit beginning in September 2002, bridging the gap in regional exchange between the Regional Thematic Workshops. The *Update* was a two-page summary of Initiative activities and plans, supervision and review missions and other Initiative events, and provided timetables and instructions relevant to ongoing activities.

Yet the Extension Phase saw no real improvement in regional cooperation *between* regional meetings. National teams seldom if ever read the reports on each others' activities that were diligently produced by the Facilitation Unit for presentation at the workshops. Nor is there any indication that the electronic library assembled by the Facilitation Unit was ever used. The lack of communication and dissemination was moreover not at all limited to the Arab-Israeli dimension, for little or no such exchange took place between Arab teams either. Harmonization of terminology, standards, and methodologies between national teams working on the same topic matter was never accomplished.

What the Extension Phase did see was a normalization of interaction into regular, systematic meetings attended by colleagues who otherwise never would have come together. In those Regional Thematic Workshops and Regional Capacity

Building Workshops, direct personal interaction would lead to an atmosphere of collegiality and open communication that warrants merit, however far short of the original conception of regional cooperation it may have fallen.

B. Institutional Capacity Building

Building the capacity of participating national agricultural research systems and other technical institutions was a fundamental objective of the Dryland Initiative, particularly on the part of Palestinian participants whose representative government was just two years old when the Initiative itself was implemented. Palestinian national institutions required time to gain experience and to define and establish and divide roles and functions. The original program of the Initiative (Phase 1) explicitly recognized the priority that institutional capacity warranted in the Territories by assigning the Palestinian national team no Regional Support Program to lead. Palestinian National Support Activities were rather to concentrate overwhelmingly on capacity building, and in each of the four Regional Support Programmatic areas: the Egyptian-led *Germplasm for Arid Lands* program, the Israeli-led *Economic Forestry and Orchards* program, the Jordanian-led *Rangeland Management and Livestock* program, and the Tunisian-led *Marginal Waters and Saline Soils* program.

The *Regional Capacity Building Workshops* that paralleled the Regional Thematic Workshops during the Extension Phase of the Initiative were preceded by a number of meetings and seminars that related to capacity building. Financial management and monitoring varied widely by country and this raised concern over participants' ability to meet international accounting standards after the Initiative. The Facilitation Unit organized two capacity building workshops in Cairo in 2000 relating to the financial management of national program components. These were intended to promote regional exchange between administrative teams in the Initiative.

Another capacity building need which became apparent relatively early on during the life of the Initiative related to the quality of oral and written presentation by Initiative participants. This had been found wanting in a number of meetings, and planners recognized that the ability of research teams to engage in activities after the Initiative would depend heavily on their ability to compile proposals that could successfully compete for project funding. In Bonn in September 2001 the Cooperative Monitoring Center at Sandia National Laboratories sponsored workshops on *Ecological Data Management* and *Knowledge Management Conceptual Design*.

In June 2002 an International Workshop on Sustainable Agroecosystems was organized by the Dryland Agriculture Institute at West Texas A&M University, where participants were able to examine semi-arid farming in the southern United States and were briefed on a variety of prevailing practices, technologies, and problems.

The Regional Capacity Building Workshops continued along the lines of the September 2001 Bonn workshops, beginning with a workshop titled *Writing and Presentation* that was hosted by the International Service for National Agricultural Research (ISNAR) in The Hague in December 2003. In April 2004 a Regional Capacity Building Workshop on *Socioeconomic Surveys and Data Analysis* was conducted by the Statistical Services Centre of the Applied Statistics Department of the University of Reading in April 2004. The Workshop focused on the design and conduct of socioeconomic surveys, and the analysis and interpretation of survey results. Attendees were organized into groups with members from the different countries who described and discussed specific problems *in their national* activities with each other and with trainers. They also had the opportunity to consult with trainers individually.

In December 2004 another socioeconomic workshop on *Cost-Benefit Analysis* was organized by Calibre Consultants in the UK, in association with the Statistical Services Centre of the University of Reading. The Workshop was inspired by the need for Initiative activities to assess the economic value and community benefits of alternative land and water use practices. It was conducted at the Statistical Services Centre's facilities at Reading.

National level capacity building events were also arranged for Initiative team members, some in response to a Regional Expert or National Coordinator noticing a need for capacity building in a particular area, or to orient staff on an issue that was going to be particularly prominent in a national program's agenda, for instance when countries were assigned Regional Support Programs in Phase I. A number of national level thematic workshops on dryland agriculture and natural resource management were held in 1998 and 1999 for attendance by Initiative teams in Egypt, Jordan, the Palestinian National Authority, and Tunisia. The Egyptian Watershed Management program arranged workshops on range and farmland management, and on the conservation and sustainable use of biodiversity. Similar workshops were held for Palestinian and Jordanian staff, in addition to a workshop on herbal and medicinal plant cultivation in Jordan. Tunisian staff attended a workshop on land degradation issues.

Between November 1998 and March 1999, each national team organized national planning workshops for its staff and other national stakeholders, as a first step towards planning Phase II. These workshops were conducted using GTZ's *Zielorientierte Projektplanung* (ZOPP) or "Objective Oriented Project Planning" approach developed by the GTZ, which was facilitated by a qualified moderator provided by the Facilitation Unit. A regional level ZOPP workshop was held in Sharm el Sheikh in February 2000 to undertake joint design of the Phase II program. The Sharm el Sheikh Workshop saw a high volume of interaction between national teams, and in this was itself a valuable instrument for capacity building.

Some national Initiative programs looked outside of the Initiative to develop capacity among staff members. A number of national Initiative programs sent individuals for short training courses at institutions abroad. A Tunisian team member attended a seminar on Regional Strategies of Agricultural Development in Oases and Irrigated Perimeters of the Mediterranean Region delivered by the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) in Cairo in May 1997. A Palestinian team member was trained in plant taxonomy by NCARTT staff in Jordan in 2004, and a member of the same team was sent to the USA for training in plant water requirements at a US Department of Agriculture facility. Technical training events were also held for small groups. Five Jordanians attended a program on the development of an information system for resource management in Lebanon in 2002. Four Egyptian staff members participated in an eight-day geographic information systems training course run by the Remote Sensing and GIS Unit of the Agricultural Research Center in 2002.

Jordanian and Palestinian programs sent individuals to obtain advanced degrees from universities, an avenue which may have disrupted project work but which should have lasting impact beyond the life of the Initiative. Six Jordanian team members were enrolled in an Initiative-CIDA/Agrodev sponsored M.Sc. rangeland program at the University of Jordan. The Palestinian team sent seven team members to read for a Ph.D., and three others for M.Sc.

programs in environmental, agricultural, and natural resource management at the University of Lille and the University of Twente (Figure 36).

A small number of visits took place between Arab and Israeli Initiative teams, and were arranged through direct communication between the partners. Early on in Phase I, an Israeli team member traveled to Al Arroub in the West Bank and advised the Palestinian Marginal Water team on the design and operation of wastewater treatment using duckweed. The Israeli Regional Expert twice hosted the Jordanian Regional expert. The first visit involved a meeting with a farmer organization, the second visit a meeting with researchers at the Ben Gurion University of the Negev. The Jordanian Economic Forestry team leader and four Jordanian farmers visited the Blaustein Institutes for Desert Research (BIDR) at Ben Gurion University of the Negev, and a Jewish National Fund nursery in September 1999.

Some interaction took place among Arab participants to the exclusion of Israelis, including a number of visits exchanged with non-Initiative partners like Morocco and Syria. In June 1999, 15 Jordanian team members of the CIDA/Agrodev-supported Initiative project stayed for a month of workshops

Figure 36: Rectangular ("diamond-shaped") micro-catchments, Hebron Region, West Bank (PNA).

and study tours on Rangeland and Feed Resources in Tunisia. That same month, the Tunisians hosted a study tour of four Moroccan scientists, to which Jordanian experts active in the Initiative were also invited. Other interaction with Arab counterparts not participating in the Initiative included a visit by all four Arab Regional Experts to a rangeland management project in Morocco. Senior Ministry of Agriculture officers from the Arab Initiative countries visited the Arab Center for the Study of Arid Zones and Drylands and the Syrian Ministry of Agriculture in May 1999. In August 1999, officers from the ICARDA office in Tunisia visited Syria to observe work on medicinal plants.

C. National Integration and Coordination

Most national components of the Initiative established some manner of linkage with related programs carried out by other organizations and institutions. These included programs and projects administered or supported by local non-governmental organizations, governments, international organizations, and bilateral agencies. The relationships varied from infrequent contacts and mutual awareness to intensive, systematic coordination. In fact, the Phase II Initiative program even required national activities to be anchored in larger national programs that addressed issues related to Initiative objectives.

Both the Egyptian Rangeland Management and Watershed Management programs were linked to the Matrouh Resource Management Project (MRMP), which provided a development project site for their work on the country's northwest coast (Figure 37). Greenhouses operated by the Egyptian Germplasm for Arid Lands program produced thousands of seeds that were provided to the MRMP. The Egyptian Watershed Management program interacted with the Egyptian government's Qasr Rural Development

Figure 37: Farmers participating in the Initiative's field work; Matrouh, Egypt.

Program, which was supported by the German *Gesellschaft für Technische Zusammenarbeit* (GTZ). Together with the program's close collaboration with the World Bank-supported Matrouh Resource Management Project, this connection led, among other things, to a *Range Strategy* that was subsequently implemented in Egypt's coastal northwest. (ICARDA and IPGRI were also involved in the development of the *Range Strategy* document.)

The Israelis anchored their Treated Wastewater program to an ongoing governmental monitoring project on agricultural uses of treated wastewater. The Jewish National Fund, to which the Israeli Economic Forestry and Watershed Management programs were both linked, is for all practical purposes a government-contracted afforestation and land management agency.

Members of the Jordanian Watershed Management team, in their capacities as Ministry of Agriculture and NCARTT researchers, drafted a proposal for a non-Initiative *Conservation of Medicinal and Herbal Plants* project that received a US$10 million grant from the Global Environment Facility. The subcomponent of Jordan's Germplasm for Arid Lands program that worked on the cultivation of medicinal and herbal plants was closely linked to the larger project. PNA national activities were linked to the UNDP/PAPP *Program for the Rehabilitation of the Eastern Slopes of the West Bank* during Phase I of the Initiative. Canadian bilateral support was particularly strong in Jordan. The Jordanian Rangeland Management and Watershed Management programs were both carried out in part through the CIDA/Agrodev-supported *Sustainable Rangeland Management Project*, which the government of Canada had contracted with the Jordanian Ministry of Agriculture and Royal Society for the Conservation of Nature. Joint project sites at Faysaliya, Buseira and Muaggar saw strong participation by local communities, and saw excellent dissemination of results to neighboring communities.

A number of Palestinian Initiative projects and activities were carried out in close collaboration with local non-governmental organizations, and similarly achieved high levels of local community participation. PNA Initiative teams worked with the Agricultural Workers Union and with the Palestinian Hydrology Group, sharing human and financial resources in community projects on cistern rehabilitation and forest and orchard plantations. The PNA *Jericho Botanical Garden Project* was assisted by a local non-governmental organization that worked extensively with the local community on the *Conservation of Vegetable Field Races Project*.

The Tunisians anchored their Watershed Management program to the government's *Commissariat Régionaux au Développement Agricole* (CRDA) program on land management in Menzel Habib. Like the Palestinians, the team also collaborated closely with local non-governmental organizations, including the *Association Tunisie Mediterranée Pour le Développement Durable* (ATUMED) and with *Les Jeunes de Zammour*. The Tunisian Treated Wastewater program was involved in the development of the *Office National De L'Assainissement* (ONAS) drinking water treatment station in the Gabès area. Both government programs were supported by Germany's *Deutsche Forschungsgemeinschaft* (DFG). A number of other ongoing programs and projects to which Initiative national activities were linked were supported by international organizations and donor agencies.

The purpose of integrating the in-country programs of the Drylands Initiative with related national programs during Phase II was to increase the Initiative's influence over national policy making and research practices, and extend capacity building beyond Initiative participants themselves. This objective was rather more subtle than outreach and dissemination, and targeted changes in the working environments and cultures of the national institutions the Initiative collaborated with – changes that would endure beyond the life of the Initiative itself. Interaction with cooperating international and bilateral agencies were expected to complement this purpose, particularly perhaps with respect to the Initiative's and its partners' desire to improve policy making.

There is, however, little tangible evidence that the Initiative had a significant impact on national policy-making and institutional programs. The reasons for this may be rooted in the stark contrast between the period when the Initiative was conceived and the period when it was implemented. The Initiative was conceived in a period of great expectations. Breakthroughs in the Arab-Israeli peace process created a sense of forward momentum, with mounting anticipation that further breakthroughs were imminent, and would open the region and its countries to new opportunities for economic development. The Initiative lost most of its potential as an instrument with which to influence national policy, let alone regional policy, when such hopes were not realized. Even had substantial national policy impacts been achieved, the integration of Initiative programs with ongoing national projects would have made those impacts difficult to discern. Attributing the source of policy and other changes to the Initiative itself would have been quite speculative, and hard to distinguish from changes attributable to other government and international programs.

Figure 38: Earthen dyke (or bank); Jordan.

D. Community Participation, Dissemination, and Outreach

The participation of local communities was not explicitly addressed in the Initiative's original program. As a result of this omission, there was neither reason to expect nor any subsequent evidence to suggest that elements of the Initiative's Phase I program were in any way demand driven. The Phase I program was rather conceived by government policy makers and shaped by the technical inclinations of its planners.

Although the participation of local communities was overlooked in the Initiative's original program, Initiative teams would commonly engage local communities in the conduct of projects and activities. The land used in Initiative projects was often owned by the community members the project engaged – providing ownership as well as participation, and deepening the sense with which participants can be referred to as 'stakeholders.' Initiative teams would select highly representative or suitable communities or land-owners (or communities or land-owners in highly representative or suitable areas) to be approached for permission to carry out projects on their lands, and then seek formal agreement to do so. The Tunisian Rangeland Management and Watershed Management teams carried out rangeland rehabilitation using just such local agreements (Figure 39). The rangelands on which project activities were carried out were used cooperatively by several communities and the agreements were reached with a number of NGOs representing local farmers. The Israeli Treated Wastewater and Biosolids Re-use team gained the permission of local orchard and farm owners to irrigate their fields using treated wastewater. The owners of the farms and orchard of course took full part in monitoring results, and their support of the activities increased as results were observed.

Three types of inducements were used to encourage land owners and users to participate in Initiative activities. The first was to persuade land owners to set aside parts of their plots for experiments intended to demonstrate better practices or other uses, with the incentive of financial assistance in cultivating other parts of their plots. The Palestinian Watershed Management team used this approach to encourage farmers to allocate areas to field experiments using runoff harvesting structures, by providing the owners with seeds and saplings to be used in their non-experimental plots. The second approach was to employ land users as salaried field workers in local projects in order to provide them with first hand experience in the techniques being introduced, a practice used by the Tunisian *Range Rehabilitation* program. The third approach was to persuade land users to refrain from activities that earn short-term income but cause long-term degradation, using Initiative funds to compensate them for forgone income. The approach was used extensively in rangeland conservation and rehabilitation programs in Jordan and Tunisia, where sheds constructed for flocks and provision of barley seed to replace free range fodders were introduced to remove grazing pressure. Gas-operated cookers were similarly introduced as a replacement for fuelwood collected from areas set aside for rehabilitation.

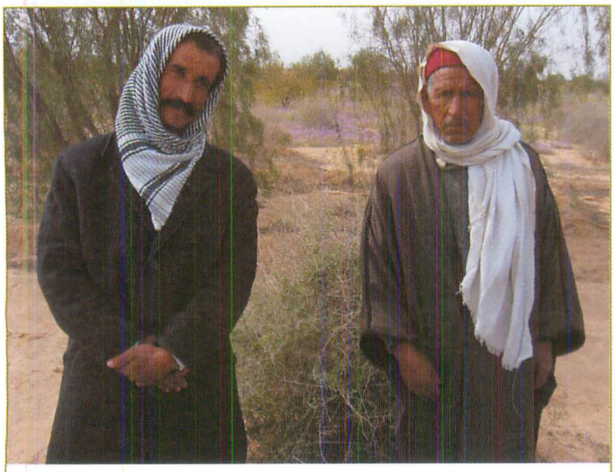


Figure 39: Farmers participating in the Initiative's field work in Tunisia.

Co-financing and cost-sharing arrangements were the most successful methods used to encourage sustainable practices among local land users. Egyptian programs used Initiative funds to purchase agricultural inputs like fertilizer, seeds, seedlings, and irrigation equipment co-financed by local farmers to improve soil fertility and water-use efficiency. In Jordan range improvement activities co-financed labor and material inputs in the cultivation of herbal and medicinal plants, including the provision of seeds and machinery. A Palestinian team cooperated with the local NGO *Agricultural Workers Union* to rehabilitate cisterns and plant forage seedlings, equally sharing labor and material costs. All of these generally one-off arrangements enabled land users to evaluate the results of new practices and to compare them to traditional practices.

Evidence of the impacts of participatory activities in and around project sites suggests that local awareness of them in nearby communities was sometimes substantial. Water harvesting techniques demonstrated by Initiative activities made a particularly strong impression. The introduction of water harvesting techniques on demonstration farms in Egypt, Jordan, and the Palestinian Territories prompted wide interest among neighboring communities, who often requested that similar techniques be made available to them. Water harvesting experiments and demonstrations by the PNA national program influenced a large number of farmers in the vicinity to rehabilitate terraces on their land, plant fruit trees, and fence their plantations to reduce overgrazing. The Jordanian team noted steadily increasing adoption of its demonstrated cultivation of medicinal plants in both rainfed and irrigated areas, until by the end of the Initiative these had replaced traditional crops (chiefly barley and lentils) on some 243 hectares, earning measurably higher earnings among the cultivators. Having observed the results of the Tunisian team in rehabilitating degraded sandy rangelands, herders and farmers in nearby areas agreed to refrain from grazing and firewood collection in order to prevent local rangelands from again turning into shifting sand dunes.

