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Water Resources Sustainability Project

Final Report

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ACRONYMS

ADPN	Agency for the Development of Northern Provinces
CLIN	Contract Line Item
CMPP	Moroccan Center for Clean Production
CSE	Superior Water Council
DPA	Provincial Directorate of Agriculture
DRH	Regional Directorate of Hydraulics
EAU	Environmental Alternatives Unlimited
EIA	Environmental Impact Assessment
ERAC-Sud	Regional Agency for Planning and Construction
GIS	Geographic Information System
NGO	Non-Governmental Organization
ONEP	National Potable Water Agency
ORMVA	Regional Offices for Agricultural Development
PLLA	Participatory Landscape/Lifescape Appraisal
RADEEF	Fez City Water, Electricity, and Sewage Utility
RAMSA	Agadir Multiservice Utility
RBA	River Basin Agency
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
USLE	Universal Soil Loss Equation
WPM	Watershed Protection and Management
WRS	Water Resources Sustainability

Acknowledgements

The success of the Morocco Water Resources Sustainability (WRS) project is attributable to the efforts and support of many people. We do not have space to thank them all here, but we wish to acknowledge those who made significant contributions to the project.

At USAID, we first wish to thank Alan Hurdus, who developed the project and launched its implementation. Alan was a relentless supporter of WRS and created the conditions and expectations to make it successful. After Alan’s departure from Morocco, we were fortunate to work with John Thomas and M’Hamed Hanafi, who were both unwavering in their support of the project. Jim Bednar provided leadership at USAID during most of the project’s lifetime.

The active participation of the Moroccan Ministry of Environment is one of the success stories of WRS. The energy and vision of the late Bani Layachi was a driving force in putting the project on the map in Morocco. We dedicate our successes to her memory. El Kebir M’daghri Alaoui was actively engaged in the project start-up and feasibility study phases. Meryem Bolata, the project’s coordinator with the Ministry of Environment, made significant contributions and, through her hard work and enthusiasm, ensured complete synergy between the project team and the Ministry. In the last years of the project, Taha Balafrej, director for international cooperation, continued the exemplary support of the project by our key counterpart.

Of our many Moroccan partners in the field, we wish to especially recognize Mohamed Rachid Faraj of the Wilaya of Fez for believing in the Dokkarat project when others did not; as well as Saâd Zerouali and Selwa Alaoui Chafaii of the Fez City Water, Electricity, and Sewage Utility for taking on the management responsibilities of the Dokkarat chromium recycling plant. In Drarga, Brahim Zergdi was the first to conceive of the wastewater treatment and reuse project and, as president of the commune, gave the project high visibility. Brahim Agouch, manager of the wastewater treatment plant, provides a living example of sustainability through his dedication, competence, and in-depth knowledge of the plant. In the early stages of the project, Haj Mohamed Alimam, president of the Al Amal water users association, galvinized essential local support for the project. In the Nakhla watershed, we especially want to thank Mohamed Bouymaj, director of the Provincial Directorate of Agriculture in Tetouan, and his team for their support in making the soil erosion control project a success. The work of the Work Center of Ben Karrich under the direction of Youssef Laghmouchi and with the tireless energy of Mohammed Ain was essential to the achievements of the Nakhla project.

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At ECODIT, Jean Tilly provided exemplary technical supervision throughout the project and ensured that our deliverables were always of high quality. Joseph Karam made valuable contributions to the Drarga pilot project and to many training activities.

The WRS project benefited greatly from the contributions of many consultants. Special thanks go to our core team of consultants: Fouad Rachidi, Rachid Bouabid, Mohamed Tayaa, and Mohamed Mounsif for the Nakhla soil erosion control project; Driss Messaho and Said Bouanani for the Dokkarat chromium recycling project; and Brahim Soudi and Khalid Khalaayoune for the Drarga wastewater treatment and reuse project. This outstanding group of consultants demonstrates that Moroccan talent was largely responsible for the successes of WRS, which bodes well for the sustainability of the project's results.

Finally, WRS staff—Mario Kerby as chief of party, Redouane Choukr-Allah as technical coordinator, Nadia Afsahi as office manager, and Hassan Nablaoui as driver/courier—kept this $12-million project moving for seven years as a small but effective team. We all enjoyed working on WRS. It was an enriching experience, both professionally and personally. We worked as colleagues with our many Moroccan partners and consultants, and we forged lasting friendships. The seeds of sustainability have been planted for the WRS pilot activities to continue long after the project, and for the methodologies we used and the lessons we learned to serve as models for future projects.

We are also grateful to all those who we did not name above, but whose contributions were essential to the success of WRS.

Executive Summary

Executive Summary

A. Introduction

The Morocco Water Resources Sustainability (WRS) project was developed in the context of USAID/Morocco's strategic objective to "improve water resources management in the urban, agricultural, and industrial sectors" through the implementation of pilot activities. Under the project's terms of reference, the WRS team was expected to implement up to three demonstration projects integrating water-related technology, regulatory concerns, financing options, and public participation. The success of the demonstration efforts would then lead the Government of Morocco, other donors, multilateral lending institutions, or even the private-sector to consider using the technology and decision-making framework developed by WRS in other locations for eventual post-project applications.

The achievements of the WRS project were to be measured against the following indicators of performance:

- Reduction in the amount of water pollution in target areas
- Volume of water savings in target areas
- Reduction in the volume of soil erosion in target areas
- Progress toward the adoption of key policy reforms
- Percent of tanners adopting chromium recycling technologies
- Number of environmental activities implemented with non-governmental partners

Between 1996 and 2003, the WRS project achieved results pertaining to each of these indicators and more. Specifically, WRS successfully implemented three pilot projects showcasing water-related technologies:

- A wastewater treatment and reuse project in Drarga near Agadir, in which more than 175,000 m^3 of treated wastewater is reused annually, resulting in water savings and pollution abatement

- A chromium recycling project for the tanneries of Dokkarat in Fez that provides significant opportunities for tanneries to reduce pollution and reuse an important input in the production of leather

- A soil erosion control project in the Nakhla watershed of northern Morocco that combines innovative direct and indirect interventions to reduce the silting of an important dam and that is projected to prolong the lifetime of the dam by 15 years

B. Project Achievements

Below, we highlight the results achieved by the WRS project with respect to each performance indicator.

Reduction in the amount of water pollution in target areas. In Drarga, we succeeded in eliminating water pollution from 500 m^3 of raw sewage that was being discharged on a daily basis directly in nature, contaminating the aquifer. Wells that had been abandoned due to contamination are once again being used. In Fez, the Dokkarat chromium recycling plant has been fully tested and will prevent nearly 65 tons of chromium per year from being discharged into Oued Fez.

Volume of water savings in target areas. About 150,000 m^3 of treated wastewater per year from the Drarga plant is reused for irrigation. This leads to significant water savings because farmers receiving water from the treatment plant no longer have to pump the aquifer for their irrigation needs.

Reduction in the volume of soil erosion in target areas. As a result of the Nakhla soil erosion control project, sediments are being retained in the watershed and are not reaching the dam. We estimate that soil losses in the watershed will be reduced by 20 percent as a result of project actions.

Progress toward the adoption of key policy reforms. WRS helped the Moroccan Ministry of Environment develop norms and standards for wastewater reuse and the release of chromium effluents in water bodies. Our environmental impact assessments led to the Ministry's drafting of the National Law on Mitigating Environmental Impacts, which was approved by Parliament in 2002.

Tanners adopting chromium recycling technology. In the Dokkarat pilot project, all tanners in the target area separate their chromium effluents and send them to the chromium recycling plant. We conducted a successful test of the reuse of recycled chromium in a tannery. This allowed the Fez City Water, Electricity, and Sewage Utility (RADEEF), which manages the chromium recycling plant, to sell recycled chromium to the tanners of Dokkarat.

Activities implemented with non-governmental partners. For the Drarga wastewater treatment and reuse pilot project, WRS worked with the Al Amal water users association on planning for the wastewater treatment plant and on securing community buy-in for implementation of the project. For the Dokkarat chromium recycling pilot project, the tanners of Dokkarat were involved in the selection of appropriate technologies, the separation of chromium effluents, and the reuse of recycled chromium. In the Nakhla soil erosion control pilot project, village farmer committees were created and served as the interface between the project and farmers for the implementation of activities. Women's cooperatives participated in a program to introduce improved cookstoves, and an association of beekeepers was involved in an apiculture program.

C. Difficulties Encountered

While the Dokkarat chromium recycling project was ultimately successful, we faced a number of delays and difficulties in starting plant operations. Following the inauguration of the plant, a period of testing began, highlighting a number of problems that had to be resolved. Most importantly, the piping network was leaking in some areas, resulting in diluted chromium effluents reaching the recovery plant. Repairs to the piping network began in the fall of 2000 and concluded in the spring of 2001. In the summer of 2001, the initial testing phase was completed and the facility began operations. Chromium was successfully precipitated and the filter press functioned normally. However, further leaks were discovered in the piping network and operations were halted once again.

In a second attempt to fix the piping network, WRS conducted a camera inspection of the network to identify the leaking portions and repaired the deepest portion of the network. As a result of these repairs, the network became considerably more reliable. However, in preparing lessons learned from the project, it became apparent that, due to the hydrogeology of the site (i.e., a high water table with significant fluctuations), we could not be sure of the long-term reliability of the piping network. Consequently, we proposed implementing an alternative solution whereby chromium effluents would be transported by tanker truck from the tanneries to the chromium recovery plant.

The WRS project was extended until April 2003 to allow for implementation of the alternative tanker truck transportation option and for the proper training of RADEEF staff. During the project's extension period, we conducted further tests at the facility, purchased the tanker truck and storage tanks, trained RADEEF staff on plant operations, retrofitted and improved the incoming chromium storage tank, resurfaced the pavement above the piping network, and conducted a study for RADEEF on improvement of the drying basins for olive oil residues (margines).

After our main consultant became ill, we requested another extension until September 2003 to complete the recycling portion of the project. In early August 2003, recovered chromium from the Dokkarat plant was successfully reused in trials at a Fez tannery. On September 23, 2003, we conducted a full-scale demonstration of the reuse of recovered chromium in a Fez tannery in full view of all the tanners. We then held a workshop to explain the process of collection of the chromium effluents from the tanneries of Dokkarat, sale of the recovered chromium by RADEEF to the tanners, and reuse of the recovered chromium in the tanneries.

While the difficulties encountered delayed the start of operations, the successful recycling of chromium in Dokkarat tanneries and the tanners' willingness to use the recycled product provide strong opportunities for the project to be sustainable.

D. Introduction of Appropriate Technologies

Under WRS, the Drarga wastewater treatment plant was constructed using a sand filtration system including anaerobic basins, sand filters, denitrification basins to reduce nitrate levels, and reed beds for tertiary treatment. The technology has met or exceeded all pollution abatement standards, and the treated wastewater meets World Health Organization standards for unrestricted use in irrigation. With monthly operating costs of less than $2,000, the plant is inexpensive and easy to maintain.

The Dokkarat chromium recovery plant uses widely known technological processes to precipitate, filter, and acidify chromium effluents. Technical staff of the water utility (RADEEF) received training on plant operations and are fully capable of performing their functions.

The soil erosion control project in the Nakhla watershed relies on a variety of watershed management tools and techniques—all well suited to the Moroccan context—to reduce soil loss and increase rural incomes. We planted more than 150,000 fruit trees along contour lines; distributed 100 beehives to an association of beekeepers for the production of honey; introduced 50 goats adapted to local conditions in the watershed; delivered improved cookstoves to women's cooperatives; and trained farmers on soil conservation techniques.