Longer term, more widespread impacts of Initiative projects and activities beyond participating communities and their neighbors cannot yet be evaluated. Field level technical work undertaken during the Initiative carries the potential for considerable impact if adopted on a sufficient scale. Farming and land use practices developed by the Egyptian teams can significantly increase the income of farmers who adopt them times more than the cost of the necessary investment – this assuming a sufficiently wide pattern of adoption. The Jordanian programs' work on entrepreneurship development to encourage more advanced and efficient production and effective marketing of modern crop varieties, livestock, and dairy products has considerable potential for expansive adoption, which if achieved would be likely to significantly reduce rural poverty in Jordan. Scaling up rangeland rehabilitation and conservation methods developed by the Tunisian Initiative program has the potential to quadruple rangeland productivity, again assuming extensive adoption by Tunisian rangeland users. Palestinian public awareness activities and Israeli demonstration activities publicizing the social and environmental value of afforestation and other methods of watershed management may very well increase demand for and adoption of such methods.

The impact of activities undertaken under the Initiative was of course not intended to remain confined to areas and populations in the immediate vicinity of active projects. Dissemination, and training and outreach were an essential part of the Initiative's overall program. Initiative outreach activities employed a variety of methods to disseminate information among a variety of audiences, including demonstration sites and facilities, training courses, and extension services (Figure 40).

Demonstration was the most direct form of dissemination, and demonstration sites were widely

Figure 40: Farmers discussing crops at Initiative nursery; Egypt.

used throughout the life of the Initiative. In Egypt, sites established on 12 privately-owned farms demonstrated improved farming practices in arid areas, while the Palestinian program established botanic gardens and a herbarium to increase public awareness of the value and importance of biological diversity. The Jordanian team working on the cultivation of medicinal plants in semi-arid areas established demonstration plots on 118 farms across 34 villages.

Training programs were another prominent facet of information dissemination under the Initiative, and were designed for a variety of audiences, including farmers, extension officers, and policy makers. Some specifically targeted women audiences. Jordanian training programs were devoted to forage improvement, the cultivation and processing of herbal and medicinal plants, and rangeland improvement by planting indigenous and exotic plants. They were attended by farmers, extension officers, and representatives of NGOs and government agencies throughout the country. 13 Jordanian seminars on rangeland improvement specifically targeted women and were carried out in local schools. The Egyptian program organized a one-week training course in Cairo on water harvesting, irrigation, fertilizers, and other subjects relating to dryland management for extension officers. Another one-week training course for a mixed audience of Egyptian extension officers and community leaders was conducted at a local research station, providing instruction on seedling production and planting methods.

The Egyptian Marginal Water and Treated Wastewater and Biosolids programs coordinated training courses with *field days*, including programs on the reuse of treated wastewater for irrigation, and the use of biosolids in composting and biogas production. Other such field days were arranged around improved tillage practices designed to increase efficiency in the use of irrigation water and reduce salinization risks. Egyptian teams working under the Initiative promoted farmer attendance in these training programs in a series of some 70 meetings with farm leaders. The Tunisian Marginal Water and Treated Wastewater and Biosolids teams organized similar extension and field day programs in close cooperation with CRDA, ARI, CITET, and the Ministry of the Environment.

The generation of written material for consumption by land users and a variety of other audiences was another means of dissemination under the Initiative. Leaflets and booklets produced for land users could be highly tailored around local conditions and concerns, using photographs and other illustrations to make instructions and topic matter more explicit. In Jordan, leaflets providing instruction on ditch construction and range seeding methods made use of such photographs taken within local communities and demonstration sites, and were widely disseminated. Jordanian teams also produced pamphlets on methods of ryegrass cultivation and fertilizer application.

Egyptian and Israeli Treated Wastewater teams prepared a range of Arabic and Hebrew language extension materials which were translated into English in the spirit of regional exchange (Figure 41). The Israeli material included a series of four "extension pages" on *Water Sampling, Boron in*

Figure 41: Extension brochures, produced by the Egyptian Initiative team.

Wastewater, *Nitrogen in Wastewater*, and *Heavy Metals in Treated Wastewater*, detailing problems that farmers should anticipate and recommended solutions. Palestinian and Tunisian Watershed Management teams produced a field guide and booklet on herbal, medicinal and other high value plants that stressed the importance of conserving biodiversity.

Plant biodiversity was the most prominent theme of Palestinian public awareness raising activities on environmental issues, and popular lecture series and seminars targeting school children and their parents stressed the significance of biodiversity conservation for rangeland management and for combating desertification. The PNA Initiative team also mobilized youths in the Hebron and Bethlehem areas to participate in tree planting campaigns. Palestinian public awareness campaigns also took up the matter of the public acceptability of wastewater reuse, and these too targeted young audiences. Some 1,500 school children and youths in the district of Hebron took part in guided tours of the Palestinian Treated Wastewater and Biosolids Reuse program's water treatment facility at the Al-Arroub Farm Complex. The message conveyed was to regard wastewater, properly treated, as a valuable productive resource rather than as an unsanitary nuisance or threat to public health.

The production of documentary and instructional videos attracted considerable interest within the Initiative. During Phase I, the Israeli and Tunisian teams recorded a series of short videos of their national programs. In 2004, the Initiative produced a longer promotional video of genuinely regional scope. Entitled *Establishing a Bridge of Confidence*, the video presented personal accounts of the individuals involved in the Dryland Initiative during the Extension Phase, and solicited their impressions of regional collaboration and recommendations for its future.

The dissemination of knowledge generated within the Initiative to the academic community took place principally through conference presentations. A member of the Egyptian Initiative team attended the *National Symposium on Problems of Land Degradation in Egypt and Africa: Causes, Environmental Hazards and Conservation Methods* in March 2002, and presented a paper titled "Preliminary Guidelines for Yield Response to Salinity and Sodicity of Irrigation under North Delta Conditions." A member of the Jordanian Watershed Management team persuaded managers at Balqa University for Applied Sciences in Jordan to include curricula on medicinal plants, and another team member assisted in the curriculum's development. Outside the MENA region, Initiative researchers took part in numerous international fora and professional conferences, including the International Rangeland Congress in Townsville, Australia, July 1999, and the meeting of the International Water Association in Xi'an, China, in May 2005. The latter was attended by an Egyptian and an Israeli researcher who each presented a paper reporting on Initiative research results in their respective countries: "Agronomic Aspects and Environmental Impact of Reusing Marginal Water in Irrigation: A Case Study from Egypt," and "Linking Environmental and Economic Sustainability in Establishing Standards for Treated Wastewater in Israel." Finally the Israeli National Coordinator, who also served as the Israeli focal point for the UNCCD, presented results of technical work undertaken within the Initiative at several UNCCD.

If Arab-Israeli cooperation was the driver behind the Dryland Initiative, outreach and dissemination with impacts on local communities, rural livelihoods, and environmental sustainability were the technical objectives of the Initiative's work. The regional meetings and workshops in which the weight of regional interaction took place were devised to plan and report on national program activities which were almost entirely local in scale. Engagement with local communities and land users was something much deeper than adherence to the principle of participation. Community participation in the Initiative's applied and adaptive research was a vital and necessary aspect of Initiative activities, most of which took place on their lands. Without access to their land, and with it their active involvement and participation, much of the research and development that took place under the Initiative would have been confined to research stations, government or private greenhouses or gardens, or laboratories conducting upstream research. Participating communities, farmers, and herders were therefore Initiative stakeholders in a very meaningful way. Their perception of the value of innovations and new practices made them the principal agents on which the impacts of those innovations and practices would rely – they were the first line of prospective adopters. Much of the dissemination of knowledge generated under the Initiative was therefore quite

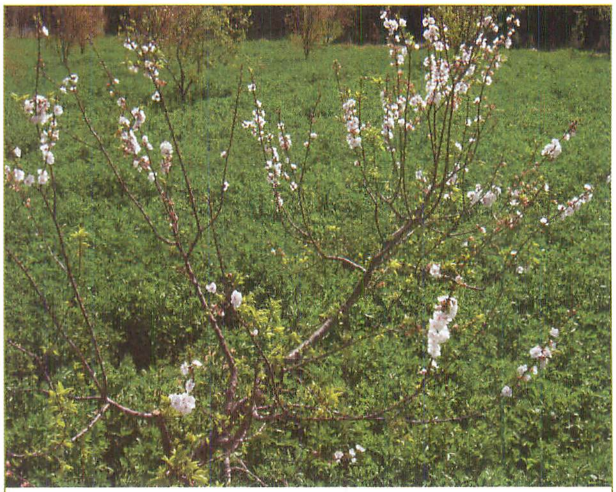


Figure 42: Treated wastewater reuse in Gabès; Tunisia.

natural, as neighboring communities and land users observed or heard by word of mouth the results of recently introduced practices. This means of dissemination preceded the training and outreach programs introduced under the Initiative, but some significant part of the demand by local farmers and land users to participate in Initiative training may well have been the product of that original awareness.

V. TECHNICAL ACTIVITIES OF THE DRYLAND INITIATIVE

Technical work undertaken under the Dryland Initiative was principally carried out at the local scale and addressed issues that were highly relevant to local communities. Its focus was the local management of natural resources, and given the dryland conditions prevailing throughout all five partner countries, the management of scarce water resources assumed a central place in much of the applied and adaptive research carried out under the Initiative. As such, research and development in the two consolidated thematic areas "*Watershed Management*" and "*Treated Wastewater and Biosolids Reuse*" were in fact activities aiming at improved *Water Resources Management* which would attempt to increase the net availability of water (through water-harvesting and -storing technologies), improve water-use efficiency (drought- and salinity-adapted species and appropriate irrigation technologies), and recycle existing water sources (reuse of treated wastewater and biosolids in agricultural production).

A. The Watershed Management programs of the Dryland Initiative

Watershed management program activities were divided into five areas, themselves consisting of component items, some of which in turn consisted of individual technology packages. Thus conceived, the program assumed a taxonomy that is best represented in outline form, and described in detail in the sections that follow (also see Figure 43).

1. *Increasing water availability through Water Harvesting and Storage*
   a. Water harvesting and soil water storage
   b. Water storage in wells, cisterns, and rehabilitated springs
2. *Crop production and rangeland management*
   a. Improved agro-technical packages for cereal production
   b. New fodder crops on rangeland
   c. Approaches to reduce grazing pressure
3. *Fruit and non-fruit tree cultivation*
   a. Tree crops and tree-field crop intercropping
   b. Fuelwood production
   c. Afforestation and carbon sequestration
   d. Sand-dune fixation
4. *Genetic resources and biodiversity*
   a. Plant biodiversity surveys
   b. Ex-situ genetic resource facilities, including genebanks, botanical gardens, and nurseries
   c. In-situ biodiversity conservation and eco-tourism protected areas
5. *Diversifying farming systems and promoting off-farm activities*
   a. Socio-economic analyses
   b. Non-conventional crops
   c. Dairy production

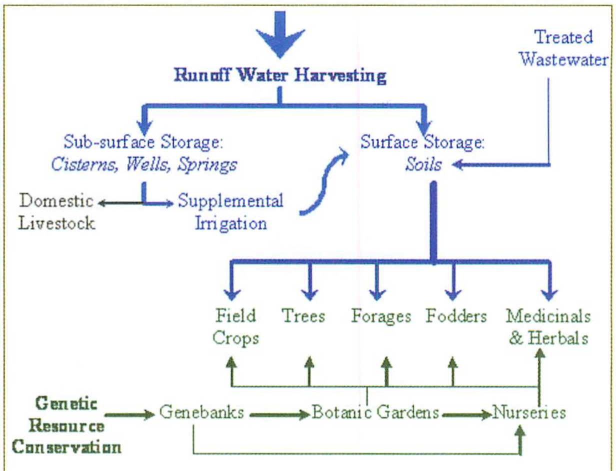


Figure 43: Watershed Management.

Increasing Water Availability through Water Harvesting and Storage

Water harvesting *techniques* developed and/or tested under the Initiative included three types of *contour ridges* and *terraces* which were constructed and tested for their effectiveness in rehabilitating rangelands and supporting a variety of crops, forages, and stabilizing plants. Earthen contour ridges constructed on sloping surfaces with ditches dug along the upslope sides were designed principally to rehabilitate degraded rangelands. The ditches served as sinks for runoff generated by the sloping surface between two successive ridges. The water stored deep in the soil supported a variety of bushes, trees, and forages planted along the ditches. In two Jordanian demonstration sites at Mohareb in the Muaggar area and Sabha in the Mafraq area, local bushes of the genus *Atriplex* cultivated along these ridges covered 2,500 hectares. Spillways were repaired as necessary after each rainy season and ridge-supporting bushes that did not survive were systematically replaced (Figures 44, 45, 46)

Another type of large scale earthen contour ridge was constructed on slopes with relatively more gentle gradients, and was used to slow down rather than concentrate runoff flows. The flows were spread over the surface between two successive ridges, and

Figure 44: Gullies and large-scale earthen ridges in an Egyptian watershed.

Figure 45: Contours, terraces, and gullies in sloping arid drylands; Israel.

Figure 46: Large-scale contours and terracing in the West Bank semiarid drylands.

used to cultivate barley at the principal Egyptian Watershed Management site in the upper Wadi Um Ashtan. At the Jordanian Watershed Management site in the upper Wadi Mujib, deep soil ripping was introduced to the contour areas to improve water infiltration, and resulted in markedly increased forage production (Figure 47). The Jordanian Watershed Management team calculated the returns from the increased production to be 50 percent higher than the cost of constructing and maintaining the contour ridges.

The third type of large scale structure consisted of a system of *contour terraces* that were constructed in lower areas of local watersheds. Permeable stone dykes built at the ends of tributaries and at the tips of wadis were used to support the terraces and to regulate water flows, spreading them down-slope

Figure 47: Contour "sinks" on gentle slopes in Jordan through deep ripping.

along the catchments of area foothills (Figure 48). The contour terrace systems were tested at the Egyptian Watershed Management site in the lower Um el Ashtan, and in wadis at six Palestinian project sites in the Hebron area. The Palestinian terraces were supported by 30 centimeter high rocky walls on the up-slope side, and by the tough, thorny *Sarcopoterium spinosum* on the down-slope side. These pillow-shaped bushes increased water holding capacity behind the terrace wall, on which olive saplings were planted and existing olive trees were monitored.

Structures known as "*micro-catchments*" were a smaller-scale technology introduced under the *water harvesting* components, and were used to support individual trees or small groups of trees (Figure 49). In the Egyptian Watershed Management site at Wadi Um Ashtan, diamond shaped pits for runoff harvesting were constructed in the upper reaches of the watershed (Figure 50), while semi-circular micro-catchments of between 100 and 120 square

Figure 48: Contour terraces in a Wadi; West Bank.

Figure 49: Micro-catchments in Northwestern Egypt.

Figure 50: Rectangular ("diamond-shaped") micro-catchments, Hebron Region, West Bank (PNA).

meters were constructed in the watersheds' lower reaches. These were used to grow fruit trees, often intercropped with vegetables. Measurements of the volume of runoff harvested in a given area would be used to determine the micro-catchment's size after experiments showed that a micro-catchment area 15 times the size of the crop target area is generally required to sustain crop production.

The Palestinian Watershed Management team constructed diamond-shaped micro-catchments at eight sites to support almond, peach, apricot, and olive trees. Experiments carried out near the end of the Initiative compared these micro-catchments to the larger scale permeable stony terrace contours described above. The Tunisian team dug rows of pits in sandy soil to collect runoff for soil conservation purposes, and for use in supporting trees used for fuelwood.

The Israeli Water Management team used measurements of rainfall, runoff volume, and soil moisture to assess the efficiency of micro-catchments in supporting afforested trees. The assessment concluded that micro-catchment dimensions should be specifically tailored to site-specific slope and soil characteristics, rather than being uniformly applied and carried out using heavy machinery.

A new system of runoff harvesting was designed to support olive cultivation in areas that typically experienced about 100 millimeters of annual rainfall. The system consisted of trenches or ditches to reduce moisture loss from evaporation. The high cost of digging these trenches required the cultivation of high value produce, thus the focus on olives. The system was also used to test the resilience of water harvesting and storage to prolonged drought conditions in these areas. An inherent problem in channeling surface runoff to ditches for deep soil storage is the lateral dispersion of the water across the ditch's shallow subsurface before its downward vertical infiltration carries it to depths at which the moisture is no longer subject to evaporation.

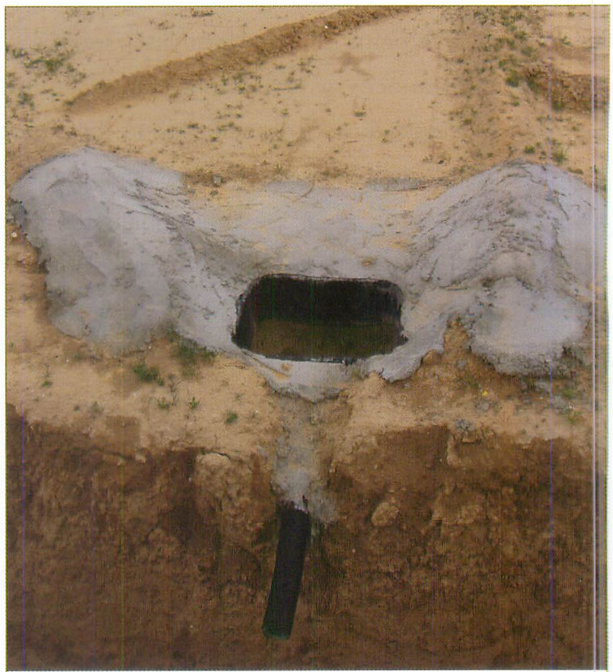


Figure 51: Runoff conveyed to trench through pipe after going through a stilling pond. Mashash Experimental Farm, Israel.

Two approaches to reducing the evaporation of horizontally moving water were tested at the Mashash Experimental Farm and the Yatir site in Israel. The first approach involved alternative methods of ground cover, including plastic covers, crust-breaking, and mulching. The use of plastic covers proved more effective at reducing evaporation than crust-breaking treatments. The use of mulches to reduce evaporation loss at the Yatir site was found to have no significant affect on the growth of trees within the ditches. The second approach to reducing evaporation focused on increasing the runoff water's downward movement to soil depths exempt from evaporation. This involved deepening trenches to 1.2 meters, which significantly reduced shallow lateral movement and evaporation loss, increasing the amount of runoff water received by the trees five-fold._The canopy of trees planted at the bottom of the trench are expected to completely shade the deep pits once the trees are older, thus further reducing evaporation (Figure 51 and 52).

Figure 52: Increasing water storage by deep trenches, supporting olives at 100 mm rainfall; Mashash Experimental Farm, BIDR, Israel.

Finally, the Israeli Watershed Management team tested the potential of water harvesting for increasing soil water storage in arid areas in a context of prolonged drought. Between 1996 and 2000 the Mashash area experienced the longest drought recorded locally in the last 60 years. Soil moisture levels and productivity and mortality rates among olive and *Acacia saligna* trees were recorded. Most trees survived and damage was quite limited. Among the trees that did not survive however, no soil moisture was found in the root zones, suggesting that proper techniques of runoff harvesting can support economically valuable trees in arid areas *except* during rare cases of extremely severe droughts.

Water storage in wells, cisterns, and springs entailed the construction of new wells and cisterns as well as the rehabilitation of old (sometimes ancient) and abandoned wells and cisterns, and the restoration of neglected springs.

The Egyptian Watershed Management team took part in the construction of 20 meter deep cisterns, and in the rehabilitation of old sub-surface canals in the lower reaches of Wadi Um Ashtan. The additional surface and sub-surface runoff water stored was applied to crops on two demonstration sites using two methods of irrigation. On one site, cistern-stored rainwater was applied to wheat and barley crops mixed with acacia trees, using portable sprinkler irrigation. The other demonstration site applied groundwater pumped from a 20 meter well to winter vegetables intercropped with figs, using a drip irrigation system.

The Jordanian Watershed Management team took part in the construction of 37 shallower cisterns, between three and seven meters deep, at three demonstration sites in the upper catchments of the Wadi Mujib watershed (Figure 53). Construction was co-financed with 80 households in four villages near the Muhareb, Shoushan, and Kteifa demonstration sites. The cistern water was distributed between livestock (52 percent), domestic uses (28 percent), and supplemental crop irrigation (20 percent). Financial returns would be estimated at between 1.4 and 1.7 times the cost of cistern construction.

The Palestinian Watershed management team undertook a survey of 118 springs, cisterns, and wells extant within the Hebron area. 82 of these were selected for a detailed inventory of depth, flow rates, surrounding lithology, chemical composition, ownership, and water use (domestic, irrigation, and livestock). Chemical and bacteriological analysis was conducted on some 50 springs, 95 percent of which were found to be bacteria-contaminated to the point of posing serious risk to public health. The team concluded that most were however suitable for agricultural uses, despite high levels of nitrates and chloride in a number of the springs. The inventory was used to populate a database, which was in turn used to identify the three most promising springs for rehabilitation, which involved removing debris, replacing dilapidated structures, installing PVC pipes, and building protective concrete structures.

Figure 53: Runoff collection in cistern; Jordan.

Field Crop Production and Rangeland Management

Crop production and rangeland management activities of the Initiative's Watershed Management program employed packages of improved technologies and practices to capitalize on the increased availability of water achieved through harvesting.

The Egyptian Watershed Management program introduced an agro-technical package of improved wheat and barley varieties fed by harvested runoff. The seeds were soaked and coated with bio-fertilizer containing microelements and nitrogen-fixing bacteria (Figure 54). Plots were tilled and fertilized with slow-release fertilizers. Grain and straw yields increased by 250 percent in the lower Um el Ashtan watershed, and by 50 percent in the upper watershed. Economic analysis found the market value added by the combination of the water harvesting structures and the application of the package was 30 percent higher than the cost of constructing the structures and purchasing the package, although some of the additional product was used on farm and never sold to market. Wheat production, principally for direct human consumption, increased as a result of the package's introduction. Barley production, entirely for fodder, increased as well, but not as much as wheat production. Yet barley production was more efficient in terms of resource use, and proved more profitable than wheat production. However, in order to provide sufficient household income from livestock production by growing enough supplemental feed to effectively reduce grazing pressure, the productivity of barley would have to increase to levels greater than those achieved by the project.

Figure 54: Improving cropland and rangeland productivity in Egypt.

National Watershed Management programs introduced new forage species to support livestock in rangelands that benefited from the local runoff harvesting efforts. These forages further encouraged measures to protect the rangelands from overgrazing. Range improvement activities on 72 *feddans* in Egypt and across 2,500 hectares in Jordan grew thousands of *Atriplex* seedlings in degraded rangelands which capitalized on local runoff harvesting. In Jordan, succulent leaf *Opuntia* cactus was also introduced in alternating "inter-ditch" strips of cactus and barley. In Egypt, exotic acacia species were introduced as well. Land owners were advised to refrain from grazing for several years until saplings were well established. The Jordanian team monitored rainfall, soil composition and moisture, and seedling survival and growth rates. The Egyptian team successfully promoted these fodders on the terraces of reclaimed wadis in conjunction with high-value horticultural crops at the wadi bottoms. The success notwithstanding, the team estimated that its range improvement efforts led to 10 percent increase in profits – far less profitable than investments in improved cereals or in olive cultivation in the same watersheds. Yet in both Egypt and Jordan, the shift from natural rangeland to a mixed rangeland–crop system increased carrying capacity and yielded higher net returns to farmers.

The Palestinian and Tunisian Watershed Management programs worked with very large numbers of forage and medicinal plants, including sea orach (*Atriplex halimus*), saltbush (*Atriplex nummularia*), golden leaf wattle (*Acacia cyanophylla*), and sturt's cassia (*Cassia sturtii*). The Tunisians planted bushes and trees in pitted rows in sites from 6 to 300 hectares, and promoted their establishment with fertilization and irrigation with brackish water from adjacent wells. Seedling survival and growth rates were closely monitored, as was the degree of sand stabilization achieved. The activity brought about measurable regeneration of indigenous vegetation on degraded rangelands, and contributed to the stabilization of sandy soils (Figure 55). Livestock grazing and firewood collection were excluded from the plots by fencing and through agreements with local land owners. 150 families received 80 kilograms of barley a year as compensation, as well as a large number of olive tree seedlings.

The Jordanian Watershed Management team's work on rangeland management stressed alternatives to grazing, and its strategy to reduce grazing pressure included a co-financing arrangement with farmers owning fewer than thirty heads of livestock to construct animal shelters. The strategy also included supplementing or replacing grazing forages by providing fodders, both dry feed blocks and fresh opuntia cactus cladodes were cultivated in the runoff harvesting project (Figure 56). Several training events provided farmers instruction on the preparation of feed blocks using a variety of farm residues. The team was also involved in maintaining and monitoring government range reserves, and organized a number of "cut and carry" operations among local farmers, providing another source of fresh fodder.

Figure 55: Rangeland rehabilitation in Henchir Senoussi and Ouled Hfaiedh, Menzel Habib region, Tunisia. Overgrazed sandy rangelands (forefront) degraded into shifting sand dunes (background, right)

Figure 56: Opuntia cactus produced at eco-tourism site; Jordan.

Fruit and Non-Fruit Tree Cultivation

Dryland Initiative work on tree cultivation included ***fruit trees***, combinations of fruit and non-fruit trees, and intercropping fruit trees with annual crops. The Palestinian Watershed Management team selected a number of watersheds in which to test the effects of a novel run-off harvesting structure on nearby trees, both established and newly planted. The watersheds were selected on the basis of detailed soil chemical analyses and soil profiles which revealed evidence of soil degradation, low water holding capacity, and reduced infiltration – but also the availability of soil nutrients vital to the cultivation of trees. One-year old saplings of improved, drought-tolerant varieties of almond, apricot, peach, and fig trees were planted in ten sites. Four other sites with existing olive trees were also selected, and the 14 sites were used to test the efficiency of two water harvesting techniques in supporting the trees. The Israeli Watershed Management team monitored the long term responses of almond and pistachio orchards to floodwater harvested at an experimental farm at Avdat (Figure 57). The changes recorded in almond and pistachio yields were entered into a database that was used to collect information presented in Watershed Management training programs.

Intercropping fruit trees and annual crops is a particularly efficient practice in utilizing harvested

Figure 57: Run-off harvesting for tree cultivation. Almond trees on the Avdat Runoff Agriculture Demonstration Farm; Israel. Run-off generating area is the rocky slopes at the background. Small dykes (arrows) lead the runoff to the terraces.

and stored runoff. In the rainy season, topsoils are moist and water is readily available to shallow-rooted annual crops. In the dry season, topsoils are parched but the water stored in deeper soil layers is available to deep-rooted trees.

The Egyptian Watershed Management team intercropped fig and olive trees with tomatoes, onion, and faba beans on sites supported by both harvested water (stored in the soil), and water stored in shallow wells that was transported through non-pressurized drip irrigation (Figure 58). This method of supplemental irrigation increased water use efficiency among trees by between 50 and 60 percent, and raised fig and olive yields by between 60 and 70 percent. Water use efficiency among the intercropped vegetables increased by factors of between three and five, and yields were between 9 and 17 times higher than those achieved without irrigation. The investment in olive production was especially profitable, with returns projected at 11.5 times the cost of constructing and maintaining the runoff harvesting structures.

Israeli experiments at the BIDR Mashash farm intercropped olive trees and orange wattle (*Acacia saligna)* with English Sudan grass (*Sorghum vulgare*) and went on to achieve maximal non-competitive utilization of stored water throughout the soil profile (Figure 59). The Israeli Watershed Management team also experimented with an innovative runoff harvesting method for supporting olive cultivation in deep trenches. These experiments took place in the context of the extreme drought conditions described earlier under *Water Harvesting Techniques*, and were supported by a model that projected the trench runoff storage technology to be less successful than irrigation, but more successful than conventional rainfed olive cultivation.

Figure 58: Drip irrigation system, using pumped groundwater from a 20-meter deep well, used in winter vegetables intercropped with figs; Egypt.

Figure 59: Firewood and fodder trees. *Acacia saligna* is cultivated for perennial production of firewood. Regeneration following lopping. Runoff through a wadi bed is channeled to this run-off collecting enclosure circled by earthen dykes.

The Tunisian Watershed Management team planted olive trees in degraded sandy rangelands at low densities of between 17 and 20 trees per hectare. The low density sowing would enable the regeneration of indigenous pasture vegetation, thus promoting the transformation of the degraded range into a stable and sustainable sylvi-pastoral system.

Non-fruit bearing trees are important sources of fuelwood and fodders, and benefit soil conservation both directly and indirectly. Their direct benefits apply through the effects of their deep root systems and canopies, which protect soil from being swept away by floodwater and surface soil from being impacted by raindrop and eroded, respectively. Their indirect benefits relate to their role as fuelwood sources, which - sustainably harvested - can remove pressure from surrounding vegetation.

The orange wattle (*Acacia saligna*) tree used in the Mashash farm intercrop proved to be very efficient in producing high quality firewood in arid areas where concentrated runoff is sufficient to promote its post-harvest regeneration. This exotic (Australian) species is an aggressive alien invasive species in non-arid areas, but fortunately it can not germinate in arid areas, hence its introduction into runoff harvesting systems in arid areas for firewood production does not cause an uncontrolled invasion, since the plant cannot spread out of the runoff catchment and into the dryer areas outside it. Israeli research in the Yatir area found that non-fruit tree species of arid origin such as *Acacia negevensis* respond better to harvested runoff in degraded arid areas than do species of semi-arid origin, and are more useful in arresting soil erosion.

Israeli and Palestinian afforestation activities also recognized the cultural significance of non-fruit bearing trees, which became the focus of Palestinian tree-planting campaigns in public gardens and recreational parks and along roadsides. Thousands of saplings were planted in cooperation with schools and local communities throughout the Hebron area, with public awareness messages stressing the cultural and aesthetic value of trees as well as their role in environmental stewardship.

The tree-planting ethos inspired earlier *afforestation* efforts in Israel during the 1960s and 1970s at Yatir, and the Israeli Watershed Management team analyzed the pros and cons of those past efforts. The team concentrated much of its afforestation efforts at a 3,000 hectare site in Yatir, and found that only 3 percent of the rainfall in the watershed becomes surface runoff, and that *none* of it escapes the watershed in flash floods. Soil erosion in the watershed is therefore negligible. Since the trees were found to transpire 60 percent of the rainfall, 40 percent remained available to wild indigenous vegetation within the forest.

Dryland afforestation was found to be instrumental in soil conservation, and in controlling destructive and wasteful flash floods – but at the cost of reducing indigenous non-woody biodiversity. Afforestation in the Yatir area reduced the productivity of indigenous annual plants by 48 percent, and the productivity of perennial shrubs by 93 percent, as compared to non-grazed and non-afforested parts of the Yatir area. A controlled field experiment carried out in the forest demonstrated that arboreal and herbaceous vegetative cover both reduce runoff and increase soil moisture, and that mixed arboreal–herbaceous cover is slightly more effective in doing so. The finding led to the conclusion that sustainable rangeland management is likely to be as effective in soil and water conservation as replacing rangeland with forest, though the combination of planted trees and indigenous flora is likely to prove most effective.

The ***carbon sequestration*** implications of dryland afforestation lend the practice a novel economic potential in addition to its fuelwood, forage, and recreational values (Figure 60). The Israeli team valued the carbon sequestration returns to afforestation at US$18 per hectare annually on the global carbon market. Pruning afforested areas for fuelwood and fire prevention was valued at $63 per hectare per year, and forage production was valued at $43 per hectare per year. Finally the recreational value of afforested areas was valued at $0.7 per hectare per year based on travel cost methods by which an average tourist's willingness to pay for travel to the site is estimated. On the other hand, an Israeli socio-economic survey established that local Bedouins earn less than 1 percent of their overall income from forest grazing. Yet this grazing is quite valuable to forest managers as a measure to prevent forest fires, which are often ignited by the annual under-story if it is not grazed in spring but remains as standing-dead fuel during the dry season (Figure 61).

Figure 60: Exploring the pros and cons for arid afforestation. Afforested (back) and non-afforested (front) areas of the Yatir Watershed in the spring growing season; Israel.

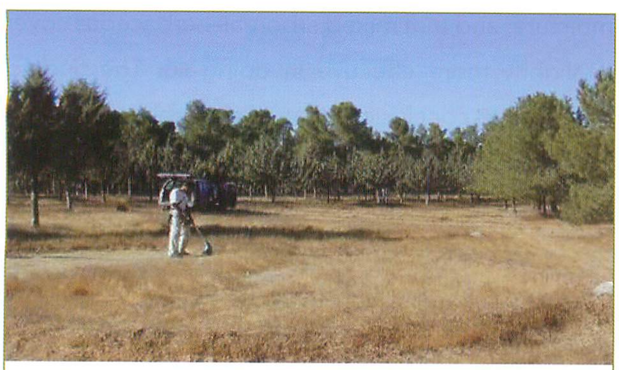


Figure 61: Summer, non-afforested vegetation is mostly standing-dead. The Israeli WSM team harvests the annual production of the indigenous vegetation cover.

Taken together, the combined annual monetary benefits derived from forests were estimated to be double the annual cost of forest maintenance. But the economic value of the water used by the forest proved to be higher than the value of the forest itself. This negative equation of dryland afforestation can be offset by the non-industrial MENA countries through income to be generated under the Carbon Finance Mechanism within the framework of the Kyoto Protocol, especially given the relatively high carbon sequestration potential of this afforestation.

The Tunisian Watershed Management program saw notable success in using tree-bush combinations to ***fix dunes*** in its rangeland restoration efforts. A large, sandy traditional rangeland in the Gabès area had been overgrazed to the point that the land base was seriously destabilized, with widespread degeneration into shifting dunes. The Tunisian team collaborated with the Ministry of Agriculture and the *Institut National de la Recherche en Génie Rural Eaux et Forêts* (INRGREF) in implementing the restoration program with the participation of local land users. Water harvesting methods included irrigation using water from local wells (with 17 grams salinity per liter), and areas of sand were overlaid with a checkerboard pattern of palm leaves and straw to prepare the soil for planting. Drought- and salt-tolerant bushes and trees, including date palms and olives were then planted to serve as dune stabilizers, in addition to their roles as sources of fruit, forage, and fuelwood. By the end of the sixth year of the project, which included five years of drought, sand drift was totally arrested, natural vegetation spontaneously emerged, and overall range productivity increased four-fold.

Genetic Resources and Biodiversity

The Palestinian Watershed Management team surveyed the Hebron area to assess the status of medicinal plants and to compile a wild flower guide including photos of 300 local species. The Tunisian team conducted a vegetation survey carried out principally in a protected area within the Menzel Habib project site, where the range was not degraded and hence most rangeland species were represented.

An Egyptian Watershed Management program survey of 45 sites throughout the Sinai Peninsula characterized each by its soil properties, plant community, and the economic properties of its species. 62 species were found, 16 of which were identified as prime fodder species, and 19 of which were identified as medicinal species. Chemical analyses were used to establish their nutritive and pharmaceutical properties. Another Egyptian project activity carried out vegetation transects in 12 land cover types in the Um el Ashtan watershed and identified 53 species, half of which were forages. The project team calculated the relative abundance, cover, and standing crop of all 53 species, and determined their protein, carbohydrate, ether extract, fiber, and ash compositions.

An Israeli survey collected seeds and samples of two wide-ranging high-quality forage species, orchardgrass (*Dactylis glomerata*) and the legume purple clover (*Trifolium purpureum*), from their marginal populations at the desert edge and from more mesic populations. 6,000 orchardgrass and 7,000 purple clover offspring of the sampled field populations were tested in a greenhouse experiment to determine variability in morphological and reproductive traits, the heritability of these traits, and the relations of the variability to the persistence of the populations when exposed to environmental stresses (Figure 62). The Israeli Watershed Management team also conducted a survey of climatic arid–semi-arid transition zones in Israel. The survey revealed that most of the 140 plants species found in the transition area were represented by their peripheral populations. The results of the studies suggest that the rangeland plants in the transition zones are potentially highly resistant to environmental stresses. They are therefore good candidates for use in rangeland rehabilitation when transplanted to dryland climates that differ from those of their indigenous locations.