E. Cost Recovery and Financing

All WRS pilot projects include cost-recovery mechanisms that enhance sustainability. The Drarga wastewater treatment plant recovers costs through the sale of treated wastewater to farmers; the sale of reeds from reed beds; the use of sludge for compost; and the recovery and conversion to energy of methane gas from the anaerobic basins, which reduces energy costs. The commune of Drarga is also adjusting water and sewer tariffs to cover costs for equipment replacement and future expansion of the plant.

Chromium produced by the chromium recovery plant in Dokkarat will be sold back to the tanners, defraying most of the plant's operating costs. In Nakhla, the activities of the soil erosion control project (e.g., tree planting, honey production, improved goats) provide sources of income to the local population.

F. Public Participation

Our participatory approach to project implementation has been a cornerstone of WRS. From the start of the project, local institutions, NGOs, beneficiaries, and private sector partners were involved in project activities. Collective agreements specifying the roles and responsibilities of each partner were signed for each pilot project. Through these agreements, the project was able to obtain commitments for co-financing, cost sharing, and project management.

Specifically, the Regional Agency for Planning and Construction, a parastatal developer, contributed $300,000 to the cost of the Drarga wastewater treatment project by financing the main collector and flood control work. In the Nakhla watershed, the Agency for the Development of Northern Morocco contributed $100,000 to project activities. In Fez, the tanners of Dokkarat financed the separation of chromium effluents within their tanneries.

Our participatory approach also ensured transparency in the design and implementation of pilot projects. After the feasibility study drafts were completed, we organized stakeholder workshops to present options and ensure buy-in from all interested parties, including government institutions, beneficiaries, the private sector, and NGOs.

G. Improved Capacity of Moroccan Institutions to Manage Water Resources

Building institutional capacity at the Ministry of Environment and other Moroccan institutions involved in water resource management has been a key focus of WRS. Our team conducted training workshops and seminars on water protection and management, organized observational study tours to the United States, and worked closely with staff from partner institutions on design, planning, implementation, and monitoring of pilot activities. Specifically, our capacity-building activities included the following:

- We organized workshops on cost-benefit analysis of environmental issues, cost recovery for wastewater treatment and chromium recycling plants, industrial pollution prevention and control, wastewater treatment and reuse technologies, norms and standards for chromium effluent releases, norms and standards for wastewater reuse, soil erosion prevention techniques, and environmental impact assessments.

- We organized three observational study tours to the United States covering chromium recycling from tanneries, wastewater treatment and reuse, and the development and implementation of water protection policies.

- Technical working groups including staff from the Ministry of Environment and institutions involved with water management at the local level participated in all phases of the project. The Provincial Directorate of Agriculture and agricultural extension agents from the Work Center of Tetouan trained farmers in the Nakhla watershed on soil erosion control and served as an interface with the farmers. The water utility of Fez (RADEEF) provided primary oversight for the construction of the chromium recovery system and currently manages the plant. In Drarga, the commune manages the wastewater treatment plant and reuse system. WRS provided extensive on-the-job training to these partners and benefited tremendously from their contributions to the project.

H. Project Impact: Toward Water Resources Sustainability

Our team helped ensure the sustainability of the pilot projects through a variety of products:

- Reports on lessons learned, detailing the successes and problems encountered on each pilot project, along with suggestions for replicating successes and overcoming difficulties on similar projects to be implemented in the future

- Detailed operational manuals for each pilot project specifying all aspects of technical and cost management

- A dissemination strategy identifying key steps to successfully replicate WRS pilot projects

- A marketing strategy identifying local champions that can serve as catalysts for the replication of pilot projects

- Guidelines for preparing feasibility studies, design, bid documents, and implementation of pilot projects

- Methodological guides detailing all the steps and tasks involved in preparing and implementing pilot projects

All these documents were presented at the project's close-out workshop, held on April 8, 2003. The work begun under WRS is now being carried forward by the Watershed Protection and Management (WPM) activity managed by Chemonics International, ensuring the sustainability and replication of WRS activities. Launched in October 2001 as a continuation of WRS, the WPM project focuses on disseminating best practices in the Souss-Massa area and on extending soil erosion control activities in the Nakhla watershed. Dissemination activities under WPM include an industrial pollution prevention and control project with the COPAG dairy in Taroudant; a wastewater treatment and reuse project in the commune of Sidi Bibi; and a watershed management project in the Bigoudine watershed. The early successes of these activities are largely due to the application of methodologies and lessons learned from WRS. In addition, successful implementation of WRS activities ensured quick buy-in from project partners and increased levels of participation among stakeholders.

SECTION I

Introduction

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Introduction

This report documents the activities of the Morocco Water Resources Sustainability (WRS) project from its launch in July 1996 to its conclusion in April 2003. It describes how the project's expected results were achieved, detailing our pilot activities (Section II), our capacity-building initiatives (Section III), our institutional development and policy work (Section IV), the communication, dissemination, and marketing strategies used to promote sustainability (Section V), lessons learned (Section VI), ending with a brief conclusion (Section VI). Annex A includes a breakdown of project expenditures, and Annex B provides a list of deliverables and reports submitted over the course of the project. Below, we begin by describing the context and objectives of the WRS project.

A. Context

Morocco is a semi-arid country facing severe water shortages in the future. If current trends continue, it will be classified as a water-deficit country with less than 1,000 m^3 of water per person per year by 2020. Repeated and more frequent episodes of drought, combined with increased demand for water resources and spreading pollution of fresh water, threaten the balance of water in Morocco.

Chronic water shortages are exacerbated by soil erosion, industrial pollution, and domestic sewage from urban areas. In northern Morocco, soil erosion reduces the capacity of water reservoirs, thus limiting the ability to store sufficient quantities of water for long periods of drought. Industrial pollution in large cities affects the quality of water in streams and rivers and can compromise the operation of water and wastewater treatment plants. The release of raw domestic sewage in nature results in the contamination of aquifers and creates heath problems for urban populations, particularly children.

When the WRS project was launched in 1996, soil erosion rates were very high in the Rif mountains of northern Morocco, and the Nakhla watershed, which provides water to the city of Tetouan, had lost 40 percent of its capacity. In Fez, leather tanneries were releasing 65 kg of chromium per day that reached rivers and streams, contaminating precious water resources. In Drarga, near Agadir, 400 m^3 per day of raw wastewater was being released in nature, creating cesspools of sewage that contaminated nearby wells and became breeding grounds for mosquitoes.

B. Objectives

Under the project's terms of reference, WRS was to implement up to three demonstration projects integrating water-related technology, regulatory concerns, financing options, and public participation to help reduce threats to water resources. In turn, these demonstration efforts were expected to generate interest in the technology and decision-making framework introduced by the project among the Moroccan government, donors, multilateral lending institutions, and/or the private sector for eventual post-project replication.

Under this broad objective, three sub-results were sought:

- Development of a strategic policy framework promoting an integrated and comprehensive approach to water management, including both supply and demand management
- Exposure of Ministry of Environment management and staff to a wide spectrum of appropriate technologies and new ways of doing business
- Creation of a framework or process for collaborative development of regulations, standards, guidelines, and technology selection based on the demonstration projects and policy discussions

The WRS project was developed in the context of USAID/Morocco's Strategic Objective 2 to "improve water resources management in the urban, agricultural, and industrial sectors" through the implementation of pilot projects. Exhibit I-1 below illustrates the USAID Mission's strategic objective and performance indicators governing the WRS project.

Exhibit I-1. Strategic Objectives and Performance Indicators

STRATEGIC OBJECTIVE 2:

Improved Water Resources Management in the Agricultural, Urban, and Industrial Sectors

Indicators:

- Amount of water pollution in target areas
- Volume of water savings in target areas
- Volume of soil erosion in target areas

INTERMEDIATE RESULT 2.1:

Improved Policy, Regulatory, and Institutional Framework

Indicators:

- Number of environmental laws and decrees promulgated and implemented

INTERMEDIATE RESULT 2.2:

Improved Environmental Technologies

Indicators:

- Percent of tanners adopting chromium recycling technologies and improved management practices in target areas

INTERMEDIATE RESULT 2.3:

Broadened Public Participation for Environmental Action

Indicators:

- Number of environmental activities implemented with NGO partners
- Number of public awareness activities implemented

SECTION II

Activities and Achievements

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Activities and Achievements

A. Pilot Project for Treatment/Recovery of Chromium Discharges From Fez Tanneries

A1. Background

The city of Fez is an important industrial center in Morocco. Unfortunately, its economic development has been accompanied by polluting activities from olive oil processing plants, metal plating operations, and tanneries. In 1997, the tanneries of Fez discharged up to 360 kg of chromium per day into the sewer network. Tanneries discharge trivalent chromium, which is toxic for aquatic life. Chromium concentrations greater than 1 mg/liter in effluent prevent biological oxidation of carbon-containing organic matter, as well as nitrification. The effluents discharged by the tanneries and other industries into the sewer have contaminated the Oued Fez, which is released into the Oued Sebou downstream, making this river one of the most polluted in Morocco.

The city planned to build a wastewater treatment plant, but it would not function properly if heavy metals like chromium continued to be discharged into the sewer. After consulting with members of the community, tanneries, the Fez City Water, Electricity, and Sewage Utility (RADEEF), and other stakeholders, the WRS project established a pilot chromium recycling plant for tanneries in the industrial area of Dokkarat. The plant serves as a demonstration site for promoting pollution prevention to other tanneries and industries throughout Morocco.

Replicating this project will contribute to testing the provisions of Water Law 10/95, which focuses on improving the quality of surface and ground water. The law states that entities polluting the waterways or ground water are responsible as polluters. In the case of the Dokkarat tanneries, the Fez water utility would be held responsible because it is the organization discharging the untreated wastewater into the Oued Fez. However, under the provisions of the law, water utilities can monitor industries and prevent the discharge of certain pollutants into the utility's wastewater collection systems and treatment plants, or they can charge a special fee for processing these pollutants. A combination of environmental enforcement and efforts to convince polluters of both the financial and social advantages of pollution prevention will be key to replicating recycling projects.

A2. Feasibility Study

In 1997, the WRS team prepared a feasibility study for the pilot project and established a goal of reducing the amount of chromium discharged by the tanneries of Dokkarat by 99 percent.

Dokkarat tanneries. Located on the right bank of the Oued Fez in the northeastern part of the city, the industrial zone of Dokkarat extends over 90 hectares. The agro-processing industry, 80 percent of which is represented by olive oil processing plants, and the tanning industry predominate. There are 16 tanneries, 12 of which were operational in 1997. The tanneries employ 400 people and process 3,226 metric tons of hide each year, which is equivalent to 14.25 metric tons per day (about half of their processing capacity). Except for two tanneries, all of the units in Dokkarat specialize in cattle hides.

The total annual sales of the Dokkarat tanneries amounted to DH 120 million in 1997. The industry is quite volatile as it depends on international markets and can be affected by rapidly changing conditions. During the life of the project, there were significant fluctuations in tannery production in Dokkarat. Moreover, the scarcity of raw hides has caused prices to rise, which sharply reduced the profit margin of the tanners and in some cases even obliged them to operate at a loss during certain periods.

The tanneries discharge their liquid effluent, which is loaded with organic and toxic pollutants, as well as considerable solid waste. The tanneries in Dokkarat make up one-third of Fez' tanning activity and discharge 14 m^3/day of spent chromium baths, with an average chromium concentration of 6,230 mg/liter.