Figure 62: Exploring within-species variability and trait heritability of two forage plants, *Dactylis glomerata* and *Trifolium purpureum*, collected along a rainfall gradient in Israel.

Seeds collected and evaluated during field surveys were selectively deposited in genebanks and cultivated in botanic gardens. The genebanks and botanic gardens both provided material to nurseries, which came to be used intensively by the national Watershed Management programs.

The Tunisian Watershed Management team consulted with a range of experts and local informants familiar with indigenous knowledge to identify plant species known to be drought tolerant, well adapted to saline conditions, or useful in stabilizing sand dunes. Some of the species had all three characteristics. The team collected 33 such species— mostly wild herbaceous and woody forage plants—and deposited their materials in a seed bank established at the *Institut National de la Recherche en Génie Rural Eaux et Forêts* (INRGREF) in Tunis. (A second cold chamber was available at the INRGREF Research Station at Gabès.)

The Egyptian team used a number of genebanks to store seeds of promising species collected during the biodiversity surveys of the Sinai Peninsula and the Northwestern Coast, and enlarged a botanic garden to accommodate the seedlings of 25 species for investigation and seed production. Studies in the botanic garden compared the fodder yields of forage species collected during the Um el Ashtan biodiversity survey and other species imported from Jordan and Tunisia. Saltbush (*Atriplex nummularia*) was found to have the highest fodder yield and *Ononis vaginalis* to have the lowest.

The Palestinian team established 13 botanic gardens and one herbarium. The 15 hectare botanic garden in Jericho was fitted with a drip irrigation system. The garden in the Hebron area accommodated 60 indigenous plant species. Another large botanic garden in Idna carried 500 West Bank plant species. The remaining 10 botanic gardens were established in schools in Hebron area villages, and were used to promote public awareness focusing on children audiences (Figure 63).

Nurseries were established and operated by all five national Watershed Management programs and used to propagate plant species selected for their suitability to different local conditions and Watershed Management projects. Seedlings were distributed to watershed users free of charge.

Figure 63: In-situ conservation, establishing an educational protected area; West Bank.

The Palestinian Watershed Management team rehabilitated and upgraded a nursery at the Al Aroub School that was supplied with treated wastewater from the nearby wastewater treatment plant that was also operated by the team. The nursery produced thousands of seedlings of some 50 forage and afforestation species used for range and woodland rehabilitation. Over 11,500 seedlings of *Acacia sp.* and *Atriplex sp.* cultivated at this and other Initiative nurseries were planted on a total of 80 hectares at Wadi Nar, Dahria, Ennab Al-Kabirah, Ratheem, and the Al-Kaabneh catchments.

The nursery at the El-Qasr Research Station produced thousands of saplings of nine forage bushes and trees used in the Egyptian rangeland rehabilitation project at Wadi Um Ashtan. The nursery was used to cultivate both exotic and indigenous species of shrubs and trees that were selected by virtue of their drought-tolerance and their forage and fuelwood productivity. The facility was an improved nursery, where production costs were 36 percent lower than in traditional nurseries, and sapling survival rates were 55 percent higher. Seedlings and seeds were distributed to farmers for demonstration and the establishment of small on-farm nurseries. Thirty-thousand seedlings were distributed to farmers in the 2002–2003 growing season alone, and 30 Bedouins were trained in the production of seedlings.

Nurseries were also established to germinate seeds collected during project activities. Two such Tunisian nurseries in Oued Zeyed and Menzel Habib produced thousands of seedlings of a score of species for rangeland rehabilitation from seeds collected at project sites (Figure 64). The Egyptian Wadi Sudr and El Sheikh Zuwayid nurseries produced seedlings from the seeds collected during the Egyptian biodiversity survey of the Sinai Peninsula, which were later planted in newly reclaimed sites on the Peninsula (Figure 65). The Jordanian team established a one hectare nursery for thornless

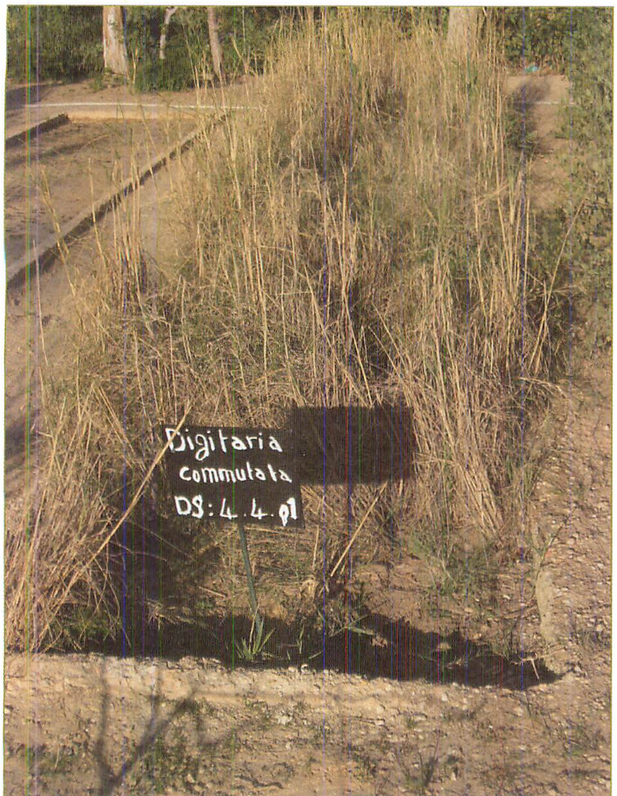


Figure 64: Gabès Nursery, Tunisia.

Figure 65: Nursery Egypt.

Opuntia cactus in the Wadi Mujib watershed, and helped improve six other government and private nurseries to support cactus plantations.

The *in-situ* conservation of plant genetic resources on farms and rangelands was another focus of Watershed Management activities relating to biological diversity, and included work within protected areas that had eco-tourism components.

The Palestinians compiled a comprehensive biodiversity conservation plan with recommendations for the designation and management of protected areas in the West Bank and in the Wadi Gaza watershed in the Gaza Strip. The Jordanian team surveyed areas along the eastern coast of the Dead Sea and likewise identified a number of places that would make suitable protected areas. The team developed a framework plan for eco-tourism in the areas that were set aside for conservation purposes. Plant cover was rehabilitated at eco-tourism sites using thornless cactus and forage species, and an agreement was made with local Bedouins to protect the area against grazing. A system of paid grazing was tested by the Jordanian team at the Sura Nature Reserve (Al Mafraq) where grazing was banned for four years and reopened for paid grazing of privately owned herds of sheep. The revenues earned were used to maintain the Reserve. Israeli work on *in-situ* conservation included a study of within-species genetic diversity of selected forage plants from the transition zones between arid and semi-arid drylands. These forages exhibited both high between- and within-species diversity that suggested their suitability for rehabilitating degraded rangelands. Based on this research, the Israeli team would recommend the establishment of biodiversity conservation areas in a number of these transition zone rangelands.

Diversifying Farming Systems and Promoting Off-farm Activities

The Egyptian team conducted a baseline survey of dryland farming systems involving 100 land users in the northwestern coastal zone at Wadi Um Ashtan and Halk El-Dabaa, and evaluated a number of rangeland use practices. The Palestinian team conducted a socioeconomic survey of a number of its water harvesting activities, and found that the terracing technique was most preferred by local farmers, even though its construction was the most costly. Income returns from olive cultivation on the terraces was the highest of any of the water harvesting methods tested. The Israeli team examined the benefits accruing to Bedouin herders from purchasing permits to graze in an arid afforestation project, and compared these to the benefits of herding flocks to more distant but more productive agricultural fields where the Bedouins could purchase foraging rights on stubble. The results of these farming systems analyses and other socio-economic studies led the Watershed Management teams to promote the cultivation of a number of non-conventional crops as well as a variety of other land-based income-generating activities.

The cultivation of non-conventional crops moved farm production towards higher value crops. These crops included cacti of the genus *opuntia* and a number of herbal and medicinal plants. Opuntia cactus cladodes were cultivated as both fodder and a fruit crop. Though not a traditional animal feed in the MENA region, the thornless cactus produces edible succulent cladodes as well as a marketable fruit. The plant is productive in areas with 150 millimeters annual rainfall, is drought-tolerant, and its water-use efficiency is high. The Jordanian team established six ad-hoc cactus nurseries for propagating the thornless variety, which had been imported from Tunisia. Jordanian farmers and livestock owners readily accepted the cacti, both as a cash fruit crop and as a cheap fodder supplement. 127,000 cacti were planted on 67 hectares on 14 private farms, and in a protected area in the Wadi Mujib watershed. The Jordanian team also co-financed small beekeeping and rabbit husbandry operations together with individual farmers and rural NGOs using microcredit.

Large scale farm cultivation of high market-value medicinal and herbal plant species was hindered by limited access to improved plant stocks, insufficient knowledge as to how to farm them under dryland conditions, and inadequate extension (Figure 66). These species were mainly non-domesticated wild plants traditionally gathered in MENA rangelands. The Jordanian team was particularly active in this area, and first experimented with rainfed cultivation of cumin, fenugreek, black cumin, anise, caraway, and fennel in collaboration with the National Center for Agricultural Research and Technology Transfer (NCARTT). These experiments were followed by tests with irrigated cultivation, which was also applied to oregano, sage, chamomile, rosslle, mellisa and arak. Seed quality, germinability, leaf chemical properties, and weed control methods were improved and field-tested, resulting in recommendations for attaining high yield and high quality of each species. For example, growing thyme under plastic house conditions maximized yield and return, while sage was recommended to be cultivated under open field conditions. For chamomile, the team sought to develop techniques to extend flowering time to increase yield. Arak, mellisa and rosella cultivation was found to be feasible under conditions of high heat and salinity, particularly when mulched.

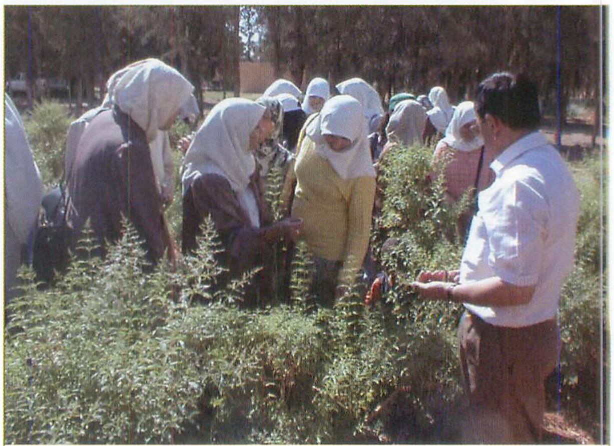


Figure 66: The Jordanian Initiative team raises awareness for the production of herbal and medicinal plants among rural women.

Figure 67: Jordanian lavender sold on a French market.

The highest dollar value added was achieved with cumin, and was 3.3 times higher than that of traditional wheat and lentil crops. The lowest value added was achieved with fenugreek, which was still 20 percent higher than these traditional crops. Field demonstrations were conducted on several hundred hectares working with more than 100 farmers in 32 villages in three regions, including sites in the Wadi Mujib and Madaba areas. The returns farmers derived from cultivating medicinal and herbal plants was generally greater than the production cost – 240 percent higher for fennel, the most profitable species. Chemical analyses of the active ingredients in thyme, sage, mellisa, rosella tea and arak were conducted in collaboration with the Faculty of Pharmacy at the University of Jordan, and yielded valuable results that were incorporated into the technical assistance provided to participating farmers. The integration of medicinal plant production with beekeeping was also tested. Farmers were interviewed to identify constraints to and opportunities for commercialization, and the team produced a report on the competitiveness and marketing of medicinal and aromatic plants. The report was subsequently used to prepare a successful grant proposal to the Global Environment Facility (GEF).

Farm-based dairy facilities were another focus of farm diversification and transition to higher value production. These facilities would process the milk into higher value products than raw milk, and the products would be directly marketed by participating farming groups. The improved dairy production would increase livestock profitability without any need to raise stocking rates. A women's cooperative in Faisalyia village specializing in milk processing was monitored by the Jordanian team to gather information on the milk market chain, and to illustrate the link between forage production, milk production, and its processing. The cooperative's 25 producers together processed 400 kilograms of milk a day, and the product's successful marketing created 107 jobs down the supply line. Later, following a survey of several communities, the Jordanian Watershed Management team co-financed the establishment and operation of two dairy units which were regularly supplied with fresh milk from neighboring communities. Women in these communities were employed both in processing the milk products and in marketing them. One of the dairy units achieved returns 20 percent higher than the cost of investment and operations. The other dairy unit was not profitable. Livestock producers also benefited from additional fodder sources introduced under the programs; including the rainfed thornless opuntia cactus described above, and treated wastewater-irrigated rye grass (Figures 68). These represented non-conventional fodder sources with zero impact on surrounding rangelands.

Figure 68: Rye Grass is being fed to sheep, reducing pressure on over-exploited rangeland; on-farm trials; Jordan.

B. The Treated Wastewater and Biosolids Re-use programs of the Dryland Initiative

Wastewater Treatment

In Tunisia, Initiative funding was used to assist the government's *Office National de l'Assainissement* (ONAS) in upgrading the treatment plant in Gabès. The existing plant employed a secondary treatment process with capacity to produce 17,000 cubic meters of treated water a day (Figure 69). The Tunisian Treated Wastewater and Biosolids Reuse team invested US$120,000 in the construction of an infiltration and percolation pilot station that generated 150 cubic meters of tertiary treated water a day (Figure 70). The pilot station was constructed near the existing wastewater treatment plant, and the Tunisian team purchased a variety of laboratory equipment that was used to test water quality. Experimenting with the tertiary treatment process, the team explored the potential of a sandy layer in filtering the water, and determined optimal filtration rates. Experiments with filtering agents, with systematic monitoring of water quality, were carried out on silvo-pastoral, ornamental seedlings, and vegetables cultivated in a nearby nursery. The experiments were likewise conducted on vegetables on experimental plots in the Dissa irrigation perimeter, making for somewhat greater approximation of cultivation under less controlled conditions. The results enabled the team to identify the water quality and treatment levels required to support the different types of plants. Water treatment could therefore be tailored as necessary to support specific plant species.

Figure 69: Secondary treatment of wastewater in Gabès, Tunisia.

Figure 70: Tertiary wastewater treatment funded by the Initiative; Gabès; Tunisia.

At the outset of the operation there was no demand for treated wastewater for agricultural use. Lack of local irrigation infrastructure, technical extension, and knowledge of treatment levels appropriate to individual crops made it difficult to coordinate the pilot facility activities with the needs of prospective customers. Towards the end of the Initiative, the tertiary-treated water was being routinely used to irrigate the garden of the treatment plant and fruit trees of one farmer in the Dissa perimeter, and its demonstrated usefulness is hoped to stimulate demand if publicized. Some of the treated water was used to recharge local groundwater following its use in irrigation. The rest was disposed at sea, a marked improvement to disposing raw sewage or secondary treated wastewater into the Mediterranean.

The Palestinian Wastewater Treatment and Biosolids Re-use program was the only other Initiative program to construct and operate its own wastewater treatment facilities. Whereas the Tunisian team worked on transforming secondary treatment to tertiary treatment, the Palestinian team was initially engaged in primary treatment and later secondary treatment processes. In 1997 the Palestinian team installed a treatment system for the wastewater produced at the Al Arroub Agricultural School in the Hebron area (Figure 71). The facility was intended to serve both educational (demonstration) and experimental (research) purposes. The small facility processed between 300 and 400 cubic meters of wastewater a month. The facility was later upgraded with a mechanized treatment unit, which was useful in comparing its performance with that of Palestinian wastewater treatments that used duckweed.

Duckweed (*Lemna*) is a tiny floating, flowering plant which has proven effective in reducing biological oxygen demand (BOD) and in removing total suspended solids (TSS) and nitrogen and phosphorus levels in the water. Owing to its fast growth rates, duckweed can serve as a supplement or even a substitute to the bacteria and algae used in conventional wastewater treatment. But duckweed has an additional advantage in that its high protein content makes it a valuable fodder. The Palestinian team investigated the use of duckweed and systematically monitored the system's performance. They also conducted experiments in composting harvested duckweed. The duckweed-treated wastewater was used to irrigate plants in a nursery, in a botanic garden, and in other experimental plots. Palestinian experiments were purposefully conspicuous and demonstrations were often targeted at public audiences with regular emphasis on students in addition to the documentation of findings among professional scientists.

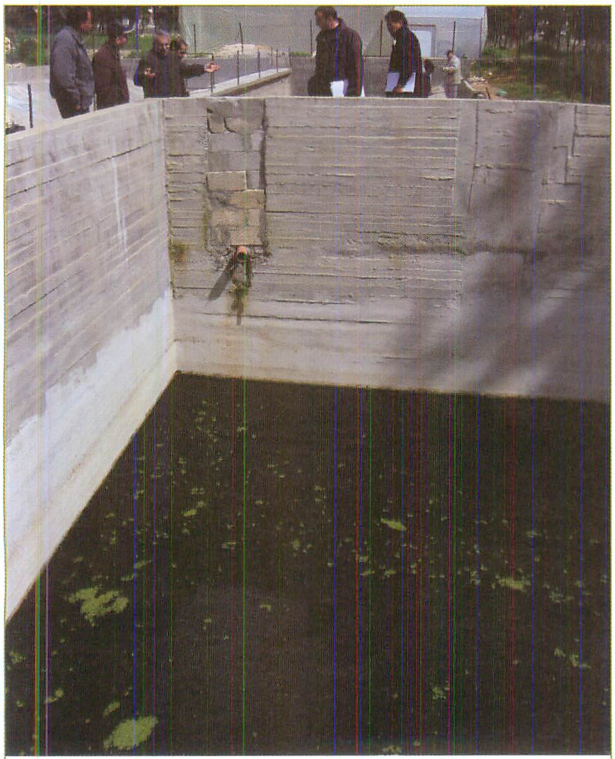


Figure 71: Wastewater Treatment Plant at Al Arroub Agricultural School, West Bank.

Treated Wastewater Reuse in Agriculture

The effects of the differently treated wastewater on irrigated soils were measured using soil samples that were sent to certified laboratories in Egypt, Israel, and Jordan. Samples of soils irrigated with treated wastewater were compared to soils irrigated with freshwater for control purposes. The results depended on soil type, crop, and the amount of rainfall as well as on the quality of the water used (Figure 72). Boron concentrations (both naturally occurring and resulting from the amount of detergents in the treated wastewater), increased in both the Egyptian and the Israeli plots. The Israelis found these boron concentrations to depend on the amount of absorbing clay and on the intensity of leaching by rainfall.

Figure 72: (Primary) Treated Wastewater. Visual appearance gives first indication of water quality and often causes social rejection of wastewater reuse, especially on food crops.

Phosphorous concentrations, salinity, and sodium absorption ratios (SAR) increased in the Israeli and Jordanian herbal and medicinal plots. (The SAR is particularly important in its effect on soil structure, aeration, and infiltration rate.) But in Jordanian plots of woody trees, where soils were relatively saline, salinity and SAR values decreased. The results of irrigation therefore depended on the type of crop, and also varied by soil type, soil depth, and season. In the Israeli plots of annual field crops, differences in salinity between wastewater- and freshwater-irrigated soils depended on their location in relation to the country's north-south rainfall gradient, and on the proportion of sand in the soil composition. Concentrations of heavy metals increased in Egyptian, Israeli, and Jordanian plots, but remained at levels well within those recommended for long term irrigation. A few Israeli soil samples exhibited fluoride concentrations higher than US Environmental Protection Agency regulations would permit. The Egyptian team also conducted microbiological tests and revealed, as expected, a higher incidence of pathogenic organisms in the treated wastewater-irrigated soils.

Treated Wastewater and Biosolids Re-use program experiments on the effects of treated wastewater irrigation on crops classified these crops according to their importance to human health and consumption. By this criterion, field and fodder crops were purposefully prioritized, followed by fruit- and fiber-yielding trees, and finally afforested trees. The effects of the treated wastewater were tested by comparing chemical composition, crop health and condition, and yield to the same crops irrigated with non-wastewater sources.

Field crop effects. The effects of treated wastewater irrigation on field crops were researched by the Egyptian, Jordanian, and Tunisian teams. Egyptian experiments worked with a traditional integrated farm management system in the Nile delta in which the same field is used to cultivate five different crops in sequence; soybean, sugar beet, sunflower, canola, cotton and maize. The crops were irrigated sequentially or alternately with freshwater and drainage water. Three irrigation sources were tested: secondary-treated wastewater, treated wastewater alternated with fresh water, and drainage water alternated with fresh water. The overall exposure of crops to treated wastewater was therefore diluted in a number of the experiments. Each of the treatments was applied through both surface and drip irrigation, and each of the crop species (grown in sequence) was tested both in the field and in lysimeters (Figures 73 and 74). The quality of the irrigation water was measured against World Health Organization standards. Based on its findings, the team recommended that drip irrigation be used in the alternation of fresh water with each of the marginal water types. Undiluted wastewater was found entirely suitable for cotton and canola cultivation. The plants remained healthy with each type of treatment, and the alternations with marginal water sources achieved fresh water savings of up to nearly 50 percent.

There is an important distinction between annual field crops and perennial crops like citrus – annual crops require far less water throughout the year than perennials, and they are tilled whereas perennial

Figure 73: Treated wastewater trials, Kafr El Sheikh, Egypt. Indoor experiments.

Figure 74: Treated wastewater trials, Kafr El Sheikh, Egypt. Outdoor experiments.

crops are not. These differences may modify the impact of treated wastewater on annual crops and soils. Both the Israeli and the Tunisian teams tested the effect of tertiary-treated wastewater on annual field crops. The Tunisian Initiative team, together with CITET and IRA, experimented with drip- and furrow-irrigation of green pepper, tomatoes, potatoes, and lettuce using tertiary-treated water on a farmer's plot in the Dissa Perimeter. The team found that fruits and leaves of pepper, potato, and tomato irrigated with tertiary-treated wastewater had bacterial flora similar to the bacterial flora typical of these crops sold in the local market. When these crops were furrow-irrigated with secondary-treated wastewater however, bacterial contamination increased considerably. The Israeli team also explored the long-term effects of tertiary-treated irrigation on a large number of plots subjected to frequent field-crop rotations, in order to monitor the water's cumulative effect on the soil. This soil monitoring was undertaken prior to testing the effects of the tertiary-treated wastewater on crops.

Fodder crop effects. The response of fodder crops to irrigation using treated wastewater was a focus of research among the Israeli, Jordanian, and Tunisian programs. The Israeli team studied the nutritional value of treated wastewater applied to corn grown as fodder, and was able to demonstrate substantial reductions in the amount of fertilizer required. The team found no reduction in crop yield, in spite of increases in salinity parameters in the wastewater-irrigated soil.

The Jordanians used secondary-treated wastewater from the Madaba Wastewater Treatment Plant to irrigate the green fodder sources ryegrass, sudan grass, salex, sorghum, alfalfa, and canola (Figure 75). A two hectare experimental plot in the vicinity of the Madaba facility, and a 17 hectare farmer's field were used as experiment and demonstration sites. The irrigation enabled four to five harvests a year, and increased ryegrass productivity by some 40 percent. On the 17 hectare field, the irrigated ryegrass earned 25 percent more than the barley the farmer had previously cultivated. The soil and the forage were tested for chemical and bacterial composition, and values were found to be compatible with World Health Organization standards for livestock fodder. In addition, fat and milk from cows fed with TWW-irrigated fodder crops were found to be similar to those produced using freshwater-irrigated fodders.

Figure 75: (Primary) Treated Wastewater Reuse in fodder and tree crop production; Jordan.

Blood tests for potentially toxic metals (cobalt, chromium, cadmium, nickel) showed concentrations within EU and Codex Alimentarius standards.

The Tunisian team irrigated furrows of alfalfa and oat fodders in the Dissa Perimeter with secondary-treated wastewater from the treatment facility at Gabès (Figure 76). *Office National de L'Assainissement* (ONAS) technicians regularly monitored water quality. The Dissa Perimeter was intended to eventually receive tertiary-treated wastewater in order to assess the marginal contribution of the tertiary plant in improving the quality of treated wastewater and the productivity of the crops.

Fruit tree effects. Israeli experiments with fruit trees used secondary-treated and tertiary-treated wastewater to irrigate experimental plots in some 140 citrus and avocado orchards (Figure 77). Irrigation using fresh water was employed as a control. The orchards were distributed along an aridity gradient from northern to southern Israel. The investigators monitored chloride, sodium, potassium, boron, phosphorous, nitrogen, and heavy metal concentrations in both leaves and fruit. Boron concentrations in all parts of the treated wastewater-irrigated trees were found to be significantly higher than in trees irrigated with fresh water, and the number of fruits produced per tree

Figure 76: TWW reuse in Tunisia.

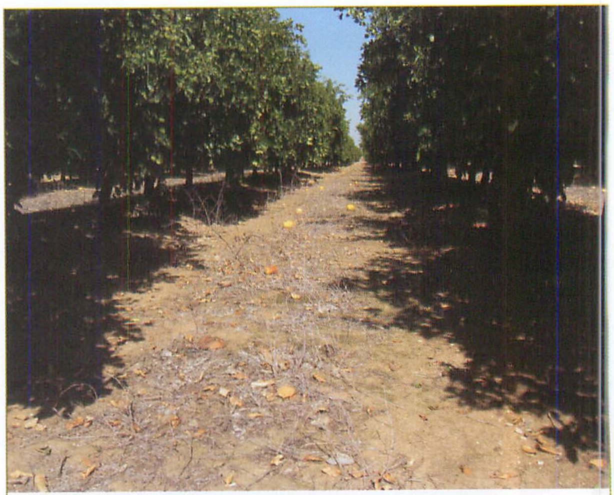


Figure 77: Citrus irrigation with treated wastewater; Israel.

declined. Reducing domestic and industrial uses of boron-containing detergents would therefore clearly increase the safety of wastewater irrigation. Tunisian experiments irrigated pomegranate trees in the Dissa Perimeter with treated wastewater provided by the facility in Gabès.

Non-fruit tree effects. Considering the low risk to human health of applying treated wastewater to afforested, ornamental, and fuelwood- and timber-producing trees, these trees received surprisingly little attention in the Dryland Initiative's treated wastewater experiments. The Jordanians investigated the reuse of low-quality treated wastewater on *Eucalyptus camaldulensis* and on *Casuarina equisetifolia* planted at a farm site in Al Hashymeih. The two species were a combination of afforestation, windbreak and ornamental trees, and the low quality wastewater used to irrigate them was generated by the Khirbet As-Samra treatment plant (Figure 78). The team found increases in growth rates, canopy height, and trunk diameter during the growing season when the low quality wastewater was applied. Less favorably, high concentrations of iron, manganese, and zinc were found in roots, stems, and leaves of both species. The Palestinian team used the primary and secondary-treated water generated by their treatment facility at the Al Arroub School to irrigate trees in the vicinity of the school.

Figure 78: Tree crop production with treated wastewater; Jordan.

Figure 80: Cut-flowers irrigated with TWW, drip-irrigation in a greenhouse; Jordan.

The Tunisian program used secondary-treated wastewater from the treatment facility in Gabès to irrigate tree seedlings that were then distributed to schools and communities in the vicinity.

Herbal and medicinal plant effects. Herbal and medicinal plants that produce commercially valuable volatile oils are other non-edible crops that can be irrigated with lower quality treated wastewater without significant risk to human health. The Jordanian and Tunisian teams were active in this area. The Jordanian team used treated wastewater from the Ramtha Wastewater Treatment Plant to irrigate an adjacent experimental field of melissa, geranium, and lavender (Figure 79). This treatment plant produced water with trace elements and heavy metal concentrations well within compliance with Jordanian standards for irrigation water. Though soil salinity in the irrigated plots increased, nutrient ion in the soil increased as well, and the condition of the plants and the quality of their volatile oils were not impacted.

Figure 79: Herbal and medicinal plants irrigated with treated wastewater; Jordan.

Brackish Drainage Water Reuse in Agriculture

The Egyptian Treated Wastewater team explored the effects of drainage water collected from irrigated sugarbeet, wheat, and rice fields on its Kafr El-Shikh project site in the Nile Delta. After determining the water's chemical properties, the water was used to irrigate a variety of crops in lysimeters. The team ran experiments to determine the levels of salinity and concentrations of lead, boron, cobalt, and nickel that can be tolerated by several field, vegetable and medicinal crops without putting the soil at risk. Being somewhat higher in salinity and pollution content than typical drainage water, the water could still be used if diluted with freshwater in order to achieve the recommended concentrations (Figures 81 and 82).

The study also experimented with field preparation, and found that the drainage-irrigated crops benefit substantially when soil hydraulic properties are improved by deep ploughing and by the removal of excess salts away from the active root. The removal of salts was achieved using laser leveling technology

Figure 81: Mixtures of drainage water, freshwater, and TWW used in crop production (sugar beet), on-farm trial; Kafr el Sheikh, Egypt.

Figure 82: Mixtures of drainage water, freshwater, and TWW used in crop production (sugar beet), on-farm trial; Kafr el Sheikh, Egypt. Salt crust building up.

to thoroughly level the fields. The Egyptian Socio-economy and Policy team also calculated the cost-benefit ratio of different combinations of drainage-water irrigation and field preparation.

Biosolids Treatment and Use in Agriculture and Energy

The Initiative experimented extensively with a variety of biosolids, including sludge generated by wastewater treatment facilities. The experiments tested composting and digestion methods, the effects of applications on numerous crops and soil types, and a number of non-agricultural uses, including the production of biogas.

The Jordanians experimented with manures generated by the large Hamodah dairy farm in Khaldeah and a number of poultry farms in the Mafraq governorate (Figure 83). The experiments sought to provide farmers with safer and more effective composting alternatives to the current practice of applying raw manure. The team systematically monitored temperature and carbon dioxide levels during the composting processes. Carbon-nitrogen ratios and plant nutrient concentrations were determined by the laboratory at the National Center for Agricultural Research and Technology Transfer (NCARTT).

The Israeli, Palestinian, and Tunisian programs concentrated on the composting of sludge mixed with varieties of other biosolids. The Palestinians experimented with composts of virtually every biosolid source generated at the Al Arroub agricultural school, including tree trimmings, grass, straw, cow and chicken manure, slurry from their biogas facility, and sludge and harvested duckweed from their pilot wastewater treatment facility. They constructed a fully operational composting plant and demonstrated successful techniques to students and visitors. The Tunisian team experimented with composts from the secondary sludge of the Gabès treatment plant, to which they added different quantities of straw and olive oil production byproducts, testing their effects on increasing carbon-nitrogen ratios in the composts (Figure 84).

Figure 83: Manure treatment, Jordan.

Figure 84: Composting sludge, ONAS Plant in Gabès, Tunisia. Drying sludge before grinding.

The Egyptians applied lime-treated sludge compost, and sludge composted with rice straw to crops at the Sakha Agricultural Research Station in the Nile delta. Electrical conductivity, sodium absorption ratios, and lead concentrations varied depending on the crop. The experiments measured the effects of these lime-treated and rice straw-mixed sludge composts on the chemical properties of a range of crops, including mango, maize, soybean, rice, sugar beet, canola and sweet pepper. In all treatments and crops, biosolid application increased nitrogen, phosphorous, and potassium concentrations in the plants, but also increased those of boron, cobalt and lead. The findings suggested that sludge produced from wastewater treatment can in most cases be used safely, and reduce the need for mineral fertilizers when mixed with rice straw.

Israeli experiments measured the effects of a wider variety of mixed biosolids applied as composts and mulches to wheat in dryer semi-arid areas, using municipal waste compost, partially digested primary and secondary sludge, and mulches of sludge, sludge compost, and wood chips (Figure 85). The Egyptian and Israeli experiments both increased soil nutrients and soil organic matter substantially. The increased soil organic matter measurably increased soil moisture in the strictly rainfed plots in Israel, but a number of the Israeli treatments increased soil concentrations of heavy metals, some of them to levels above international standards. (The lime-treated sludge used by the Egyptian team at Sakha actually reduced the heavy metal content of surrounding soils.) The Israelis found that application of sludge increased the wheat grain yield, with no differences between the mulched or the incorporated application. High levels of application (100 cubic meters of sludge per hectare) brought about increased protein content, but a significant decrease in the specific weight of the grain. Most importantly, the biosolid application was found to totally replace commercial nitrogen fertilization. During dry winters however, fields were prone to nitrogen excess, since water shortage reduces growth and therefore nitrogen use. These relations between biosolid application and natural between-year rainfall variations prompted a large scale experiment of 160 wheat plots with and without biosolid application in private and cooperative farms along a rainfall gradient of 750–250 millimeters. Israeli farmers were directly involved in all of the experimental applications of biosolids.

A number of Initiative activities experimented with the use of biosolids to produce ***biogas*** for domestic energy generation in rural communities. Biogas is a mixture of methane and carbon-dioxide that is generated when bacteria degrade biological material in the absence of oxygen. The mixture is

Figure 85: Experimental cereal crops with sludge application (herbizide application to separate two different treatments); Israel.

Table 2: Overview of treated wastewater and biosolids field work under the RIDM.

	Treatment facility & scale	Wastewater treatment level	Irrigation system for wastewater reuse	Crops irrigated with TWW	Biosolid application techniques
Tunisia	Pilot plant	Tertiary	Drip (gravity) Surface	Fruit trees Vegetables	Composting
PNA	Pilot plant (small scale)	Secondary & Tertiary	Sub-surface Drip Surface	Forages Olives	Composting Biogas
Jordan	Municipal Plant (large scale)	Secondary	Sub-surface Surface	Forages Wood trees Cactus	Composting Biogas Direct Application
Israel	Municipal Plant (large scale)	Secondary	Sub-surface Drip (pressure)	Fruit trees	Direct Application (surface cover & incorporation)
Egypt	Municipal Plant (large scale) Open drains & Canals	Drainage Primary Secondary Blended	Subsurface Drip (pressure) Gated pipe Surface	Field crops Vegetables (in plastic houses)	Composting Biogas Direct Application (injection)

flammable and can be used for cooking, heating, light, and even absorption refrigeration, although the low compressibility of methane makes the biogas difficult to store. The non-digested remains make superb animal fertilizer, with the advantage that it is free of weed seeds and of pathogenic micro-organisms which are destroyed by the anaerobic digestion.

The Palestinian team constructed three biogas units for experimental and demonstration purposes. Two of the units, near Hebron and near Dura, used manure from nearby animal farms. The other unit was a bio-digester built at the Al Arroub School, which used manure from the school's farm and sludge generated by the school's wastewater treatment plant to produce slurry used by the composting facility.

The Egyptian Initiative team established and operated three biogas units in Kafr El-Sheikh Governorate, cost-sharing them with local farmers and feeding them with farm-produced cattle manure (Figure 86). Rates of pathogenic microorganism removal and gas production were systematically monitored, and the units were found to be highly efficient both in terms of biogas energy production and environmental safety. Women farmers participating in the project proved to be enthusiastic beneficiaries, using manure and its agricultural residue in the household backyard for safe and odorless indoor cooking. A cost-benefit analysis of the activity indicated that returns to the investment in construction and maintenance were some 30 percent higher than cost. The team recommended the biogas technology be disseminated among small farmers who own less than five large ruminants, and who would be willing to manage the animal waste on a cooperative basis. Government subsidized cooking gas bottles in these areas would however impede the dissemination of the technology. The Egyptian experience encouraged the Jordanian team to install similar units at three sites in Madaba and Shamra. The treated wastewater and biosolids field work implemented under the RIDM is summarized in Table 2.

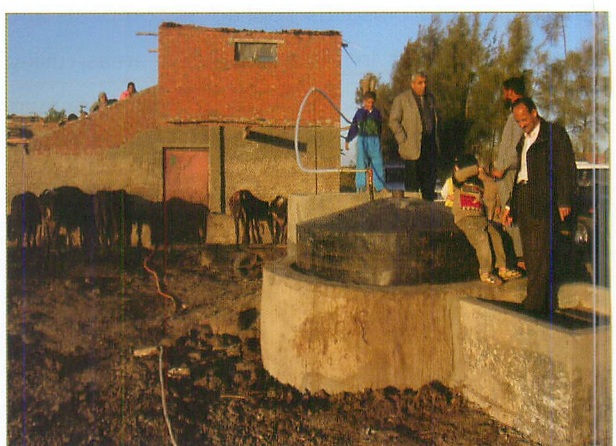


Figure 86: Biogas generation, Egypt.