Selecting the most cost-effective option to reduce chromium. To reach its chromium reduction goals, the WRS team examined four options: (1) improving the chromium fixation rate; (2) splitting raw hides; (3) direct recycling of chromium baths; and (4) precipitation and recycling of chromium.

After estimating the anticipated benefits and costs of each option, our team concluded that only the last option would enable the reduction of chromium concentrations by 99 percent in the effluents of Dokkarat. During a workshop to present the options, held in Fez on April 24, 1997, the tanners themselves also selected the fourth option, primarily because it would be least disruptive to their tanneries and working methods.

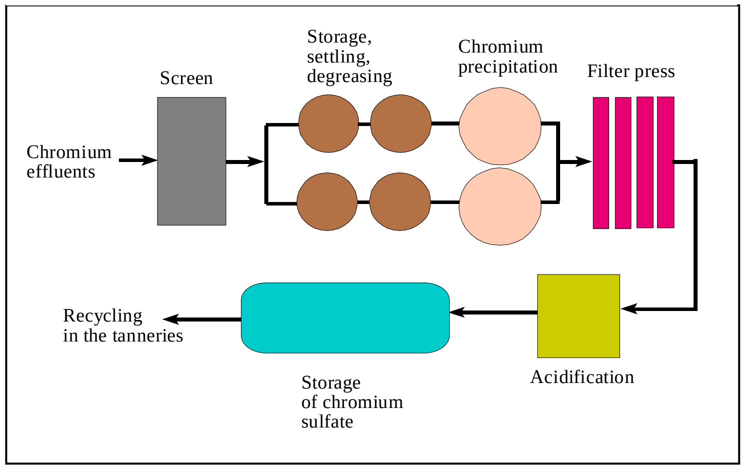
Given the small size of the tanneries in Dokkarat, it was easier to install a centralized chromium recovery facility to collectively treat the chromium-containing effluents from all units in the area. The recovery method selected is the traditional precipitation process, which has already proven successful in the United States and Europe, both in single tanneries and centralized units. It is also the process that had been prescribed for the future Aïn Nokbi plant in the Fez sewage master plan.

The precipitation process consists of four main steps: (1) precipitate the chromium with caustic soda; (2) settle to separate the substances floating on the sludge; (3) dewater the sludge with a filter press; and (4) attack the dewatered sludge with sulfuric acid to reconstitute a chromium sulfate liquor.

After comparing two options to transfer the chromium-containing effluents between the tanneries and the centralized facility (by truck or through pipeline), our team selected the pipeline option because it minimizes worker contact with chromium during transfer. Project partners also expressed concerns that transport by truck could result in spills and accidents, health and safety issues in handling of chromium-containing wastewater, truck mechanical breakdowns, and maintenance delays.

The system consists of a sewer network (three branches of a total length of 3 km), where chromium-containing effluents flow by gravity to a concrete lift station. Wastewater is then pumped to a sidehill hydrasieve-type screen to remove solids. Screenings are conveyed to a hopper by chute and into a sediment washing tank and a grease washing tank.

Exhibit II-1. Treatment Process



The chromium-contaminated rinse water is then sent through the system for treatment (see Exhibit II-1). After screening, the chromium-containing wastewater enters one of four 50 m^3 receiver tanks, where grease and finely divided leather fiber are separated and floating grease is skimmed off. The spent chromium solution is then pumped to one of two reactor tanks, where it is precipitated using caustic soda. A polymer is added to enhance precipitation. The precipitate is transferred to the filter press where it is dewatered. Sulfuric acid is added to the sludge to dissolve the precipitate and to produce a tanning liquor. The recovered chromium in liquid form is accumulated in a storage tank. Finally, carboy is used to collect the recovered chromium as needed for the tanners.

Site selection. We assessed four sites for the pilot system and selected the final site because: (1) it belongs to the municipality of Agdal rather than a private landowner; (2) liquid discharges from the tanneries could flow to the site by gravity, avoiding any pumping; and (3) it is located downstream of Dokkarat's main sewer.

Environmental impact assessment. We conducted an environmental impact assessment to identify measures to eliminate or attenuate any environmental impacts, and incorporated these measures within site selection and design of the chromium recovery facility. The study stressed the need to prevent any spills from the facility and any leaks from the sewer network.

Implementation plan. Our team presented the results of the feasibility study at a workshop held in Fez in April 1997. Participants included the tanners, RADEEF, the Wilaya of Fez, the Ministry of Environment, and various organizations involved with the project. We developed an implementation plan providing a schedule of project activities and detailing the main responsibilities of each partner, which was validated with project partners before the start of construction.

A3. Institutional Arrangements

The WRS team helped establish an effective institutional partnership with the key stakeholders involved with implementation of the Dokkarat pilot project, including the association of tanners, RADEEF, the municipality of Agdal, and the Wilaya of Fez. Each stakeholder was responsible for some aspect of project implementation:

- The association of tanners agreed to separate chromium effluents in the 16 tanneries participating in the pilot project.
- RADEEF agreed to operate and maintain the chromium recovery facility.
- The municipality of Agdal provided the land for construction.
- The Wilaya of Fez facilitated administrative procedures.

This partnership was sealed through a collective agreement signed in 1998, which included the WRS project and the Ministry of Environment. During the implementation phase, our team held regular meetings with various partners to monitor and evaluate project activities.

A4. Construction of Chromium Transportation Network & Chromium Recovery Facility

Procurement. In 1998, we completed the detailed engineering design of the system, which was presented to the WRS inter-ministerial steering committee and approved in May 1998. Our team prepared detailed bidding documents and involved beneficiaries during the selection of local subcontractors for construction of the chromium transportation network and chromium recovery facility. The main equipment (i.e., tanks and reactors, pumps, filter press, mixers, air compressors, and H_2S detectors) was purchased in the United States and shipped to Fez.

Separation of tannery effluents. The separation of tannery effluents in the 16 Dokkarat tanneries began in 1998 and was completed the following year. All 16 tanneries constructed separate canals to transport chromium effluents within their tanneries and installed gates to channel effluents and screens to filter coarse materials. Tests of the separation systems were conducted in December 1999. In 2000, the tanners improved the separation systems by building catch basins under the tanks containing chromium.

Chromium effluents in a tannery

Chromium separation system

Construction of the chromium transportation network. In 1999, the WRS project built the chromium transportation network to transport chromium effluents from the tanneries to the chromium recovery facility. The 3 km-long network links the tanneries to the facility through PVC pipes. In 2000 and 2001, testing of the network revealed intrusion of the water table into the network, which diluted the chromium effluents arriving at the facility. The contractor that built the network repaired the leaks several times. The chromium transportation network was finally completely repaired in December 2002. The WRS team also implemented an alternative transportation system to allow RADEEF to transport chromium effluents by tanker truck. With these two options, the arrival of chromium at the recovery facility is guaranteed.

Construction of the facility. Construction of the chromium recovery facility started in 1999 and was completed in May 2000. The construction of the foundations proved difficult due to the height of the water table and the unstable soil. The first contractor was unable to carry out the work and had to be replaced. By the end of 1999, the foundations and most of the pillars were ready. Once the walls were built, the storage tanks and reactors were placed in the facility by crane. The contractor then installed a prefabricated roof made of 12 m-wide reinforced concrete beams.

Construction of piping network

At RADEEF's request, we also built an office and a guard house next to the facility. In 2000, we installed a mezzanine in galvanized steel inside the plant. The filter press is on the first level, and the screen is on the second level, which also gives access to the top of the storage tanks and reactors.

Once the construction was complete and the equipment installed, the plant was inaugurated on June 5, 2000, coinciding with World Environment Day. The ceremony was attended by Moroccan Minister of Environment Mohamed Yazghi; U.S. Ambassador Edward Gabriel; USAID Director James Bednar; and the Wali of Fez, Ahmed Jellal.

Start-up problems and project completion. While all the pilot projects were ultimately successful, we encountered some difficulties during implementation, particularly with the Dokkarat chromium recycling project, which faced a number of problems and delays.

Following inauguration of the plant, a period of testing began. The testing phase highlighted a number of problems that had to be resolved, most importantly piping network leaks in some areas, resulting in diluted chromium effluents reaching the recovery plant. We began repairs of the piping network in the fall of 2000, which were completed in the spring of 2001. In the summer of 2001, the initial testing phase came to an end and the facility began operations. Chromium was successfully precipitated and the filter press functioned normally. However, additional leaks were discovered in the piping network and operations were halted once again.

In a second attempt to fix the problem, we conducted a camera inspection of the network to identify the leaking portions and repaired the deepest portion of the network. As a result of these repairs, the piping network became considerably more reliable. However, in preparing the lessons learned from the project, it became apparent that, due to the hydrogeology of the site (i.e., a high water table with significant fluctuations), we could not be sure of the long-term reliability of the piping network. Therefore, we proposed implementing an alternative solution whereby chromium effluents would be transported by tanker truck from the tanneries to the plant.

The WRS project was extended until April 2003 to allow for implementation of the alternative tanker truck transportation option and for proper training of RADEEF staff. We conducted a study of the options for implementation of the tanker truck alternative, including collection points and truck specifications. During the extension period, we conducted additional tests at the facility, purchased the tanker truck and storage tanks, trained RADEEF staff on plant operations, retrofitted and improved the incoming chromium storage tank, resurfaced the pavement above the piping network, and conducted a study with RADEEF on improvement of the drying basins for olive oil residues (margines).

Due to delays in scheduling the project engineer (Dave Bennett)’s visit to Fez and the illness of our main consultant (Driss Messaho), we requested a further extension until September 2003 to complete the recycling portion of the project. In early August 2003, recovered chromium from the Dokkarat plant was successfully reused in trials at a Fez tannery.

On September 23, 2003, we conducted a full-scale demonstration of the reuse of recovered chromium in a Fez tannery in full view of all the tanners. We then held a workshop to explain the process of collecting chromium effluents from the tanneries of Dokkarat, sale of the recovered chromium by RADEEF to the tanners, and reuse of the recovered chromium in the tanneries.

The results of the recycling demonstration were excellent, with the tanners expressing their willingness to purchase and use the recycled chromium from the Dokkarat recovery plant. The water utility reiterated its commitment to efficiently manage the plant and to provide high-quality chromium to the tanners. After the recycling demonstration, Mohammed Marzak of Al Amal, a leading tannery in Fez, reported the results of tests on three types of hides. “We used the recycled chromium at the beginning, the middle, and the end of the tanning process,” he said. “We obtained good results and we are very pleased. The leather from our tanneries will now be able to get a green label.”

While the difficulties encountered delayed the start of operations, the successful recycling of chromium in Dokkarat tanneries and the tanners’ willingness to use the recycled product provide strong indications of the project’s sustainability.

A5. Project Impacts

By eliminating the discharge of chromium from Dokkarat tanneries, the pilot project will significantly improve environmental conditions in Fez and reduce potential threats to human health and the environment. During the testing phase, the plant reached its goal of treating 99 percent of incoming chromium. This experience could be repeated in other Moroccan cities that suffer from similar pollution problems, either from tanneries or other sectors such as the agro-processing or chemical industries.

A6. Cost-Recovery Mechanisms

As illustrated in the exhibit below, investment in the Dokkarat pilot project totaled DH 17 million, or approximately $1.5 million, with equipment and construction representing 76 percent of total investment costs. Operation and maintenance costs are estimated at DH 800,000 per year, or approximately $80,000 per year.

Exhibit II-2. Costs of Dokkarat Pilot Project

Types of Costs	Items	Cost in 1,000 DH	Cost in %
Investment Costs	Studies	3,000	18
	Equipment	5,500	32
	Construction of chromium recovery facility	2,500	15
	Construction of sewer network	5,000	29
	Monitoring	1,000	6
	Total investment costs	**17,000**	**100%**
Operation & Maintenance Costs (per year)	Electricity	50	6
	Salary	350	44
	Laboratory analysis	50	6
	Chemicals	350	44
	Total operation and maintenance costs	**800**	**100%**

Cost recovery is assured by the sale of chromium to the tanners. Expected revenues depend on the quality of chromium salt recovered and the sales price of chromium salt. The maximum quantity of chromium salt that can be recovered is 110 metric tons per year, which corresponds to 19 metric tons of pure chromium. Since the sale price for chromium salt is DH 11/kg, maximum annual revenue is DH 1.2 million, which would cover all operation and maintenance costs and allow the facility to pay for equipment amortization.

B. Pilot Project for the Treatment and Reuse of Domestic Wastewater in Drarga

B1. Background

As a mainly arid country, Morocco's water resources are extremely limited. The variability in rainfall and repeated droughts in recent years are having a severe impact on water supply and pollution in many regions. Important economic areas such as Souss-Massa are already experiencing water shortages. In addition, the high degree of urban expansion has increased the production of domestic wastewater that, if left untreated, will threaten population, health, and the environment in major cities.

Minimizing the impact of wastewater on water quality is a major challenge in Morocco. Meeting this challenge requires the installation of substantial wastewater treatment facilities and systems for reusing treated wastewater in agriculture. Morocco's goal, as specified in its National Strategy for Environmental Protection and Sustainable Development Plan, is to have 40 percent of urban wastewater treated by 2020.

Our team selected the Souss-Massa (Agadir) region for the pilot project because it is becoming increasingly urbanized and offers genuine opportunities for reusing treated wastewater in agriculture. Urban expansion in Agadir has significantly increased the production of domestic wastewater, and treating this wastewater is critical to health, the environment, and tourism. Moreover, the Souss-Massa region has a water shortage of 64 million m^3 due to low annual rainfall (280 mm on average) and a high rate of evapotranspiration—the total plant water loss from evaporation and transpiration. Reusing treated wastewater could help make up for some of the shortage.

Based on an overall analysis of the Agadir region, we selected the town of Drarga, located 16 km from Agadir on the right bank of the Souss river, as the site of the pilot project. After consultation with all relevant organizations and stakeholders, we determined that the town of Drarga was the most suitable for implementation of a wastewater treatment and reuse pilot project. Some 80 percent of local households are connected to Drarga's sewage system, and the town has agricultural areas that could be irrigated with treated wastewater.

B2. Feasibility Study

In 1997, the WRS team prepared a feasibility study for the wastewater treatment and reuse pilot project, analyzing various options for selection of the site and of the technology for the wastewater treatment and reuse plant. We also performed a detailed financial and economic analysis based on different water reuse scenarios.

Drarga water and wastewater systems. In 1997, the town of Drarga had an estimated population of 7,000 inhabitants, which is projected to grow to 12,000 by the year 2010. Almost the entire population of the town is served by the drinking water system, supplied by a 500 m^3 water tower and two wells. In 1996, total household consumption was 104,000 m^3, or 46 liters per person per day, and the charge for water was DH 4 per m^3.

Prior to the year 2000, the drinking water and sewage systems were managed by the Al Amal water users association, and the collection rate of water bills was close to 100 percent. Since 2000, the commune has managed the water and sewage services.

Cesspool of raw sewage

Wastewater from Drarga is drained through four outfalls that discharge raw sewage into ponds in underdeveloped areas, which in some cases are only a few meters from residential areas. These ponds are plagued by parasites and insects and give off foul odors. The total quantity of wastewater discharged at the four points is 151 m^3/day, or 53 percent of the total water consumed each day.

Site selection. The evaluation criteria we used to select an appropriate site for the plant included the following:

- Distance between the site and the population
- Ownership of the site
- Access to the site
- Conveyance of untreated wastewater
- Topography and geotechnical characteristics
- Risks of flooding on the site
- Risks of polluting ground water
- Potential reuse of treated wastewater
- Possibilities for expanding the plant in the future

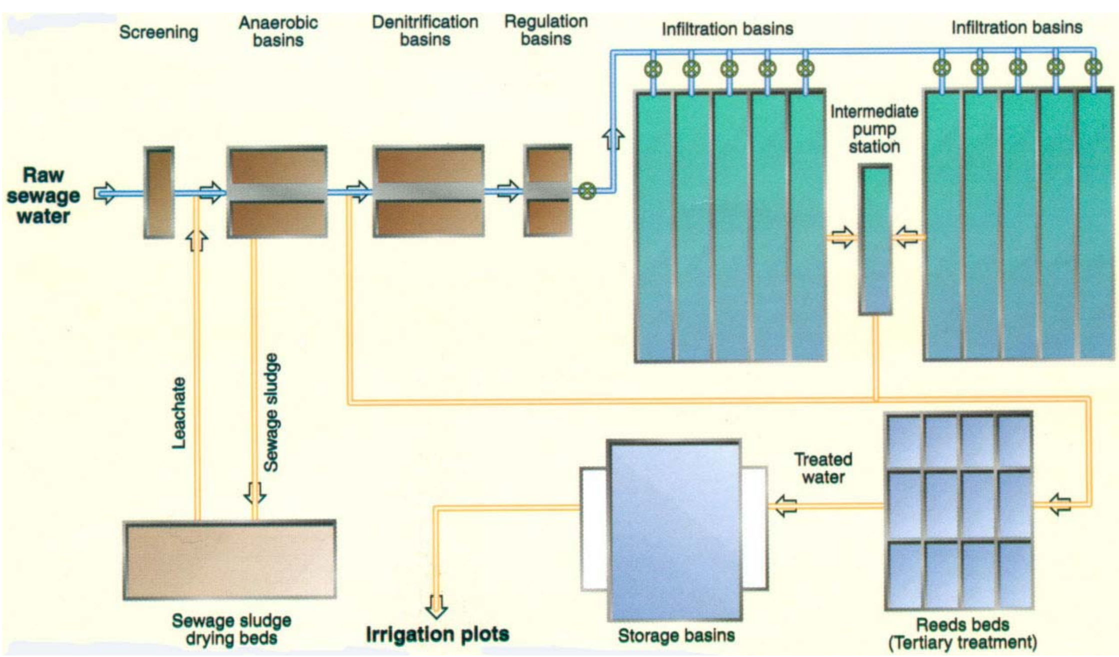
After extensive consultations with local institutions and residents, we selected an appropriate site for the wastewater treatment plant, located more than 700 meters southwest of the town of Drarga. The site is over 11 hectares in size and is adjacent to public land used by 18 small and medium-sized farmers, who would be the primary users of the treated wastewater.

Technology selection. Morocco has more than 70 wastewater treatment plants using technologies such as activated sludge, ponds, trickling filters, and stabilization and infiltration basins. Unfortunately, most of these plants are not operational. Both pond and sand filtration systems have proven to be successful for treating wastewater in small towns at relatively low cost.

We selected three wastewater treatment systems for detailed analysis: pond system, sand filtration, and sand filtration with recirculation of effluents. Our analysis was driven by the need for a low-cost, easy-to-operate treatment plant that would require minimum resources for operation and minimize the risk of aquifer pollution from nitrates. We performed a preliminary evaluation of each alternative based on the estimated average flows of effluents from Drarga in the year 2010, and selected the sand filtration system with recirculation of effluents because it requires a relatively small site and significantly reduces the risk of nitrate pollution.

The system includes anaerobic basins, denitrification basins, flow regulation basins, and sand filters, as well as tertiary treatment using reed beds to eliminate nitrates that could cause ground water pollution. The pilot project also includes a storage basin with a capacity of 5,000 m^3, and a system to distribute treated effluents to farmers for irrigation. The exhibit below illustrates the layout of the treatment system.

Exhibit II-3. Layout of the Wastewater Treatment System for the Drarga Plant



Environmental impact assessment. We conducted an environmental impact assessment to identify measures to eliminate or attenuate any environmental impacts, and incorporated these measures within site selection and design of the treatment plant. The study stressed the need for treating the effluents based on World Health Organization Class A standards for unrestricted reuse. Since the preferred location is subject to flooding, the study also recommended the construction of a flood control system to protect the site.

Implementation plan. Our team presented the results of the feasibility study at a workshop held in Agadir in June 1997. Participants included water users associations, Drarga farmers, and the technical departments of the various ministries and organizations involved with the project. We prepared a detailed implementation plan that was validated by project partners before construction of the treatment system began. The plan included a schedule of project activities and detailed the responsibilities of each partner working on the project.

B3. Institutional Arrangements

Our team established effective institutional partnerships with key stakeholders engaged in implementation of the wastewater treatment and reuse pilot project, including the commune of Drarga, the Al Amal water users association, the Wilaya of Agadir, and the Regional Agency for Planning and Construction (ERAC-Sud). Each stakeholder was responsible for some aspect of project implementation:

- The commune of Drarga provided the land for construction and is managing the wastewater treatment facility.
- The Wilaya of Agadir facilitated administrative procedures.
- ERAC-Sud financed construction of the main sewage collector, widening of the Oued Laarba to protect the site from flooding, and purchase of the land.

This partnership was sealed through a collective agreement signed in 1998, which included the WRS project and the Ministry of Environment. During the implementation phase, we held regular meetings with our partners to monitor and evaluate the project’s progress.

A provincial inter-agency monitoring committee for the Drarga pilot project was created in 2001 to monitor the plant’s technical performance, as well as the quality of agricultural products irrigated with treated effluents produced by the station. The committee comprises officials from the Drarga commune, the Wilaya of Agadir, and the regional technical services concerned, including the Regional Directorate of Hydraulics, the National Potable Water Agency, the Regional Offices for Agricultural Development/Souss-Massa, and the Department of Health. It meets on a periodic basis and has the authority to stop the delivery of treated water to farmers if monitoring analysis shows that the water fails to meet adequate reuse standards.

In 2001, we helped create an association of treated wastewater users, which is responsible for maintaining the irrigation network, collecting fees, and distributing treated wastewater to its members for irrigation of fields adjacent to the treatment plant.

B4. Construction of the Wastewater Treatment Plant

Procurement. In 1998, we completed the detailed engineering design of the Drarga wastewater treatment plant. The design was presented to the WRS inter-ministerial steering committee in Agadir and approved in May 1998. Our team prepared detailed bidding documents and involved beneficiaries in selecting a local subcontractor for construction of the plant. The main equipment, purchased in the United States and shipped to Agadir, included pumps, weirs, sluice gates, telescopic valves, and a Bobcat.

Construction of sewage collector. In 1998, project partner ERAC-Sud financed the construction of the main collector that would bring the town's sewage to the wastewater treatment plant.

Drarga wastewater treatment plant

Sand filters

Plant construction. Construction activities began in January 1999. By the end of the year, all major civil engineering works were completed, including excavation and adjustment of ten sand filters and construction of eight concrete basins, two reed beds, and one storage basin. We also installed synthetic liners in the sand filters, reed beds, and storage basin since they receive treated effluents.

Our work in 2000 included filling the sand filters with sand and gravel; installing all pumps, screens, stop plates, and accessories; installing power at the site; completing all hydraulic connections between basins; building a fence around the facility; and completing construction of the network to distribute treated water to farms for irrigation.

The plant was inaugurated on October 31, 2000, in a ceremony attended by the Minister of Environment Mohamed Yazghi; U.S. Ambassador Edward Gabriel; USAID Director James Bednar; and the Wali of Agadir, Mohamed Rarhabbi. The plant became fully operational in the summer of 2001.