Social, Economic, and Policy Implications of Treated Wastewater Reuse

When the Socio-Economic and Policy program of Phase II was mainstreamed into the two thematic programs during the Extension Phase, the weight of its work would apply to Treated Wastewater and Biosolids Re-use program, which related to a number of regulatory issues concerning quality standards. Marginal water sources are used in all five countries that participated in the Dryland Initiative. Jordan reuses 85 percent of the wastewater generated in the country. Israel and Tunisia reuse 67 and 20 percent respectively. Egypt and the Palestinian National Authority reuse smaller proportions. Each of the five countries, however, maintains its own standards and regulations for the use of treated wastewater and other sources of marginal water. These different regulatory environments were compared in a concept note after the Initiative's Granada Workshop in October 2002.

The question of the social acceptability of using treated wastewater in irrigation relates to how receptive farmers and consumers will be to the process and the resulting product quality (Figure 87). Initiative teams conducted surveys to determine this acceptability in the Hebron area in the West Bank and in the Dissa Perimeter in the Gabès region of Tunisia. The results, however, were not made public.

Figure 87: Herbal and medicinal plants irrigation with treated wastewater, Jordan.

Much more was done on the economic front. The reuse of treated wastewater clearly releases pressure on renewable sources of fresh water in MENA and raises productivity thresholds. The question of the economic viability of investments to upgrade wastewater treatment capacity relates to the value of the benefits of this fresh water savings and the increased production it enables relative to the cost of the investment.

The Egyptian team conducted a cost-benefit analysis of advanced methods for preparing fields to be effectively supplemented by marginal water irrigation. The Jordanian team conducted a cost-benefit analysis of growing ryegrass and alfalfa on treated wastewater as compared to cultivation of barley as fodder, usually rain-fed but experimentally receiving supplemental treated wastewater irrigation. The team found that the return per unit area from ryegrass was 10 times greater, and from alfalfa three times greater, than that obtained from irrigating barley with treated wastewater. Water use by ryegrass was found to be twice as efficient as water use by barley. More importantly, the analysis demonstrated that the price of treated wastewater in the analyzed Jordanian Initiative's experiment was almost equivalent to the price paid by the Jordan Valley farmers for high-quality fresh water. A similar cost-benefit analysis of cultivation of herbal and medicinal plants was also conducted, but the analysis omitted the price of water.

The Israeli Treated Wastewater team analyzed the costs of upgrading the quality of treated wastewater in response to a government decision to increase the use of treated wastewater in irrigation – a decision that required new standards for wastewater quality. The standards were established by a government-appointed committee in part based on the findings of a joint Ministry of Agriculture – Israeli Treated Wastewater team survey that tested the effects of various wastewater treatments on crops and soils.

The Israeli treated wastewater Initiative's Team Leader was a member of this committee. The new standard recommended by the committee would entail substantial added cost that would be divided between treated wastewater producers and consumers. The results were expected to determine the relative share in the cost of the elevated standard, as expressed in the Government-pricing of the treated wastewater allocated to the farmers. The Ministry of Agriculture and a farmers' association independently conducted cost-benefit analyses of the recommended standard that generated conflicting findings. Ministry of Agriculture findings suggested that farmers would enjoy stable benefits from the use of the treated wastewater. The farmer association's findings suggested that the benefits enjoyed would vary depending on whether the affected farmers use only freshwater, or if they use secondary-treated water. Farmers who use secondary-treated wastewater to irrigate low-value crops would lose when the price of the treated wastewater increases, according to the farmer association findings. Farmers who currently use only fresh water on the other hand were expected to benefit from the lower price of the treated wastewater relative to that of freshwater. A third category of farmers would lose fertilizer benefits, as the improved wastewater that meets the recommended standard would lose part of its nutrient content. The Israeli Initiative team made a comparative study of the results of the two cost-benefit analyses, based on which it recommended that the government subsidize the costs of complying with the upgraded standard among farmers who grow low-value crops, based in part on the non-market environmental benefits that would accrue from the improved wastewater treatment.

VI. IMPLICATIONS FOR FUTURE TECHNICAL COOPERATION PROGRAMS

The Drylands Initiative was implemented over a ten year period that was characterized by dramatic ups and downs in the Middle East peace process. The experience accumulated over this period and in this context suggests a number of lessons that may inform the planning and design of future programs of technical cooperation that are intended to be instrumental in bringing together parties in conflict. While individual parties are likely to draw additional conclusions, the recommendations presented below are matters of substantial consensus between Initiative participants.

Setting a clear hierarchy of objectives

Having in place a clearer hierarchy of objectives will serve to focus the work program, and to identify and establish the most appropriate institutional structure with which to carry out that work program. A better defined set of objectives and priorities is also far more likely to provide an effective framework for measuring results, identifying bottlenecks, and finding solutions. The Drylands Initiative was intended to serve dual purposes that in the optimism of the mid 1990s were thought to be not only reconcilable, but purposefully complementary. On the one hand the Initiative was intended to support the Middle East Peace Process by fostering mutual understanding—and indeed collegiality—through regional technical exchange and cooperation. On the other hand it was intended to create knowledge through applied research. A stronger focus on either Arab-Israeli cooperation or on knowledge creation would have led its work program in quite different directions, and with different expectations. Making Arab-Israeli cooperation the principal objective would have led to a program focusing primarily on regional communication and consensus building. Making knowledge generation the principal objective would have led to a research program designed to bring together the best minds to tackle technical problems, whether they be identified externally or by program participants – possibly through Competitive Research Grants.

The notion that the technical field work supported by the Initiative was required to generate knowledge and results suitable for regional (Arab-Israeli) exchange and cooperation was flawed in a number of respects. Firstly, the small scope and lack of focus on quality that was characteristic of most Initiative research resulted in minimal—if any—incremental gains in knowledge relative to the existing knowledge base among senior experts in participating countries. Secondly, the technical subjects selected for the field work simply did not require cross-boundary cooperation. Moreover, the technical subjects were not even selected by partner countries but by the country conducting the field work itself. Meaningful regional meetings could therefore be held even in the absence of meaningful technical results, and (national) field work could proceed even in the absence of cross-boundary cooperation.

Identifying technical issues that make cross-boundary cooperation not only desirable but necessary

Technical cooperation that actively aims to find joint solutions to common problems is likely to be a more effective and powerful means of achieving mutual understanding and peace than conference-style regional meetings in which knowledge is simply communicated. In this latter case of "knowledge communication", consensus building is not required, hence contentious or sensitive issues can easily be avoided, which is less likely to result in lasting and meaningful relationships between the participants. Yet technical cooperation needs to be designed around issues that actually require cross-boundary dialogue and cooperation. Ideally, this cooperation would be based on technical issues which are also addressed in ongoing peace negotiations.

The Dryland Initiative was based on a notion that Israel and her Arab neighbors share common or quite parallel priorities with respect to dryland degradation and poverty reduction – neither of which is a particularly immediate or urgent concern in Israel. These issues therefore provided somewhat limited common ground. A number of trans-boundary environmental issues suggest themselves as more suitable candidates for Arab-Israeli technical cooperation. In fact Arab-Israeli technical cooperation on a number of these issues is already ongoing. Egyptian, Israeli, and Jordanian technical experts already cooperate on pollution management in the Gulf of Aqaba, and Egyptian-Israeli cooperation in Mediterranean oceanography is long standing. Similar work on pollution management and the protection of the marine environments along the Mediterranean coast would provide an area of genuine cooperation between Egypt, Israel, Lebanon, the Gaza Strip, and countries of the Maghreb, as they seek to fulfill their obligations under the Barcelona Convention.

The trans-boundary spread of agricultural pests and zoonotic diseases is another shared issue which continues to bring together Arab and Israeli experts. Arab and Israeli epidemiologists, biologists, wildlife management experts, and other specialists do collaborate on issues like avian flu, foot and mouth disease, and rabies. Trans-boundary biodiversity concerns like alien invasive plant and animal species, endangered species of cross-boundary habitats, and protection of the cross-Middle East Palae-arctic bird migration also represent appropriate candidates for cooperation through the establishment of trans-boundary protected areas and programs to re-introduce species with long-range movement patterns. While water resource management issues carry great technical relevance across borders in the region, their political sensitivity would seriously impinge upon the potential for technical cooperation.

Identifying institutions that have a natural professional interest in the technical issues identified

The Dryland Initiative was carried out by the staff of institutions that had been identified and selected by the politically-minded designers of the Initiative. A pragmatic solution was found which made the start of the implementation of this sensitive program feasible. Yet further outreach to qualified professional institutions in the five countries remained limited—to the extent that it happened at all—throughout the lifetime of the Initiative. This limited involvement of eligible institutions and individuals would limit the relevance and practical application of Initiative-supported technical findings. This was particularly evident in the Initiative's marginal policy impact.

Future programs should cultivate engagement with and involvement by a broad range of institutional partners. Non-governmental organizations are likely to play a vital role in the conduct of future programs, perhaps alongside governmental institutions. Whether or not governmental institutions are involved, individuals who take part in assignments that involve collaborating with counterparts from states in conflict with their own assume personal risk of reprisal from those hostile to the peace process. Donors and implementing agencies need to conscientiously provide for the personal security of participating staff when program details are being negotiated.

Ensuring full institutionalization of the work program and technical cooperation

A number of individuals who were involved in the design and planning of the Initiative's original program would remain involved in the Initiative throughout its ten-year duration. This carried important benefits for the Initiative itself, particularly in terms of continuity and institutional memory, and particularly during periods of intensified conflict between Israelis and Palestinians in the broader context. Over the years however, the program would come to be more and more focused on these individuals, rather than on the institutions in which they served. This "old guard" of original participants who had been present at the creation would in certain respects come to resemble an exclusive clique with a very limited number of members and with very limited connectivity within the host institutions and with other technical institutions. This worked to the detriment of the broader institutionalization of the Initiative program, narrowing it to the discrete, personal relations of a few "insiders."

Future programs should work to minimize the risk of disconnects between the national program management and policy and operational decision-making within the implementing institutions. This offers a number of potential benefits. Involving more specialists is very likely to increase the technical quality of work undertaken. Direct linkages between the technical program and the policy and operational decision-making within the implementing institutions are likely to increase the relevance and practical application of results, including policy impacts. Basing activities on institutions rather than on individuals promises to make cooperation and partnerships more sustainable, both within and between participating countries.

Had the Dryland Initiative not been intended to support the peace process, and had it not been designed with its pre-selected roster of a small number of governmental institutions – it might have pursued the much more modest objective of cross-boundary technical cooperation among scientists similar to programs like MERC. Future program designers will have to weigh the pros and cons of such an approach. MERC-like programs are more likely to establish genuine cross-boundary technical cooperation that is less susceptible to political decisions given that they do not rely on governmental officials who are required to represent official opinions and decisions. On the other hand and for the same reason, such programs do not have the same potential of impacting on political decisions. Technical cooperation established between governmental institutions is more likely to influence political decisions such as those made within the peace process.

Develop future programs using participatory approaches to program design and implementation

Local community participation was not addressed in the Initiative's original program, nor were local communities consulted in the overall planning and design of Initiative programs. Future programs are likely to benefit from incorporating more participatory planning, assuring greater relevance to the needs, priorities, and concerns of local communities, and improve the chances that research undertaken in participating farmers' fields will yield results of greater impact as more neighboring farmers and land users adopt and adapt the techniques developed. Program design should pay careful attention to opportunities to make research and development demand-driven. Farmer participatory research methods have evolved and matured since the mid 1990s when the original Dryland Initiative was being conceived, and future programs should seek to benefit from these developments as much as possible.

Ensuring technical quality of field work through appropriate mechanisms

Assuming that the program involves technical field work, quality assurance is a very important factor to incorporate into program design and planning. A number of factors contribute to the technical quality of research: (i) selection of the most appropriate institutions within countries; (ii) a sound procedure of peer review; (iii) an appropriate incentives framework, for example through competitive research grant mechanisms; (iv) technical assistance through the implementing agency or contracted service providers.

Within the framework of Arab-Israeli collaboration, the only competitive grant scheme compliant with the program's objective would be one which involves research proposals jointly prepared and submitted by Arab-Israeli teams. In the prevailing political context of the Initiative, however, within which the Arab League forbade official Arab cooperation with Israel, joint proposals prepared by governmental entities (which was the structure in the Initiative) would not have been feasible. In addition, an invitation (by governmental to non-governmental entities) could not be made sufficiently public to carry out a successful competitive grant program. Even if competition had been restricted to within-country competition (with fixed budget envelopes for each participating countries and Arab-Israeli collaboration limited to the regional events – as it was actually the case in the Initiative), the program would still have needed to be made public within each participating country. Any future program attempting to use competitive grant mechanisms would have to involve non-governmental entities as implementing agencies or rely on (i.e., wait for) more conducive political circumstances.

Effective regional technical cooperation programs require a broader approach to communication and knowledge sharing

The quality of cross-boundary cooperation of the Dryland Initiative suffered from the fact that technical teams with members from each participating country were never effectively assembled, and as a result cooperation and technical dialogue was limited to periodic communication during workshops and semi-annual events. In-between event communication among participating countries was close to nil, due to the fact that the field work pursued by the Initiative made this dialogue *desirable* but did not *require* it. Future programs should design an appropriate incentives framework for participants to effectively use state-of-the-art communication tools and knowledge-sharing events. Future programs should design an appropriate incentives framework for regular and substantive discussions among participants, effectively using state-of-the-art communication tools and knowledge-sharing events.

The implementing agency selected for a program of regional cooperation must be able to communicate effectively with every participant in this program

This point is self-evident, but the lack of effective communication between the implementing agency and all five partners in the Dryland Initiative emerged as a serious bottleneck for the successful implementation of the work program, due to the fact that ICARDA is based in Syria which has strained relations with Israel. Setting up the Initiative's Facilitation Unit in ICARDA's office in Egypt was an attempt to counter this problem, but the Initiative nevertheless failed to establish functioning cross-boundary technical teams which should have been *facilitated* by the implementing agency.

In conclusion, it is recommended that the objective of any new confidence building program should be to place value on technical cooperation among the parties in areas that *require* this technical cooperation and to view such a goal as an end in itself. Genuine cooperation can be built and bridges of confidence constructed if non-cooperation on the subject matter is likely to create negative effects for both sides. And maybe, this cooperation will also generate personal contacts that will facilitate, in a very modest way, an enhancement of relations between the parties, thus creating one more bridge of confidence towards peace.

ANNEX 1: PROJECT SITES AND AREAS

A. Egypt

Marsa Matrouh Governorate, Watershed Management

The bulk of Egypt's rural population is restricted to the Nile Valley and especially the delta, where the water scarcity of the surrounding desert is overcome by the Nile flow, and where the land is rather flat with no high ground in sight. The Egyptian Watershed Management program targeted the areas outside the Nile Valley, including the Northwestern Coastal Desert and the Sinai Desert, which are mostly hilly, arid watersheds.

Extending south of the 600 kilometer Mediterranean coastline between Alexandria in the East and Sallum in the west, the Northwestern Coastal Desert ranges over 10,000 square kilometers. Only 1,500 square kilometers of the area are cultivated. The Desert consists of a plateau ripped with wadis that generates runoff into hundreds of watersheds traversing lower foothills and reaching the Mediterranean coast, constituting a 20 kilometer south-north, 80-180 millimeter rainfall gradient. Rainfall runoff harvesting using several indigenous methods is practiced by mostly sedentary Bedouin communities with agro-pastoral livelihoods. The major project site is the Wadi Um Ashtan watershed, one of the several watersheds in the Marsa Matruh governorate some 300 kilometers west of Alexandria. This seven and a half kilometer long, 150 square kilometer watershed is a plateau some 115 meters above sea level, and is used mainly as rangeland. Its seaward side is ripped by wide fan of tributaries, initiated by wide "wadi tips" cultivated with figs, olives, cereals (mostly barley), and some vegetables. The watershed accommodates twenty farms owned by 25 families numbering 240 people who together own 770 sheep.

The Wadi Um Ashtan Watershed Management project objective was to demonstrate improved watershed management practices to raise local farmers' income. The demonstration activities covered 4.5 percent of the watershed area, 17 percent of its cereal production area, and just 2 percent of its rangelands – thus involving only 4 percent of its sheep. The project was supported by the nursery facilities at El Qasr Research Station of the Agricultural Research Center at Marsa Matrouh, and in addition to the Wadi Um Ashtan, its activities extended to the adjacent Wadi Medwar, Wadi Halel el Daba, and Wadi Sidi Barani watersheds.

The Sinai Peninsula, Germplasm for Arid Lands

The 61,000 square kilometer Sinai Peninsula is bordered in the west by the Gulf of Suez and the Suez Canal, in the east by the Gulf of Aqaba, the Negev and Gaza Strip, and in the north by the Mediterranean Sea. Its southern point faces the Red Sea. The Peninsula consists mainly of hyper-arid rocky desert, interspersed with sandy areas. Its northern two thirds comprise a limestone plateau traversed by large number of gullies and wide tributaries. Its southern core region is a rugged igneous and metamorphic ridge that peaks at 2,629 meters above sea level.

Vegetation structure and cover in the Sinai are determined by a rainfall gradient from 200 millimeters at the northeastern Mediterranean coast, to 20 millimeters at southern tip facing the Red Sea. In the central southern mountain ridge, this is overlaid by a sharp vertical gradient where mountain tops often exhibit a winter snow cover. The larger part of the peninsula is used as rangeland, with scant, mostly rainfed farming mainly in the northern areas. The relative isolation of the Peninsula explains the high endemism of plant species, 60 of which are endemic to the Sinai. Plant diversity is high (984 species) owing to the diversity of habitats and climates, and to the Peninsula's geographical placement at the eastern Mediterranean edge of the Saharo-Arabian desert areas. The Egyptian Germplasm for Arid Lands program, supported by the Desert Research Center's station in Sheikh Zued in the northeastern Sinai, undertook a survey of vegetation using a network of smaller stations that covered all the habitats found in the Peninsula.