Inauguration of the Drarga wastewater treatment plant

B5. Project Impacts

The pilot project has significantly improved environmental and economic conditions in Drarga and reduced potential threats to human health and the environment by eliminating the discharge of domestic wastewater into the Souss river. As its benefits to the community multiply, it will serve as a model for decentralizing wastewater management to allow greater responsiveness to local interests. One local community member commented: “Before, we had many problems due to foul odors and to mosquitoes that were everywhere, especially in the summer. Now, since the construction of the plant, our environment is much cleaner. This has encouraged people to settle here and invest in the commune of Drarga.”

Reduced water pollution. Tests conducted at the plant in 2000 show that the facility is meeting the targets set for reducing water pollution in Drarga. The exhibit below shows the characteristics of raw wastewater generated by Drarga and their levels after establishment of the treatment plant. On average, the plant generates approximately 500 m^3 of treated wastewater per day. The treated wastewater fulfills the requirements of World Health Organization Category A, which means it is suitable for reuse in agriculture without restriction.

Exhibit II-4. Performance of the Drarga Wastewater Treatment Plant

Parameters	Raw Effluent	Treated Wastewater	% Reduction
Total nitrogen NTK (mg/l)	317	10	96.8%
Biochemical oxygen demand (5 days) BOD_5 (mg/l)	625	9	98.5%
Fecal coliform (FC/100 ml)	1.6×10^7	500	99.9%
Parasites (Helminthes eggs/l)	5	0	100%

Increased water savings. The WRS project increased farmers’ awareness of the use of treated wastewater for crop irrigation by developing demonstration plots using drip irrigation. The results of the demonstration plots convinced the farmers of the benefits of using treated wastewater for irrigation. Crops irrigated with treated effluents in the demonstration plots include cereals (wheat and maize), vegetables (tomatoes and zucchini), and forage crops (alfalfa and ray grasses).

In 2001, the commune of Drarga began operating the treatment plant and providing treated wastewater to a few farmers to irrigate fields in the 6-hectare irrigated perimeter around the plant. Farmers currently grow forage crops, particularly alfalfa, clover, maize, and other vegetables.

Crops grown with treated wastewater

Farmers using treated water for irrigation benefit in two ways. First, they have access to a guaranteed amount of low-priced water. Second, they can save on the purchase of fertilizers since the treated wastewater already contains fertilizer elements required by the crops.

Exhibit II-5 below summarizes the economic savings of water and fertilizer for each crop. Total savings range from DH 2,222 per hectare for zucchini to DH 5,140 per hectare for maize.

Exhibit II-5. Economic Savings From Irrigation With Treated Wastewater

Crops	Water Savings (DH/ha)	Fertilizer Savings (DH/ha)	Total Savings (DH/ha)
Wheat	750	1,492	2,242
Maize	1,588	3,614	5,140
Alfalfa	774	1,539	2,313
Zucchini	677	1,545	2,222
Tomato	1,553	3,542	5,095

B6. Cost-Recovery Mechanisms

As illustrated in the exhibit below, investment in the Drarga wastewater treatment plant totaled DH 20.3 million, or approximately $1.7 million, with equipment and construction representing 71.4 percent of total investment costs. Operating costs are estimated at DH 260,000 annually, or approximately $22,000 per year.

Exhibit II-6. Costs of Drarga Wastewater Treatment Plant

Type of Cost	Item	Cost in 1,000 DH	Cost in %
Investment Costs	Studies	3,000	14.8
	Equipment	6,900	34.0
	Construction	7,600	37.4
	Monitoring	1,800	8.9
	Reuse component	1,000	4.9
	Total investment costs	**20,300**	**100.0**
Operating Costs (per year)	Electricity	60	23.1
	Salaries	70	26.9
	Laboratory analysis	80	30.8
	Miscellaneous	50	19.2
	Total operating costs	**260**	**100.0**

The plant has several built-in cost-recovery mechanisms:

- Treated water is sold to farmers for irrigation.
- Methane gas from the anaerobic basins is recovered and converted to energy.
- Residual sludge from the anaerobic basins is pumped onto sludge drying beds to be converted to compost and sold.
- Reeds from the reed beds are harvested and sold.

In addition, our team encouraged the commune of Drarga to charge water/wastewater customers a flat-rate fee for connection to the sewage system and a sewage fee to cover the remaining costs for operating the station and expanding or replacing it after 2010. Water bills in Drarga now include a line item for wastewater treatment, allowing the commune to establish a specific budget for wastewater treatment.

We helped the commune implement cost-recovery mechanisms for the Drarga plant by:

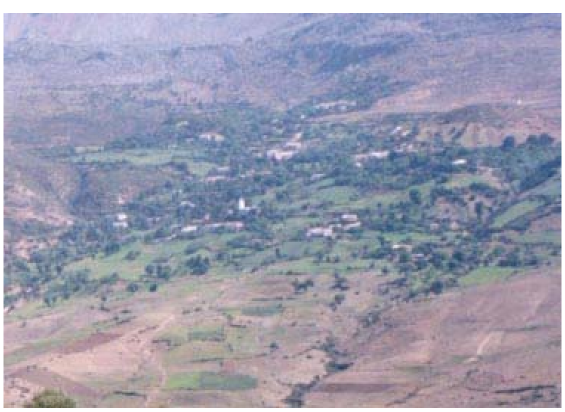
- Opening a special account to manage the costs and revenues of the Drarga wastewater plant
- Establishing a new water and sewage billing system at the plant, and installing computer equipment and software packages to help the commune track the plant's expenses and revenues
- Creating an association of treated wastewater users that will purchase treated water from the commune, partially covering the plant's operation and maintenance expenses

C. Pilot Project for Soil Erosion Control in the Nakhla Watershed

C1. Background

The Rif mountains of northern Morocco are experiencing some of the highest rates of soil erosion in the world. This affects dam siltation, aquifer recharge, and sustainable agricultural practices. The Nakhla watershed is representative of soil degradation in the Rif. Built in the early 1960s, the Nakhla dam, with a capacity to supply the city of Tetouan with 9 million m^3 of water, has been silting up as a result of erosion in the watershed and has already lost 40 percent of its reservoir capacity.

The Nakhla watershed lies 20 km south of Tetouan, on the road to Chefchouen. It is approximately 10,630 hectares in size, with elevation ranging from 200 to 1,800 meters. The watershed has a number of physical characteristics that foster soil loss, including steep slopes and relatively high rainfall, which accelerates soil erosion. The geological and geomorphological diversity of the Oued Nakhla watershed, combined with climatic conditions, has enabled a wide variety of land cover in the watershed. About 30 percent of the watershed's total surface area is under cultivation, 46 percent is covered by vegetation, mainly matorral, and the remaining 24 percent is high elevation classified as rock and badlands.



Soil erosion in the Nakhla watershed

Nakhla dam

The Nakhla watershed has an estimated population of 8,000 inhabitants that centers around a series of villages associated with springs. Irrigated areas on terraces around the villages represent 10 percent of the total agricultural area. Cultivated fruit trees include olive, fig, almond, pear, apricot, prune, carob, vine, and orange. Rain-fed agriculture makes up a large portion of the cultivated area in the watershed. Crops cultivated on rain-fed land include wheat, barley, maize, forage, and legumes. Due to the small size of landholdings, the productivity of the land is very low. The average yield for major crops is generally well below the national average. Livestock production, however, plays an important role in the economy of the watershed and provides a major source of revenue for farmers. The animals kept in the watershed primarily include goats, sheep, and cows, with goats being the most prevalent.

Our team selected the Nakhla watershed for implementation of soil erosion control activities to reduce soil loss and contribute to more sustainable water resources management. The Moroccan government has placed the Nakhla watershed on a list of priority watersheds requiring immediate action. Because its physical, climatic, socioeconomic, and other characteristics are similar to those in other areas of the Rif and northern Morocco, the types of interventions and methodologies developed in the Nakhla watershed are likely to be successful in other locations.

C2. Feasibility Study

In 1997, our team completed the feasibility study for the pilot project, based on the results of baseline data collection and a 1996 participatory landscape/lifescape appraisal (PLLA)—an evaluation method that identifies linkages between socioeconomic conditions and the physical environment of a region.

Baseline data development. During initial visits to the Nakhla watershed in October 1996, we collected background data on the causes of soil erosion, patterns in watershed hydrology and precipitation, spatial patterns in vegetative cover, and types of crops grown. Using background information from several sources, we evaluated the zones most susceptible to erosion in the watershed.

The first source, a satellite image, was used along with aerial photographs and field investigation to delineate land use classes. The second source, a detailed soil map, was developed to identify vulnerability to soil erosion in various areas of the watershed. A third source, a topographic map of the watershed, was used to delineate slope steepness. We used this information to classify the watershed into broad categories of erosion risk and to identify areas for implementation of erosion control activities. The average rate of soil erosion from the entire watershed was estimated at 64 tons/hectare/year, primarily from rain-fed agricultural land on steep slopes.

Participatory approach. The PLLA was also used as a research tool to better understand interrelationships in the agro-ecosystem, identify constraints to natural resources and agricultural sustainability, and develop strategies to promote sustainable practices. The results of the PLLA indicate that soil erosion is a pervasive and widespread phenomenon caused by multiple interrelated factors. No single land use or practice is a primary cause of land degradation. Instead, significant amounts of soil are lost from a variety of areas, including degraded matorral, cultivated land, fruit plantations, pastures, and existing gullies and ravines. Three major factors trigger the process of accelerated degradation of the natural vegetation and soil and result in significant soil loss: (1) the expansion of cultivation over vulnerable lands; (2) the use of unsustainable agricultural practices; and (3) over-grazing of natural vegetation.

Implementation plan. Our team targeted four zones in the vulnerable area located southwest of the watershed for implementation of pilot interventions to control erosion (see Exhibit II-7 on the next page). We selected these areas based on several factors, including the extent of erosion, people's dependence on natural vegetation, the preponderance of dry-land agriculture, and the importance of irrigated agriculture. These zones generate about 30 percent of the siltation in the reservoir, and the majority of farmers there indicated their willingness to work with our team to ensure the success of pilot interventions.

We prepared an action plan proposing a series of implementation activities with either a direct or indirect impact on soil erosion. We held a workshop for stakeholders in May 1997 and discussed our proposed activities for each zone with farmers and other residents of the watershed.

Direct interventions included planting dry-land cereal fields with olive trees, with bands of grass or forage between the trees, and building catch basins to collect water around the trees. Other direct interventions involved physical and biological stabilization of gullies and ravines, or revegetation of degraded mattoral with trees and grass.

Indirect interventions included introducing beehives; energy-efficient cookstoves (to reduce degradation of the mattoral); genetically improved breeds of goats combined with rotational grazing techniques; and better cultural practices such as tilling across slopes, fertilizer application, and spacing of crops when planting dry-land cereals and legumes.