The Nile Delta, Kafr El Sheikh Governorate, Treated Wastewater and Biosolids Re-use

Egyptian Treated Wastewater and Biosolids Re-use project sites were located in the Nile delta, where most of the country's agricultural production and most of its use of marginal water takes place. These project sites were therefore far removed from the Egyptian Watershed Management project sites in the arid northwest, which lack large sources of sewage. Although farming here in the delta area (together with Egypt's major urban centers) enjoys the advantages of Nile river flows, the country's 2.7 percent annual population growth rate has a major impact on water supplies. One way of alleviating the increasing water shortage is the reuse of the irrigation drainage water, which is significantly more saline than the Nile water entering the irrigation system. To reduce salinity, drainage water is blended with freshwater prior to reuse at 20 pumping stations. This preponderance of irrigation drainage water treatment and reuse—between 3 and 8 billion cubic meters annually—distinguishes Egypt from the other four countries in the Initiative, where sewage is the principal source of treated wastewater. Egypt hopes to increase this volume of diluted drainage water further, while at the same time mitigating the mounting problems that drainage water reuse poses to groundwater and soils, and to crops, livestock, and human health.

Activities of the Egyptian Treated Wastewater and Biosolids Re-use program, and the Marginal Waters program that preceded it in the first three years of the Initiative, were carried out in the Kafr el Sheikh governorate in the far north of the middle delta. The governorate is located about 150 kilometers north of Cairo, and is situated between the Nile Rosetta and Damietta branches along the Mediterranean Sea and El Brullos Lake. The Egyptian team selected four demonstration sites within the governorate: Abu Sekeen, Balteem, El-Hamoul and Sidi Salem, where they monitored drainage and well water quality, water table fluctuations inside the wells, soil properties, and crop performance. Lysimeter experiments were used to irrigate selected crops with various qualities of mixed drainage and fresh water.

The Egyptian program's biosolids projects were carried out in the same sites. The increasing health hazards of sewage generated by the rapidly growing population had prompted Egypt to increase the number of wastewater treatment plants with improved capacity to remove solids. The plants generated 10 million tons of treated wastewater per year, which – applied to agricultural production – elevated soil concentrations of potentially toxic elements, increased nitrate pollution of groundwater, and raised the risk of eutrophication in water bodies. In addition, most farmers keep between three and five heads of cattle or buffalo whose manure is added to soils. The Egyptian biosolids project tested treatments of sludge and farm manure using composting and lime applications to reduce the proportion of carbon, and tested the use of the treated sludge and manure as fertilizer and in biogas production. Results were demonstrated to farmers at the Sakha Agricultural Research Station.

B. Israel

The Yatir Watershed, Watershed Management for Afforestation

In Israel runoff harvesting is practiced only in afforestation projects, and hardly if ever in agriculture, which is rain-fed in the least arid drylands and elsewhere mostly pressure-irrigated, including in hyper-arid areas. In order to join efforts with its Initiative partners, the Israeli Watershed Management team was engaged in exploring, improving and developing runoff harvesting practices and techniques for promoting tree growth in arid drylands. These runoff harvesting activities were intended to demonstrate practices for growing trees used for fruit, firewood and fodder production and for soil conservation to farmers and extension agents in the four other countries. The research was also aimed at providing management recommendations to land users in both partner countries and Israel when the runoff practices supported tree-growing projects.

The principal Israeli afforestation project site was in the Yatir watershed, where annual rainfall is about 250 millimeters, placing it in the transition area between the arid and semi-arid regions. Here land use traditionally supported pastoral livelihoods, but during the last five decades a transition from nomadic pastoral to sedentary urban livelihoods has taken place. Livestock grazing continues but the reduced nomadism increases pressure on the range, resulting in severe gully erosion and overgrazed vegetation. Afforestation in the high reaches of the watershed was initiated in 1964 by the Jewish National Fund, motivated by ethos of "making the desert bloom." Because tree life-forms in this dryland area is restricted to channels, maintaining trees on slopes requires runoff harvesting.

The afforestation practice was to manually create a pit for each individual sapling, planted towards the end of the rainy season, when soil moisture is maximal and temperatures are the most favorable. Some saplings received a few irrigation bouts in the first two years after planting. Most saplings were of the circum-Mediterranean *Pinus halepensis*, a pine species not indigenous to the Yatir region. Survival rates were high, and a full forest cover now prevails over the 3,000 hectare "Yatir Forest." Management of the forest is focused on fire prevention, which is pursued through controlled grazing by local Bedouin herds and cutting low branches collected as firewood by local Israeli Bedouins and Palestinians from the adjacent West Bank. The forest also serves a recreational purpose. The local Bedouin community lives within and around Houra township, which only marginally depends on free-ranging livestock.

The Jewish National Fund renewed its afforestation activities in the area in 1977, but at lower reaches of the watershed, using heavy equipment to create contour ditches in which a diversity of trees—mostly indigenous and drought-adapted broad-leave species—were planted at low density. Two decades later, the Israeli Watershed Management team selected demonstration sites in this area and set about installing monitoring devices to collect data for use in the training programs planned under the Initiative. But most attention was directed to research aimed at evaluating the merits of run-off afforestation in an arid dryland, and at improving water-harvesting practices for supporting it.

Avdat and Mashash Experimental Runoff Farms, Watershed Management

The two other Israeli Watershed Management project sites are the Avdat and Mashash experimental runoff farms of the Blaustein Institutes for Desert Research (BIDR). The Avdat farm is located on the ruins of a desert city on an offshoot of the ancient Silk Road, supported by a 15 hectare runoff harvesting farm that operated in the Nabatean and Byzantine periods. The farm was reconstructed in the 1960s as a research and monitoring site in the areas of climate, agriculture and ecology. Olives, pistachios, almonds, grapes and multipurpose fast growing trees are experimentally cultivated on reconstructed terraces, fed by runoff water conveying channels extending from the adjacent slopes. The farm has generated a 35 year database on precipitation, runoff events and water volumes, temperature, and evaporation. During the Initiative the run-off harvesting structures and monitoring infrastructure were maintained and the database was updated. Topsoil is loamy, mean annual precipitation is 85 millimeters, and annual evaporation (Class A Pan) is 2,700-3,200 millimeters, leaving an aridity index of 0.03.

Mashash is a 300 hectare experimental farm in a controlled-grazing rangeland. Its runoff source is two catchments with a combined area of 6,000 hectares. Experiments with olives and intercropped acacia groves under different runoff harvesting methods have been carried out in this farm during the last 15 years. Topsoil texture is sandy loam, mean annual precipitation is 115 millimeters, and annual evaporation (Class A Pan) is 2,500-3,000 millimeters, leaving an aridity index of 0.05.

The Yatir afforestation site has 280 millimeters annual precipitation and from 1,800 to 2,200 millimeters annual evaporation, giving an aridity index of 0.14. The three Israeli Watershed Management sites, Yatir, Mashash, and Avdat, are therefore positioned along a 70 kilometer gradient of decreasing aridity of 0.002 per km. The 0.14 aridity index of the Yatir site is representative of an arid dryland in immediate proximity to a semi-arid zone. The 0.05 aridity index of the Mashash experimental farm places it solidly as arid dryland. The 0.03 aridity index of the Avdat farm is representative of a hyper-arid dryland that is in close proximity to a neighboring arid zone.

Semiarid, Coastal and Valley Agriculture in Israel, Treated Wastewater

The combination of severe water shortages, aquifer contamination, densely populated urban areas, and intensive irrigated agriculture, makes it essential for Israel to put wastewater treatment and use high among its national priorities. In 1999, treated wastewater constituted about 22 percent of the agriculture sector's water supply, by 2005 it accounted for 40 percent, and it is projected to account for 50 percent by 2020. This made the Israeli Treated Wastewater program far more relevant to national priorities than the national Watershed Management program, which conducted research principally for the benefit of Israel's developing partners in the Initiative. The Treated Wastewater project sites were located in the major farming regions of Israel – the coastal plain and the Jezrael Valley in the north. This mostly pressure-irrigated agriculture occupies land stretching about 170 kilometers from north to south, and about 20 kilometers wide. The area corresponds to a south-to-north rainfall gradient of 400 to 600 millimeters, and is characterized by relatively well-developed soils, mainly grumosols and lithosols, in some places mixed with sand. This rectangular area also accounts for most of Israel's urban population, and therefore also generates large volumes of urban and industrial effluents.

Within this area the Israeli Treated Wastewater program compared irrigation using treated wastewater with irrigation using fresh water on some 70 agricultural and experimental plots—most of them owned by cooperative *Moshav* and communal *Kibbutz* farms—between Kibbutz Yassour in the north and Moshav Hammapil in the south. In the rainier segments of the area, mainly in the north, Avocado plantations were the focus of most of the experiments, as well as corn and other field crops in the Jezrael Valley. In the somewhat drier central and southern sections, the effects of different water qualities on citrus orchards were the major concentration. On these sites the Israeli Treated Wastewater team was able to test the effects of treated wastewater on the full range of low altitude, coastal and valley systems that account for the bulk of agricultural production in Israel. The treated wastewater used in the experiments was provided by national and regional wastewater treatment plants located near urban centers in the vicinity of the project areas.

The Northern Negev, Biosolids Re-use

In 2001, sludge production in Israel reached 103,000 tons of dry matter per year. The projection for 2020 is about 250,000 tons. In a very small country like Israel, with very high population density in its major agricultural area giving rise to intense competition for scarce land, using this sludge as composted biosolids is naturally an appealing alternative to incineration or landfills. Much of its agricultural area was identified as being suitable for sludge applications, although the effects of the practice on crops and soils do require further testing and monitoring.

The Israeli Biosolids project sites were located in the Northern Negev, in the somewhat rainier segment of the country's arid area, generally experiencing between 250 and 350 millimeters of rainfall annually. Much of Israel's cereal production takes place here, where production is constrained not only by the naturally low rainfall, but by the low water holding capacity and fertility of local soils. Composted sewage sludge holds considerable promise for reducing these constraints by increasing the volume of rainwater the soil is capable of holding. Field crops like wheat are preferred to orchards in many experiments with the application of biosolids because the fields can be plowed and tilled, allowing more rapid and thorough biosolid incorporation into the soil. Ten project sites between Kibbutz Shuval in the north and Kibbutz Nirim in the south were used to test, monitor, and demonstrate the effects of different qualities and quantities of biosolids applied to soils and crops.

C. Jordan

Watershed Management Project sites

The Jordanian Watershed Management program was active in an area covering much of the country, some 800 square kilometers between Dana in the south and Irbid in the north, and from the upper reaches of Wadi Mujib in the east to the Dead Sea coast in the west. Most project sites were at areas of relatively high elevation along the country's north-south highland range, where annual rainfall is higher than 150-200 millimeters but lower than 300-400 millimeters, and where most communities are rural. The program was not active in arid and hyper-arid areas with less than 50 millimeters of annual rainfall in the east, far south, and in the irrigated Jordan River Valley north of the Dead Sea.

The program's major water harvesting and range rehabilitation projects focused on three project sites. Two of them were located in the central highland range of Jordan: one at the upper reaches of Wadi Mujib on the border between the Karak and Madaba governorates, the other near Faysalyia, in the northern part of the Madaba governorate. The third site, near Sabha, was located off the central highland range though also on relatively high elevation, close to the very arid area in the northeast known as the *Badia*. The local watersheds in these three project sites support pastoral livelihoods, augmented by opportunistic rain fed farming, or by more stable cereal, vegetable, and orchard crops supported by supplemental irrigation. All farming in these sites was supported by runoff harvesting measures. In all three sites, local population increase, land tenure issues, and other expressions of social change was leading to overgrazing, range degradation, the neglect of cisterns and wells, and a growing prevalence of relative poverty.

The Faysaliya region is at the upper catchments of watersheds draining to the Dead Sea, with annual rainfall ranging from 100 to 200 millimeters. The watersheds support rangelands of grass or shrub steppes, depending on elevation. The rangelands are heavily overgrazed and degraded as a result of local overstocking as well as the influx of sheep from eastern Jordan that over-winter near the shores of the Dead Sea. Here, two range reserves, the 1,800 hectare Faysaliya reserve, and the 8,000 hectare Ma'in reserve, were planted with shrubs. Grazing was practiced on a rotational basis, in which up to 25,000 sheep (belonging to 60 families, some 500 persons) were moved through a series of ten unfenced *paddocks*, beginning in the lower elevation, low rainfall range in the early spring, and moving to higher elevations over the course of a 30-90 day period. In these sites, and in the Wadi Mujib upper catchment, several villages and communities were targeted for demonstrating range improvement, livestock grazing management, runoff harvesting structures and cistern rehabilitation.

The Sabha area included two Watershed Management demonstration sites - the Sabha and the Mohareb stations, together covering some 1,050 hectares at altitudes between 746 and 807 meters. The sites receive under 150 millimeters of rain annually. 55 percent of the site area is used as rangeland, and 37 percent is devoted to olive cultivation, irrigated by water from artesian wells. The low precipitation, high temperature, and low soil quality make this region prone to soil erosion. Here range improvement demonstrations focused on planting range and cactus species.

The experimental cultivation of medicinal and herbal plants was carried out in 15 different sites (including several NCARTT research stations) spanning over the whole region from Rabba near Karak in the south to Irbid in the north.

Finally, two project sites, Dana in the south and the lower reaches of Wadi Mukheyres in the west, were used by the Watershed Management team to promote ecotourism as a means of generating income to the local farming communities. At the same time, the team sought to promote nature conservation through grazing control in the Dana site, and vegetation restoration in Wadi Mukheyres. The Dana project was terminated in the early days of the Initiative. The Wadi Mukheyres project only began towards the end of the Initiative.

Treated Wastewater and Biosolids Re-use Sites

Jordan's per capita availability of water is 240 cubic meters per person per year – well beneath the *water poverty level* of 1,000 cubic meters, and water scarcity is intensifying in the face of an annual population growth rate of 3.4 percent. In this circumstance, fresh water supply is inevitably directed to domestic, industrial, and tourist sectors, leaving agriculture proportionately more reliant on marginal water sources – principally treated wastewater. 20 treatment plants currently process only a fraction of the wastewater generated in Jordan. Near the Jordan's major sources of ephemeral running surface water—the King Abdullah Canal in the Jordan Valley, and the Zarqa River in the central highlands—wastewater is diluted using fresh surface water. Elsewhere wastewater treated by regional plants is used for local irrigation. Constraints to this treated wastewater reuse are insufficient transport infrastructure, and the often low quality of the treatment that discourages farmers from using the resource and deters consumers from buying the produce.

The Jordanian Treated Wastewater team therefore limited its projects to the cultivation of crops which are not for direct human consumption, including exotic fodders like ryegrass. Wastewater treated at the Madaba Wastewater Treatment Plant, 30 kilometers south of Amman was used to cultivate volatile oil crops at the El Ramtha Experimental Station. Wastewater treated at the Khirbet As-Samra Treatment Plant, 40 kilometers east of Amman was used to irrigate trees at Hashymiah.

Owing to relatively low rates of investment in wastewater treatment, Jordan does not produce large amounts of sewage sludge. The rural population does however produce large volumes of household sludge, together with plant residues and animal waste. The volume of cow manure produced annually is estimated at half a million tons. Much of this is used, untreated, as fertilizer in orchards and for vegetable production, and with unpleasant environmental consequences. The Jordanian Biosolids team therefore experimented with composting cow manure from the Ministry of Agriculture's Hamodah dairy farm, located in Al-Khaldiah-Mafraq governorate. Jordan's Treated Wastewater and Biosolids sites were all located on the central highland plateau, from 40 kilometers south of Amman to the Syrian border in the north. It shared no sites with the Jordanian Watershed Management program.

D. Palestinian National Authority

Watershed Management sites

Activities of the Palestinian Watershed Management team were carried out in three different areas of the Palestinian Territories. Most of its activities were undertaken in a large number of sites in the Hebron mountains ridge, in the southern part of the West Bank. These sites were located within a northeast-southwest oriented rectangle covering about 30 kilometers between Al Arroub in the north and Dahariyya in the south, and about 15 kilometers between Bani Noem in the east and Doura in the west. The area includes the regional hydrologic divide between the Mediterranean basin in the west and the Rift Valley in the east. The Hebron area is located at the top of the *central mountain plateau* of this rectangle, which has elevations ranging between 600 and 1000 meters above sea level. The *western slopes* descend from 600 to 300 meters above sea level, and contain watersheds that drain toward the Mediterranean. To the east of the plateau, watersheds on the *eastern slope* descend from 600 meters above sea level to *sea level* in the Rift Valley, draining toward the Dead Sea.

The rectangular area in which Palestinian Watershed Management program activities were carried out sees a north-south gradient of increasing aridity superimposed over a west-east aridity gradient in which the regional hydrologic divide is relatively less arid. In the semi-arid north of the rectangle, at Al Arroub, the aridity index is 0.04, with mean annual rainfall of 623 millimeters. In the arid south, at Dahariyya, mean annual rainfall is 348 millimeters, giving an aridity index of 0.18. The mountain plateau and western slope are both semi-arid, with a 0.31 aridity index respectively, and the eastern slope is arid, with a 0.17 aridity index.

These orders of relative aridity dominate biological production in the rectangle, and are key determinants of local rural livelihoods. With increasing aridity, vegetation height and cover decrease, and its composition gradually transforms from Mediterranean to Asian to Saharo-Arabian. Land use and livelihoods gradually change from urban to rural, and from mostly cultivation (mainly orchards), through sylvi-agro-pastoral, to mostly pastoral. Depending on the different climates, vegetation features, and land uses within the rectangle, different degrees of land degradation are evident. The degradation results from overgrazing, firewood collection, deforestation, urban sprawl, and reduced supply and quality of water resources. Yet in many parts farmers employ both traditional runoff harvesting practices and adapt and adopt advanced cultivation and livestock rearing technologies.

The Palestinian Watershed Management team carried out activities to improve range and farming as well as tree cover in both rural and urban areas in scores of sites, as well as conducting extensive surveys of biodiversity and springs, cisterns, and wells. The team used most of the sites for public awareness, demonstration, and dissemination campaigns. In its activities the team was supported by a nursery and botanic gardens it established in the agricultural school of Al Arroub and later at Al Quom. Finally, the team carried out, jointly with owners of twelve farms in the drier, southern part of the rectangle, an experiment to test runoff harvesting techniques supporting olive groves and cereal fields.