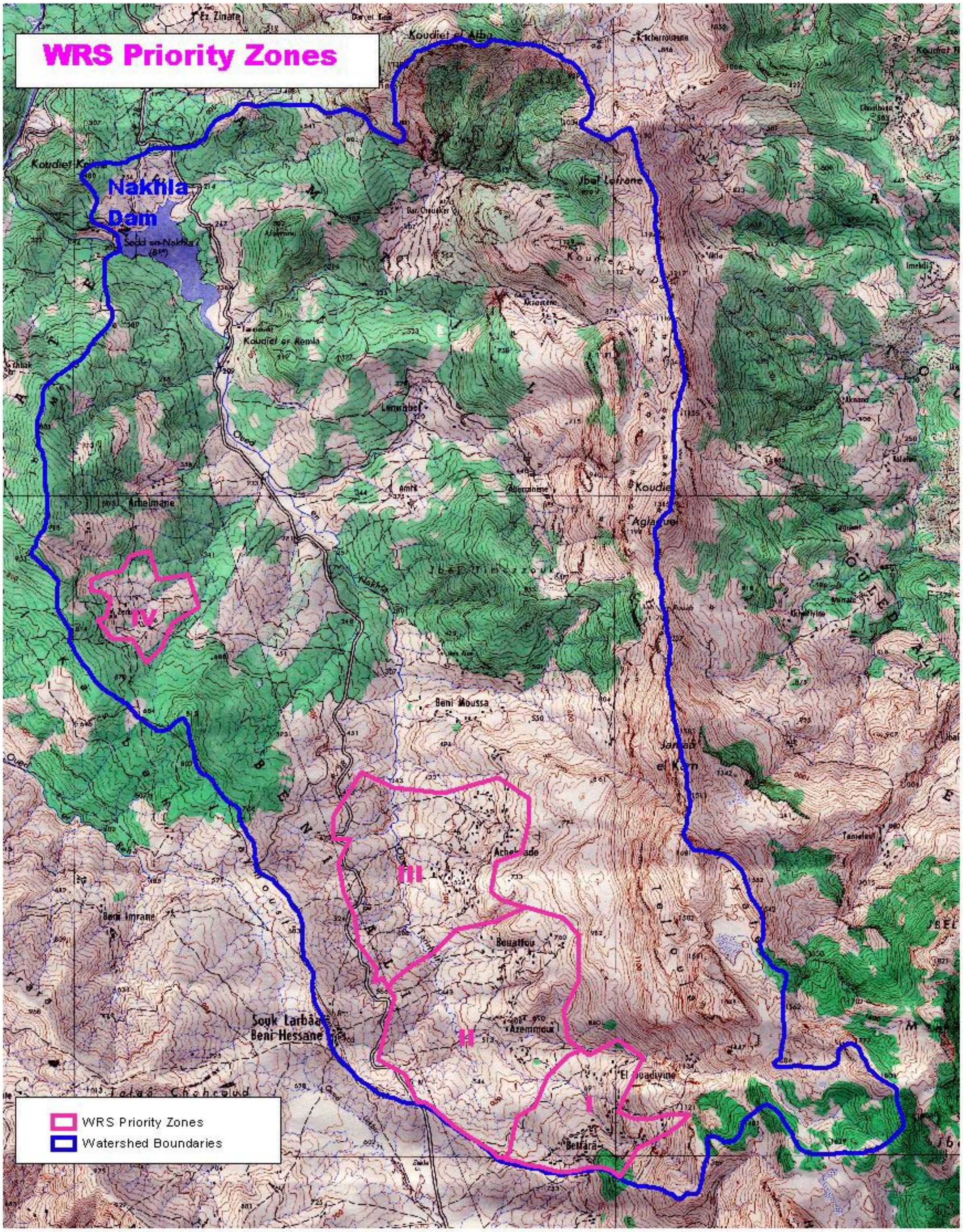
Finally, we proposed additional income-generating activities such as rehabilitation of the irrigation canal network, planting of fruit trees on irrigated terraces, and raising small animals in domestic households.

C3. Institutional Arrangements

In addition to the Ministry of Environment, which helped manage this pilot project, our team developed partnerships with various institutions to maximize the impact of project activities. Key partners included:

- The Provincial Directorate of Agriculture (DPA) of Tetouan, which had primary responsibility for implementing and monitoring project activities
- The Work Center of Beni Karrich, which has extension agents working with local farmers to implement project activities
- The Agency for the Development of Northern Provinces (ADPN), which shared the costs of the project's indirect interventions, particularly introduction of beehives and importation of genetically improved goats
- The Wilaya of Tetouan, which facilitated administrative procedures
- The Regional Directorate of Water and Forests, which provided acacia and carob seedlings and monitored the soil erosion plots

Exhibit II-7. WRS Targeted Zones in the Nakhla Watershed



Other organizations involved in the project included the U.S. Peace Corps and local municipalities and communes. The WRS project, the Ministry of Environment, the Wilaya of Tetouan, DPA, and ADPN signed a collective agreement specifying the roles and responsibilities of each partner in implementing agreed-upon pilot interventions. The agreement helped promote the active participation of all partners, close coordination of project activities, and effective working relationships.

In the initial stages of the project, our team helped create village committees in each targeted zone. These committees organized local participation in pilot interventions by:

- Mobilizing farmers to participate in implementation and education activities
- Helping determine farmer preferences for various intervention options
- Obtaining farmers' signatures on formal contracts for project benefits (trees, goats, etc)
- Helping communicate and solve problems faced by farmers and reduce conflicts between them
- Assisting in implementation and management of interventions within each zone

In general, the WRS team met with the village committees in each targeted zone before, during, and after implementation of any activity. The committees played a vital role in conveying farmer needs to project partners. For example, following the drought of 1998 and 1999, farmers—through the village committees—proposed the construction of reservoirs to store water from several springs. The reservoirs, built by the WRS project, helped them gain access to an emergency source of irrigation water for olive trees during dry seasons, thus reducing the mortality of olive trees planted for soil erosion control.

In addition to the village committees, the project also helped form a beekeeping cooperative, a women's association, and other community groups.

C4. Implementation of Activities With a Direct Impact on Erosion

Our direct interventions were designed to reduce soil erosion originating from crop lands, existing gullies, ravines, and degraded matorral. They included:

- Reducing water runoff and soil loss from croplands by over-planting the cereals along the contour with olive trees surrounded by small water catchments (cuvettes) and grass strips between the trees
- Stabilizing ravines with check dams and shrubs
- Restoring and improving production of range land by planting productive species

Reducing soil erosion by planting olive trees. Olive trees were planted along contour lines to reduce degradation of the farmlands. Once they begin producing olives, these trees will help boost the income of farmers through the production of olive oil. Our initial goal was to plant 387 hectares of steep cultivated dry-land with olive trees along the contour at a density of 100 trees/hectare, for a total of 38,700 trees. By the end of the four-year project, 113,885 olive trees had been planted on 762 hectares in the three targeted zones.

U.S. Ambassador Edward Gabriel waters an olive tree at a ceremony in Nakhla.

We provided olive trees to 1,240 village cooperators, although this number may include some duplicate cooperators whose land was planted in multiple seasons. Local farmers planted the trees, and WRS hired guards to prevent animal grazing in the plantations. An unanticipated benefit of restrictions on animal grazing was a significant increase in the level of soil cover from weeds and crop residue after harvest.

The project far exceeded its initial goals for olive tree plantations mostly due to overwhelming demand for trees by the villagers, who were primarily motivated by the potential for income generation.

Providing irrigation water by constructing water reservoirs. The highest rates of olive tree mortality (25 percent) occurred after the first year of planting because no supplemental irrigation water sources were available to combat drought. Following a request by farmers in Zone I (see Exhibit II-7), the project constructed seven water reservoirs, each with a capacity of 10 m^3, to store spring water for supplemental sources of irrigation. This water is used to irrigate olive tree plantations in the summer to prevent damage from successive drought seasons. As a result of this intervention, the mortality rate for olive trees dropped to about 5 percent per year. Villages also use the reservoirs to collect water for household use.

Reducing soil erosion by constructing catch basins. Catch basins were supposed to be constructed around each planted olive tree and maintained to catch runoff and sediment. However, villagers were reluctant to install the basins in the first year, primarily because of labor issues and a lack of understanding about the benefits of catch basins.

In the second year, our team provided farmers with an incentive, requiring the construction of catch basins around the olive trees as a condition for obtaining fertilizers for the trees. Farmers received training in olive tree fertilization and catch basin construction through workshops held by the Work Center. As a result of this strategy, catch basins were installed around 50 percent of the olive trees planted in the first year and 70 percent of the trees planted in the second year.

In the third year, the DPA provided supplemental funds to hire laborers to complete the construction of catch basins around all the olive trees planted by local farmers. Though this goal was reached by the end of the project, maintenance of the catch basins remains difficult to sustain because of the need to cultivate the land around the trees to plant wheat or legumes.

Reducing soil erosion by planting grass strips. Planting grass strips between lines of trees along the slope contour is an effective method to control erosion. The strips are easier to maintain than traditional banquettes, or mounds of soil.

Our feasibility study recommended that farmers plant grass contour strips on 183 hectares of olive tree plantations. However, only 6 hectares of demonstration sites for grass contour strips were planted prior to the year 2000. From 2000 to 2001, another 150 hectares of demonstration sites were established in the olive tree plantations in Zone II.

The lack of initial success in planting grass contour strips was largely due to the farmers' inexperience and reluctance to adopt this technique. Although the strips provide supplemental feed for their animals and help trap eroding sediments, the farmers felt they made it difficult to till the land by preventing them from plowing up and down the slope.

Reducing soil erosion by stabilizing ravines. The project constructed check dams to lessen the energy of the water as it proceeds downstream, thus reducing erosion in the edges of the ravines and catching sediments. Planting shrubs along ravines also contributes to soil retention and provides a source of firewood for the population.

The feasibility study recommended stabilizing 3.1 km of eroding ravines in Zones I and III. The project actually stabilized 3.5 km in Zones I and II, using a combination of check dams, gabions, and planting of acacia, oleander, and poplar trees. Ravines in Zone III were determined not to require additional stabilization because thick growths of oleanders grow naturally in most ravines in that area.

Despite our success with stabilization, we encountered a number of problems. The first was that the check dams and gabions were constructed without proper biological stabilization of slumping banks. As a result, bank slumping was considerable during the first year, leading to in-filling behind the check dams and gabions. The first oleander and acacia planting was haphazard, without treatment of the slumping regions of the ravines. Most of the acacias planted died due to drought. During the second planting, however, biological treatment was much more successful. In Zone I, 4,800 acacias and 500 poplar trees were planted at regular intervals along 1.5 km of ravines. Another 4,600 acacias were planted along 0.8 km of ravines in Zone II. These plantings are very healthy and will have a significant impact on ravine erosion in the long run.

Restoring and improving production of rangeland. The degradation of the mattoral through extractive uses and clearing is one of the most important factors contributing to soil erosion and overall environmental degradation in the targeted areas. Sowing appropriate species to increase the vegetation cover can significantly reduce the rate of erosion and, at the same time, increase the production of fodder and livestock, which will generate additional income for farmers.

The feasibility study recommended reseeding 92 hectares of degraded mattoral with grass seeds, forages, and carob trees. These lands are all in the public domain and are used extensively for animal grazing and fuel wood collection. In actuality, only about 11 hectares of private domain mattoral was seeded to grass (about 4 hectares in 2000 and 6.6 hectares in 2001).

Our team held numerous meetings and workshops with project participants to discuss the problems associated with degradation of the mattoral and to highlight the benefits of restoration, including a lower rate of erosion as well as increased forage crops and fuel wood. As a result, participants initially gave their approval to seed the public mattoral lands and to plant carob trees. They also agreed to all tasks associated with grass seed planting, including labor, seeding, fertilization, and protection from grazing for a year and a half after planting.

However, at the last minute, the participants backed out of their agreements for several reasons, including a perceived difference in the benefits of revegetation for people with small versus large herd sizes. In addition, the participants felt that a few individuals within the community would not honor the agreement to avoid grazing their animals in the newly seeded areas. Although most participants were well aware of the consequences of further degradation of the mattoral, no successful examples of rotational grazing on public rangeland were realized during the project.