Another major site of activity, limited to the first years of the Initiative, was the City of Jericho, where the Watershed Management team established and operated a botanic garden. Jericho is an urban-rural hyper-arid oasis, 250 meters below sea-level, close to the northern end of the Dead Sea. Very hot (49ºC record high) and dry (166 millimeter annual average) climate prevails in this desert area. Yet cultivation of a diversity of crops and advanced and intensive livestock production are practiced, made possible by a local spring that has sustained human habitation in Jericho for several millennia.

The third site was the 25 square kilometer protected area of Wadi Gaza, the only non-urbanized area in the densely populated Gaza Strip. Wadi Gaza is the furthest downstream section of the largest (3,500 square kilometer) watershed in Israel, a wetland that is formed as Israel's Nahal Habesor channel enters the Strip. It has the potential to function as a "green belt" – a sanctuary for coastal, semi-arid aquatic and riparian biodiversity, but it has become a degraded, polluted and littered ecosystem, more of an environmental and health hazard than an environmental asset. The Palestinian Watershed Management team conducted geological, water and biodiversity surveys in this wetland, to be used for supporting management and conservation efforts, which later culminated in restoration efforts to promote the quality of the wetland to the point that it can be granted nature park status.

Treated Wastewater and Biosolids Re-use

Only about one third of the West Bank's population is linked to a sewer system, and there is only one major wastewater treatment plant, in El Bireh, which is not in the Hebron region, where most of the Palestinian Treated Wastewater projects were carried out. Given the severe water shortage in the West Bank, it is not surprising that much of the untreated wastewater is used in peri-urban irrigation. With no stable source of treated wastewater, the Palestinian team could not experiment with irrigation reuse on a large scale, as other Initiative's partners did. The team therefore focused its activity on a small but stable sources of treated wastewater, at the El-Arroub agricultural school 36 kilometers south of Jerusalem. The school's chicken and dairy farms, nursery, greenhouse, orchard, and the school facilities themselves provided sources of waste that could be treated and then used locally for irrigation, composting, and biogas, which was used for cooking in the school. There, the Palestinian Treated Wastewater and Biosolids team was involved in constructing, improving, and operating the local duckweed-supported wastewater treatment plant, a composting facility, and a biogas digester.

The survey of springs, in the central and southern Hebron region, can be regarded as a joint Watershed Management and Treated Wastewater activity, since one of the important outputs of the team was the identification of springs contaminated from wastewater sources, and the characterization of the contamination, both in quality and in quantity.

E. Tunisia

The Zammour Valley and Menzel Habib, Watershed Management

The Tunisian Watershed Management team focused its activities in a relatively small 200 square kilometer area in the southeastern central part of the country, between Gabès in the north and Medenine in the south. The upper reaches of the watershed are at the Matmata Mountains in the west. The watershed's lower reaches form the Hamilet el Babouch plateau, in which the Menzel Habib region is located, draining into the Mediterranean coast in the east. The area is arid, with 150-220 millimeters of annual rainfall in the Matmata project site in the Zammour Valley, and 80-170 millimeters in the Menzel Habib project site. Sylvo-agro-pastoral livelihoods are prevalent in the area around the Matmata project site. At the Menzel Habib project site, steppe shrub and other Saharan-Mediterranean vegetation supports agro-pastoral livelihoods. Olive trees are grown in terraced wadis at the Matmata site, and the slopes of the local Matmata Mountains provide forages. Ecotourism is also promoted in the area. (Some distance south, and closer to the coast, the southern-most olive groves in Tunisia can be found.) This Matmata site was active mainly during the earlier years of the Initiative, when activities focused on improving tree cultivation and the in-situ conservation of local fruit tree varieties.

The 10,000 hectare Menzel Habib project site, 50 to 60 kilometers west of Gabès, is traditionally owned by the Henchir tribe of the Snoussi confederation. The area is about 80 meters above sea level and receives about 170 millimeters of rainfall annually – with a 60 percent coefficient of variation. The soil is sandy and the main land use is livestock grazing and opportunistic barley cultivation by 13,000 agro-pastoralists, with 50,000 livestock heads. During the 1960s much of the land was used by nomadic pastoralists, especially during years with high rainfall. Since the 1970s the population became sedentary, mostly due to governmental encouragement in the form of water and electricity infrastructure development. This social change was accompanied by significant population growth and density (24 persons per square kilometer, compared to 5 at the end of the 19th century), and intensified and expanded cultivation and intensified shrub cutting. These factors led to land degradation and shifting of previously stable sand dunes during 1980s and 1990s, and beginning in the late 1980s, government interventions to stabilize dunes and to replace livestock production with alternative livelihoods.

Tunisian Watershed Management team activities tested and demonstrated a variety of practices to accelerate range rehabilitation and soil conservation in three subsites of the Menzel Habib project site - Henchir Snoussi, Ouled Hfeiyedh, and Qued Zayed. These activities ranged from surveying for economically useful plants species, cultivating cacti, planting shrubs for range rehabilitation and trees for sandy soil fixation, as well as livestock management for range conservation. A nursery was established for these purposes among others at Qued Zayed.

Finally, the activities of the Tunisian Watershed Management team in both the Matmata and the Menzel Habib project sites were supported by nurseries and seed-storage facilities in Gabès and in the IRA research institution in Medenine.

The Dissa Perimeter, Treated Wastewater and Biosolids Re-use

Gabès is situated on the Gulf of Gabès in the Mediterranean Sea, and is the capital of the Gabès governorate which has a population of 350,000 and an area of 7,175 square kilometers. In the drier southern parts of Tunisia, water shortages linked with population increase and the prevalence of low-productivity soils, together with an existing treated wastewater facility that had been built by ONAS, motivated the Treated Wastewater team to experiment with the agricultural use of treated wastewater and treated sewage sludge in the area. The wastewater treatment plant had the capacity to generate 17,000 cubic meters of secondary-treated wastewater per day. When that facility was constructed, a canal was built connecting it to the nearby Dissa Perimeter, 10 kilometers from the plant. There, within the Dissa Perimeter, the Tunisian Marginal Waters and later Treated Wastewater teams would build and operate an experimental infiltration-percolation tertiary-treatment plant and a 50 cubic meter reservoir to receive the secondary-treated wastewater from Gabès. CITET and IRA would use tertiary-treated wastewater from the experimental plant to irrigate a local farmer's vegetable field with encouraging results, though there is no record of further dissemination. Later, the Tunisian Treated Wastewater team would construct a much larger pilot tertiary-treatment plant near the original secondary-treatment facility at Gabès, with a capacity of 150 cubic meters of tertiary-treated wastewater per day. Tertiary-treated wastewater provided by the new pilot plant was used to irrigate sylvo-pastoral and ornamental seedlings in a local nursery, and to water the plant's own garden.

REFERENCES

Dryland Initiative Program documents

Multilateral Working Group on the Environment. "Initiative for Collaboration to Control Natural Resource Degradation (Desertification) of Arid Lands in the Middle East." Sixth Meeting of the Multilateral Working Group on the Environment – Middle East Peace Process. Bahrain, October 1994. (Phase I program.)

Facilitation Unit. "Phase II. Initiative for Collaboration to Control Natural Resource Degradation of Arid Lands in the Middle East. (1 July 2000 – 31 December 2003.) Submitted to the World Bank by the Facilitation Unit, hosted by the International Center for Agricultural Research in the Dry Areas (ICARDA). Undated. (Phase II program.)

Facilitation Unit. "Proposal for an Extension of Phase II of the Regional Initiative for Dryland Management. 1 July 2003 – 31 December 2005." Submitted to the World Bank by the Facilitation Unit, hosted by the International Center for Agricultural Research in the Dry Areas (ICARDA). Undated. (Extension Phase program.)

Donor Consultation Meeting Reports

Minutes of the Steering Committee Meeting, Paris, June 2000

Summary of Minutes of the Donor Consultation Meeting, Paris, June 2001

Minutes of the Donor Consultation Meeting, Paris, June 2002

Minutes of the Donor Consultation Meeting, Paris, 17-18 June 2003

Minutes of the Donor Consultation Meeting, Paris, June 2005

Progress Reports of the International Facilitator

Facilitator's Progress Report 1 July 2000 to 30 June 2001

Facilitator's Progress Report 1 July 2001 to 30 June 2002

Facilitator's Progress Report 1 July 2002 to 30 June 2003

Facilitator's Progress Report 1 July 2003 to 30 June 2004

Facilitator's Progress Report 1 July 2004 to 30 June 2005

Country Reports (Listed chronologically)

Demonstration of sustainable reuse of blended brackish water and treated wastewater in agriculture in the North Delta. By Nabil Ell-Mowelhi, October 1998

Republic of Tunisia, Tunis International Centre for Environmental Technologies. Paris Steering Committee Meeting, Regional Initiative for Dryland Management, 22 June 2000.

"Progress Report: Jordan, 1 July 2000 – 30 June 2001." Regional Initiative for Dryland Management Steering Committee Meeting, 21 June 2001, Paris.

Palestinian National Authority, Ministry of Environmental Affairs. "Regional Initiative for Dry Land Management. A document submitted to Donor Consultation Meeting of the Middle East and North Africa." 22 June 2001, Paris.

Safriel, Uriel. "Report for Israel, 1 July 2000 – 30 June 2001." 20 June 2001.

Palestinian National Authority, Ministry of Environmental Affairs. "Regional Initiative for Dry Land Management, A Progress Report for the Period 17 June 2001 – 15 May 2002, and Workplans for the Year 2003." Submitted to the Facilitation Unit, ICARDA, Cairo.

Republic of Tunisia, Tunis International Centre for Environmental Technologies. Paris Steering Committee Meeting, Regional Initiative for Dryland Management, 10 June 2002.

Safriel, Uriel. "Report for Israel, 1 July 2001 – 30 June 2002." 1 June 2002.

Watershed Development Using Water, Harvesting Techniques and Suitable Plant Resources at Wadi Um Ashtan, (Marsa Matrouh). Progress Report, November, 2002, Egypt

Safriel, Uriel, Pedro Berliner, Moshe Schwartz, and Jorge Tarchitzky. "Revised Workplan of Israel, 1 January – 31 December 2003." 10 December 2002.

Al Qudah, Baker. "Jordan Progress Report, 2001 – 2002."

Safriel, Uriel, Pedro Berliner, Moshe Schwartz, and Jorge Tarchitzky. "Quarterly Report of Israel, 1 July – 30 September 2003." 28 October 2003.

Safriel, Uriel, Pedro Berliner, Moshe Schwartz, and Jorge Tarchitzky. "Progress Report for Israel, 1 July 2000 – 30 November 2002." January 2003.

Palestinian National Authority, Environmental Quality Authority. "Regional Initiative for Dry Land Management, Progress Report for the Period 1 July 2002 – 20 May 2003."

Regional Workshop Reports

Ahmed, Mahmood. 2003. Wastewater for Irrigation: Economic Framework for the Middle East and North Africa Region. Strategic Paper No. 1. Facilitation Unit, Regional Initiative for Dryland Management, Multilateral Working Group on the Environment. Giza, Egypt. iv + 26 pp.

Bruins, Hendrick and Uriel Safriel. Report of the First Meeting of the Regional Support Program for Rangeland and Livestock Management. Amman, Jordan, May 14-16, 1996.

Proceedings of the Regional Workshop on Treated Wastewater and Biosolids Re-use, Granada, Spain, 21-24 October 2002

Knowledge Sharing: Watershed Management. Proceedings of the First Regional Thematic Workshop on Watershed Management. Brussels, Belgium.10-12 October 2003.

Knowledge Sharing: Treated Wastewater and Biosolids Re-use. Proceedings of the First Regional Thematic Workshop on Treated Wastewater and Biosolids Re-use. Brussels, Belgium.14-16 October 2003.

Knowledge Sharing. Treated Wastewater and Biosolids Re-use. Proceedings of the Second Regional Thematic Workshop on Treated Wastewater and Biosolids Re-use, 29-31 March 2004, Reading, United Kingdom

Knowledge Sharing: Watershed Management. Proceedings of the Second Regional Thematic Workshop Watershed Management. 2-4 April 2004, Reading, United Kingdom

Knowledge Sharing. Treated Wastewater and Biosolids Re-use. Proceedings of the Third Regional Thematic Workshop on Treated Wastewater and Biosolids Re-use, 8-10 October 2004, Reading, United Kingdom

Knowledge Sharing: Watershed Management. Proceedings of the Third Regional Thematic Workshop Watershed Management. 3-5 October 2004, Reading, United Kingdom

Knowledge Sharing: Treated Wastewater and Biosolids Re-use. Proceedings of the Fourth Regional Thematic Workshop on Treated Wastewater and Biosolids Re-use, 3-6 April 2005, Reading, United Kingdom

Knowledge Sharing: Watershed Management. Proceedings of the Fourth Regional Thematic Workshop Watershed Management. 8-10 April 2005, Reading, United Kingdom

External Review Missions Reports

Kesseba, A., E. Schuh, and H. J. Regner, (External Review Mission members). "Report of the First External Review of the Initiative for Collaboration to Control Natural Resource Degradation (Desertification) of Arid Lands in the Middle East." Submitted to the World Bank, August 1999.

Tyner, Wallace, E., Ismail Hamdi Mahmoud El-Bagouri. "Report of the External Review of the Regional Initiative for Dryland Management." April 2003.

Goldberg, J., K. Winkel, and O. Lyasse. "Draft Report From the Panel on the External Review of The Regional Initiative for Dryland Management (Extension Phase II)." December 2005.

Non-Initiative Sources

Adeel, Z. and U. Safriel. "Ecosystems and Human Well-being: Desertification Synthesis" in *The Millennium Ecosystem Assessment*. World Resources Institute, Washington D.C. 2005.

Ayoub, A.T. "Indicators of Dryland Degradation," in *Drylands: Sustainable Use of Rangelands into the Twenty-first Century.* International Fund for Agricultural Development. Rome. 1998.

Egyptian National Action Program to Combat Desertification, June 2005. www.unccd.int

FAO Document Repository. *World Water Resources by Country* http://www.fao.org/waicent/portal/Virtualibrary_en.asp

Farzaneh Roudi-Fahimi, Liz Creel, and Roger-Mark De Souza. *Finding the Balance: Population and Water Scarcity in the Middle East and North Africa*. Population Reference Bureau. Washington, DC. July 2002. www.prb.org
http://www.mfa.gov.il/mfa/peace%20process/guide%20to%20the%20peace%20process/

H.P Wolff and S. Christiansen "International Middle-Eastern Collaboration in Rangeland Management" to Proceedings of the VI. International Rangeland Congress, Townsville (1999).

H. Rueff, G. Kressel, and M. Schwartz contributed an article titled "Forest Fire Control and Bedouin Pastoralism in Israel's Afforested Drylands" to the Nomadic Peoples Journal, 8: 113-137 (2004).

International Center for Agricultural Research in the Dry Areas. *Indigenous Water-Harvesting Systems in West Asia and North Africa*. Oweis, Theib, Ahmed Hachum and Adriana Bruggeman (editors) Aleppo, Syria. 2004.

International Center for Agricultural research in the Dry Areas. Indigenous Knowledge for the Future of the Drier Environments, Oweis, Theib, Diete Prinz and Ahmed Hachum, Aleppo, Syria. 2001.

Lomborg, Bjorn. The Skeptical Environmentalist: Measuring the Real State of the World. Cambridge University Press, New York, 2001

Ministry of Foreign Affairs, Israel. Guide to the Mideast Peace Process. 26 July 2003.

National Research Council. Water for the Future. National Academy Press, Washington D.C. 1999.

Palestinian National Authority. Peace Process. The Official Website. http://www.pna.gov.ps/Peace_Process/index.asp

Population Reference Bureau. Population Trends and Challenges in the Middle East and North Africa. MENA Policy Brief. Washington, DC. October 2001.

Ruef, Henri, Gideon Kressel, and Moshe Schwartz. "Forest Fire Control and Bedouin Pastoralism in Israel's Afforested Drylands: A Cost Benefit Analysis" in Nomadic Peoples, Volume 8, Issue 1, 2004

Safriel, U. and Z. Adeel. "Dryland Systems" in Ecosystems and Human Well-being: Current State and Trends: Findings of the Condition and Trends Working Group. Edited by Rashid Hassan, Robert Scholes and Neville Ash. Island Press, Washington, DC. 2005.

Scham, P. "Arab-Israeli Research Cooperation, 1995-1999: An Analytical Study." in *Middle East Review of International Affairs*, Vol. 4, No. 3. 2000.

Stein, Kenneth W. "The Arab Israeli Peace Process." in Middle East Contemporary Survey, Vol. XX 1996: pp. 34-65. Westview Press. http://www.ismi.emory.edu/BookChapters/MECS96.html

United Nations Environment Programme. World *Atlas of Desertification*. Second Edition. London. 1997

United Nations Human Settlements Programme, UN-HABITAT. "State of the World's Cities: Trends in Middle East & North Africa. Urbanization & Metropolitanization."
www.unhabitat.org

US Department of State. *The Camp David Accords: The Framework for Peace in the Middle East*, September 17, 1978.
http://www.state.gov/p/nea/rls/22578.htm

Wikipedia. Arab-Israeli Conflict: MENA region; Palestine. http://en.wikipedia.org/wiki/Arab-Israeli_conflict

World Bank. "Middle East & North Africa Data Profile" in *A World Free of Poverty*. The World Bank Group, http://www.worldbank.org/

World Bank. MNA Regional Brief: Development Challenges. http://web.worldbank.org/WBSITE/EXTERNAL/COUNTRIES/MENAEXT

World Bank. *Reaching the Rural Poor: A Rural Development Strategy for the Middle East and North Africa*. Middle East & North Africa Region Water, Environment and Social Group. July 2002.

World Bank. World Development Indicators Database. August 2005.
http://ddp-ext.worldbank.org/ext/DDPQQ/member

World Resources Institute. *EarthTrends 2003*.
http://water.wri.org/publications.cfms