Improving the management of irrigated terraces. Irrigated agriculture is a major source of income for villagers in the Nakhla watershed. Farmers use spring water to irrigate terraces surrounding their village habitations, but these terraces are often eroded and in a degraded condition. Moreover, the irrigation system is in poor condition and inefficient in delivering water.

The WRS team distributed 12,800 fruit trees to 459 recipients in Zones I-III, including 3,838 plum trees; 3,457 pear trees; 2,942 apple trees; and 2,563 persimmon trees. In the long run, these trees will produce fruit that can be sold on the market, leading to increases in household income.

In 1998, our team studied the irrigation delivery network in Zone I and identified several major rehabilitation requirements, including the need to protect springs and to line the primary canals with reinforced concrete. We issued a call for a subcontractor to rehabilitate the irrigation network in Zone I, an initiative financed by ADPN.

Installing soil erosion measurement plots. In 1997, we installed eight soil erosion measurement plots on different slopes and land uses in the watershed. The plots were equipped with a sediment trap, which allowed the project to measure soil loss after rainfall events. These measurements helped us compute the parameters of the universal soil loss equation (USLE) used to estimate erosion rates in the Nakhla watershed.

C5. Implementation of Activities With an Indirect Impact on Erosion

In addition to activities with a direct impact on soil erosion, our team designed various indirect interventions to create alternative sources of income that can reduce population pressures on forest resources, particularly the need for grazing and firewood.

Introducing genetically improved breeds of goats. Raising livestock is estimated to account for 95 percent of farm income in the Nakhla watershed. The PLLA conducted in the watershed in 1996 indicated that the productivity of livestock raising is generally mediocre. Intervention at this level involves progressively improving the efficiency of goat raising because goats are the species best suited to conditions in the region. The production of goat meat can be improved by crossbreeding existing herds with males of breeds that are suitable to the local environment.

The feasibility study recommended introducing 36 male Murciano-Granadina goats, or about 1 male for every 25 females in the targeted areas. Due to an overwhelming demand for goats, however, we successfully introduced 50 Spanish male goats, purchased by ADNP in 2000, into four zones in the watershed. WRS and the herders who received the new goats signed a contract specifying the details of raising the offspring from crossbreeding. As of 2002, the first 25 males introduced into the herds had fathered a total of 105 offspring.

To prevent the spread of disease from local to imported goats, all 4,000 goats in the target zones were immunized by the DPA prior to introduction of the improved goat breeds. We also organized several workshops to train beneficiaries of the improved goats program on the proper techniques for parasite control, nutrition, and reproductive methods.

One herder participating in the program commented: “The offspring from these goats are sturdier and give more meat. They can reach twice the weight of local goats. They have an interesting shape in terms of size and the quality of their hides.” The success of the cross-breeding program and the potential for increased income provide additional incentive for the herders to abide by the terms of their contracts. This initiative should control the load of animals on the matorral and maintain the number of animals owned by the farmers.

Introducing modern apiculture. The Nakhla watershed has a diverse, abundant assortment of flowers that offer a valuable potential for the production of honey. Traditional apiculture already exists in some villages. However, the traditional wooden hives are poorly maintained, and annual production is very low. The invention of the mobile frame has provided a new impetus for beekeeping, and frame hives have simplified the work of beekeepers.

The feasibility study recommended introducing 100 beehives in Zone IV, along with all the equipment necessary for the extraction of honey. In 1999, 100 beehives were purchased by ADPN and distributed in Zone IV. ADPN also purchased two sets of beekeeping equipment, including protective suites, knives, collectors, smokers, extractors, vats, and tubs. A beekeeping cooperative consisting of 25 villagers was formed to manage beekeeping operations.

Due to severe drought and the reduced availability of flowers and nectar in the mattoral, 25 hives were lost in the first year and 12 in the second year. Measures were taken to provide alternative sources of nourishment in the form of sugar and rose pollen. Additional measures are needed for the sustainability of the beekeeping operations, including appropriate choice of location to ensure the availability of nectar and protection from parasites and predators.

Introducing improved cookstoves. The women living in the Nakhla watershed spend several hours a day collecting firewood and branches for animal feed. Most of the firewood is used for cooking, baking bread, and heating, and much of the wood used is cut from the local matorral. The destruction of this mattoral leads to bare land, which in turn causes soil erosion.

In 2001, the WRS project decided to introduce one improved cookstove into the village of Bouattou in Zone II to reduce the consumption of wood. This two-compartment stove is capable of cooking 12 pieces of bread in 15 minutes with 7.2 kg of wood. A communal shelter was built to protect the stove from rain and to vent the smoke. Women from nine households in Bettara were trained in proper usage of the cookstove. Twenty households now use the improved cookstoves at least four days a week, for four hours a day.

On average, the quantity of wood burned has been reduced by half, from 16 kg/day to 8 kg/day. Because the new cookstoves are more efficient and require less wood, women in the village spend less time collecting wood and more time on education for their children and on income-generating activities. Incidentally, the women are also extremely satisfied with the quality of the bread produced by the stoves.

Creating a women's association. In 2001, WRS helped establish a women's association in Zone II for crafts-making as well as poultry and rabbit raising. Under the follow-on Watershed Protection and Management (WPM) activity, the association is receiving technical assistance with rabbit production.

C6. Costs and Benefits

As illustrated in the exhibit below, investment in the Nakhla pilot project totaled DH 10 million, or approximately $1 million. At 83 percent of the total investment costs, technical assistance and training comprise the major cost components.

These investments have reduced soil erosion, increased water savings, and boosted the productivity and profitability of farmers in the watershed. A cost-benefit analysis of the project has estimated its net present value at more than $500,000 and its internal rate of return at 13.6 percent.

Exhibit II-8. Costs of Nakhla Pilot Project

Type of Intervention	Item	Cost in 1,000 DH	Cost in %
Direct Interventions	Olive tree plantings	910	63.2
	Fruit trees for terraces	110	7.6
	Stabilization of ravines	170	11.8
	Spring water development	180	12.5
	Seeds	70	4.9
	Total cost of direct interventions	1,440	100%
Indirect Interventions	Improved cookstoves	7	2.4
	Beekeeping	16	5.5
	Small equipment	40	13.7
	Fertilizer	30	10.2
	Equipment and monitoring of land erosion plots	200	68.2
	Total cost of indirect interventions	293	100%
Training and Technical Assistance		8,267	

C7. Training

Our team implemented several training activities in the Nakhla watershed to capitalize on the project's interventions and ensure sustainability.

Farmer education and training. Farmers in the watershed received regular education and training before, during, and after the introduction of any new intervention. This approach reduced the risk of improper management and diminished the potential for failure. As a result of these efforts, farmers gained confidence, knowledge, and new skills with each new management practice.

WRS staff and consultants from the Work Center of Ben Karrich organized and led the education and training sessions, emphasizing best management practices as opposed to traditional approaches. Most of the sessions were repeated in each zone and involved an actual field demonstration of each technique. Examples of the topics covered include:

- Olive tree management (planting, fertilization, rationale/methods for constructing cuvettes around olive trees, insect and disease control, pruning, harvesting)
- Improved crop production for cereals, legumes, and forage crops (soil preparation, certified seed and variety selection, fertilization, weed and disease control, crop rotation)
- Fruit tree management (planting, fertilization, insect and disease control, pruning)
- Installation and maintenance of contour grass strips
- Improved degraded mattoral (revegetation and forage crop planting in the mattoral)
- Improved goat management techniques (breeding, nutrition, and disease control)
- Beekeeping management techniques (feeding, diseases, parasites, and honey extraction)
- Improved cookstove usage techniques

Field trips. To complement the training sessions, we organized field trips for Nakhla farmers to visit other regions where farmers were already practicing the techniques to be introduced in the Nakhla watershed. Examples of the sites visited include:

- Cheese factory in Chefchaouen
- Collective cookstoves in Chefchaouen
- Olive plantations in Loukous
- Goat farmers in Khenifra, Ouazzane, and Meknes

Seminars and workshops. We organized a number of seminars and workshops for WRS partners and stakeholders to discuss issues related to successful implementation of interventions in the watershed. Some of these include:

- Erosion control pilot project stakeholders' workshop, May 27, 1997
- Nakhla pilot project replication workshop, June 14, 1999
- Goat management workshops
- Beekeeping workshops
- Lessons learned from the Nakhla project workshop, November 15-16, 2000

C8. Project Impact on Soil Erosion and Water Savings

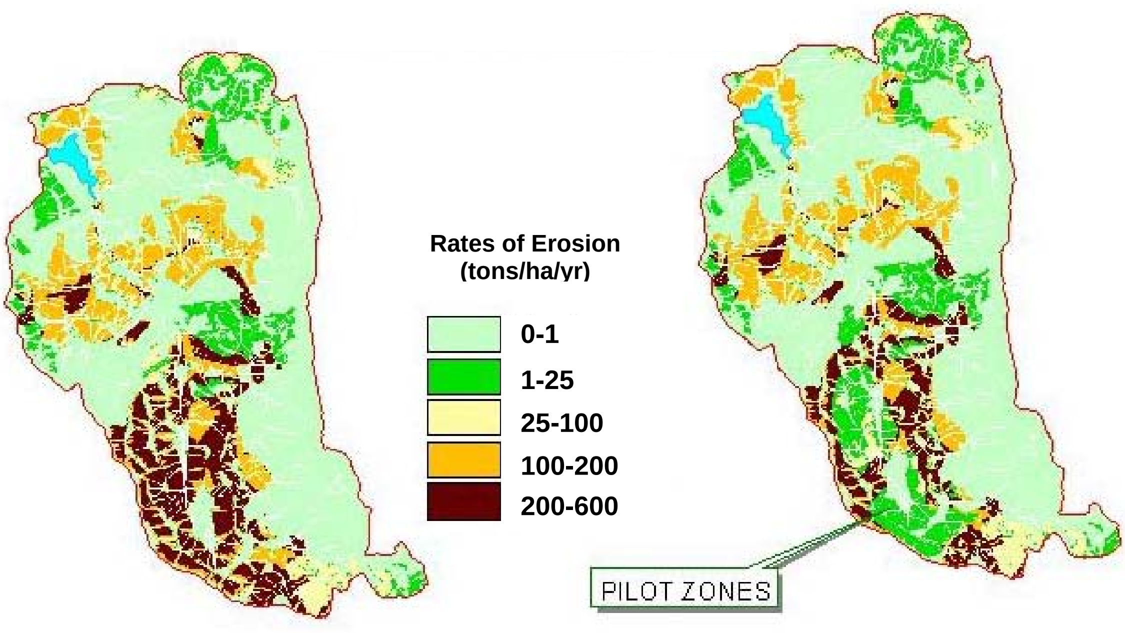
By reducing soil erosion in the Nakhla watershed, the pilot interventions will lower the rate of loss in the holding capacity of the Nakhla dam, leading to a longer lifetime for the dam and increased water savings.

In early 2001, our team completed work on a geographic information system (GIS) application for the Oued Nakhla watershed. The objective of the GIS application was to visually show the capacities of various pilot project activities; estimate the impact on erosion and sediment transport to the Nakhla reservoir; and assist in disseminating project results to policy makers, funding agencies, and potential new partners. The principal thematic layers of the GIS include:

- Baseline data layers (rivers and streams, elevation contours, satellite imagery, infrastructure, villages, etc)
- Geo-referenced data layers of several project interventions (planted zones of olive trees, stabilized ravines, soil erosion measurement plots, improved springs and reservoirs, improved rangeland, improved goat breeds, etc)
- Soil map
- Land use map of the watershed before and after project interventions

We developed several other GIS layers to estimate the impact of project interventions on annual soil erosion and sediment transport to the Nakhla reservoir. These layers were used to estimate USLE parameters, including topography (slope length and steepness), rainfall erosivity, soil erodability, land use factors before and after project interventions, and cultural and conservation practices before and after project interventions. Using the USLE and ArcView /GIS Spatial Analyst, we developed thematic maps of the annual erosion rate before and after project interventions, as illustrated in the exhibit below.

Exhibit II-9. Impact on Soil Erosion Rates in the Nakhla Watershed



Before Project Interventions **After Project Interventions**

The average rate of erosion without project interventions was estimated at 64 tons/hectare/year. After project interventions, erosion from the watershed will be reduced to 51 tons/hectare/year. This represents a projected 21-percent reduction in erosion rates for the entire watershed once olive trees have reached maturity (i.e., after five years). Without project intervention, the Nakhla reservoir was expected to be completely filled with sediment in 25 years. However, because of the success of pilot activities in the targeted zones, the useful lifetime of the reservoir will be extended by an additional eight years.

WRS soil erosion control interventions targeted four vulnerable zones located southwest of the watershed. Our team used the GIS application to simulate the impact of a potential extension of the project's conservation practices to the entire Nakhla watershed. By replicating plantation with cuvettes to all dry-land farming fields, we expect to reduce erosion rates from the whole watershed to 7 tons/hectare/year—i.e., by about 90 percent. By increasing the life expectancy and storage capacity of the dam, this extension effort will have an enormous positive impact on the conservation and productivity of natural resources in the Nakhla watershed.

SECTION III

Capacity Building

SECTION III

Capacity Building

A critical objective of the WRS project was to develop the capacity of local institutions to contribute to the sustainability of water resources in Morocco. To that end, we organized a number of training activities, study tours, and workshops aimed at strengthening partner institutions that deal with integrated water management.

The WRS project worked closely with institutions, both at the national and regional levels, to coordinate and implement pilot activities. Ministry of Environment staff were fully integrated in project teams engaged in various aspects of implementation—from the feasibility studies, to contractor selection, to construction oversight, to results monitoring. The institutional partnerships we developed through collective agreements also ensured the participation of local institutions in pilot interventions.

A. Strengthening the Ministry of Environment

Our team worked closely with the Ministry of Environment to enhance its role as coordinator of environmental policy. The Ministry was not only included as a full partner in all implementation phases of the pilot projects, but also participated with other partners in major training sessions supported by WRS.

The WRS project also provided several opportunities to enhance the Ministry's visibility. For example, we organized high-profile events for each of the pilot projects, which were attended by the Minister of Environment and the U.S. Ambassador. These events received extensive media coverage that prominently featured the Ministry's crucial role in the WRS project.

B. Workshops

Staff from all partner institutions received regular training throughout the course of the WRS project. Training sessions were designed to build the capacities of partner institutions to support pilot projects during and after implementation, and to develop local capabilities to disseminate best practices. Key WRS-sponsored training activities are described in Exhibit III-1 below.

Training at Drarga treatment plant

Training for farmers in Nakhla watershed

Exhibit III-1. Key WRS Training Activities

Activity	Location and Date	Participants	Purpose
Participatory Landscape/ Lifescape Appraisal (PLLA) training	Meknes November 1996	Ministries of Environment, Water and Forests, and Agriculture (12)	Conduct PLLA. Emphasize the tools of rapid rural appraisal to understand the dynamics of a watershed, and the use of transects as a method for gaining an understanding of interrelationships between physical and human environments.
Stakeholders' workshop for tanners	Fez February 1997	Dokkarat tanners (40)	Raise awareness of negative impacts of pollution generated by tanneries and discuss potential solutions.
Workshop on rapid appraisal techniques	Agadir April 1997	Drarga community (10)	Determine degree of acceptance in the community for a project to treat wastewater and reuse the treated effluents for irrigation.
Cost-benefit analysis workshops	Tetouan May 1997	National and local representatives (40)	Share techniques of analyzing costs and benefits of projects while integrating the environmental dimension. Present key concepts of environmental externalities, net present value, and internal rate of return.
Workshop on wastewater treatment options	Agadir June 1997	Drarga stakeholders (40)	Drarga stakeholders validated the technical option for the plant and selected a different site from the ones presented in the feasibility study. WRS changed the site selection as a result.
Workshop on wastewater reuse	Agadir October 1998	Institutional partners and stakeholders (20)	Secure a strong commitment from stakeholders to support the wastewater reuse component of the project.
Cost-recovery workshops	Agadir and Fez December 1998	Project partners (50)	Show techniques for estimating cost recovery based on capital/operating costs and revenues generated by the projects. Provide spreadsheets to calculate the break-even points based on different scenarios.
Technical training on Drarga plant	Agadir November 1999 and November 2000	Project partners and technical staff from the Commune of Drarga (12)	1999: Provide technical training on the functioning of the Drarga wastewater treatment plant. Present details of every operation of the plant. Provide operational guide. 2000: Provide further technical training after the plant became operational.
Seminar on the reuse of treated wastewater in agriculture	Agadir May 2001	Project partners (30)	Address institutional, technical, health, and regulatory issues related to the reuse of treated wastewater for irrigation.
Workshop on the dissemination of appropriate technologies for treatment of urban wastewater	Agadir February 2002	Partner institutions and potential beneficiaries from future wastewater treatment projects (42)	Discuss costs and performance of different technologies for the treatment of urban wastewater. Disseminate best practices in the Moroccan context.
WRS final workshop	Rabat April 2002	Project partners (72)	Present results of the WRS project and lessons learned. Prepare methodological guides for implementing pilot projects on soil erosion control, watershed management, industrial pollution prevention, and wastewater treatment and reuse.

C. Study Tours

In addition to workshops, WRS organized study tours to the United States for project partners, as illustrated in the following exhibit. Through the study tours, participants learned about various technologies and policies that are relevant and applicable to the project's objectives.

Exhibit III-2. WRS Study Tours

Event	Location	Date	Participants	Purpose
Tannery study tour	Minnesota and Wisconsin	April 1998	Dokkarat tanners; representatives of the Ministry of Environment, Wilaya of Fez, Fez-Agdal municipality, RADEEF, Regional Directorate of Hydraulics (DRH)-Fez, National Potable Water Agency (ONEP), Ministry of Commerce and Industry, and Urban Agency (18)	Demonstrate chromium recycling technologies at tanneries in Minnesota and Wisconsin similar to those implemented in Dokkarat.
Wastewater treatment and reuse study tour	Maryland and California	June 1998	Representatives of Al Amal water users association, Drarga commune, Wilaya of Agadir, DRH-Agadir, Regional Offices for Agricultural Development/Souss-Massa, Agadir Multiservice Utility, ONEP, Ministry of Environment, and other key partners (20)	Examine sand filtration technologies at wastewater treatment plants.
Water policy study tour	Washington, DC, and Maryland	May 1998	Staff from the Ministry of Environment, Department of Hydraulics, Ministry of Agriculture, and ONEP (18)	Observe how water protection policies become effective programs and the relationships between legislators, regulatory agencies, enforcement agencies, NGOs, and the public.

SECTION IV

Policy Issues

SECTION IV

Policy Issues

One of the goals of WRS was to use the implementation of pilot projects to inform the policy dialogue on key issues in Morocco. Through the implementation of pilot projects dealing with various aspects of the water challenges facing Morocco, we gained insights into policy issues that impede sustainable water management. This section describes the policy work undertaken by our team and presents a framework for dealing with water policy issues in light of the lessons learned from the WRS experience.

A. Activities Related to Policy Issues

Policy assessment study. In September 1996, shortly after the project was launched, we prepared a policy assessment study to evaluate the new Water Law 10-95 and its potential implications for implementation of the pilot projects.

Cost-benefit analysis workshop. In May 1997, we organized a workshop on the cost-benefit analysis of environmental projects for representatives of partner institutions at the national and regional levels. The goal was to introduce participants to tools and techniques for evaluating water projects, taking into account environmental externalities. These tools are essential for a rational prioritization of water projects in the context of integrated demand management.

Policy study tour. In May 1998, we organized a study tour to the United States on water protection policy for staff from Moroccan institutions involved in water policy formulation, including the Ministry of Environment, the Department of Hydraulics, the Ministry of Agriculture, and the National Potable Water Agency. Participants visited the U.S. Environmental Protection Agency (USEPA), the Maryland Department of Environment, members of Congress, the Water Federation, and USEPA-Region III, where they learned about water protection policy development and enforcement. The tour allowed them to gain a better understanding of how water protection policies are translated into effective programs and to observe the relationships among legislators, regulatory agencies, enforcement agencies, NGOs, and the public.

Conference on water as an economic and social good. In June 1998, the WRS project organized a conference on water as an economic and social good, led by Professor Peter Rogers of Harvard University. The conference attracted key decision makers in the Moroccan water sector. Professor Rogers examined important principles on the value of water as an economic good and demonstrated how inadequate tariffs and water pricing lead to waste and inefficiencies.

Norms and standards for the tannery sector. In November 1999, WRS fielded a team of experts to prepare a background document for the elaboration of norms and standards for the tannery sector. The goal was to provide the rationale for the development of norms specific to the Moroccan context. Beginning with a description of the tanning industry in Morocco, the document discusses the environmental impacts of tannery releases; the current regulatory and institutional context related to pollution generated by the tannery sector; the methodology for establishing norms and standards; the proposed norms and standards; the potential impact of the proposed norms on the industry; and the administrative burden on the Moroccan government with regard to application of the norms. The document was provided to the Norms and Standards Committee and is being used to support application decrees related to the Water Law. It also serves as a model for the establishment of norms and standards in other industrial sectors.

Norms and standards on wastewater reuse. In August 2000, we fielded an expert to prepare a background document for the elaboration of norms and standards for wastewater reuse in Morocco. The document describes the current situation with respect to wastewater reuse, international norms, and the Moroccan regulatory context. It also presents proposed norms and standards tailored to the Moroccan environment, sound agricultural practices with respect to the reuse of treated wastewater, and procedures for effective monitoring of wastewater reuse. The document was provided to the Norms and Standards Committee and is being used to support application decrees related to the Water Law. Like the tannery sector study, this document serves as a model for the establishment of norms and standards in other industrial sectors.

B. Key Policy Issues Addressed

In addition to the specific policy work undertaken by WRS, a number of policy issues were addressed through the implementation of WRS pilot interventions.

Progressive pricing policies. Adequate valuation of water and the consequent repercussions on water pricing remain the principal water policy issue in Morocco. While certain sectors, such as potable water in urban areas, reach water prices in line with marginal costs, water for irrigation remains heavily subsidized, under-priced, and under-valued, leading to inefficiencies and a significant rate of unaccounted-for water.

In the coming years, it will be important for the Moroccan government to move toward marginal cost pricing of water to make the resource sustainable. Failure to do so could have significant impacts in areas such as Souss-Massa, where water scarcity has become chronic. International pressure to liberalize prices of commodities and raw materials through the Treaty of Association with the European Union and the recently signed U.S-Morocco Free Trade Agreement can provide an opportunity for Morocco to review its water subsidies in the agricultural sector.

The Moroccan government should consider establishing different pricing schemes for different regions based on water scarcity, not only on mobilization and exploitation costs. Similarly, the value of water contained in crops, or “virtual water,” could be calculated to help set priorities in terms of crops to be grown. For example, as tariff barriers are removed, crops requiring large amounts of water, such as bananas, should stop being produced on a large scale in Morocco.

In implementing WRS activities in Drarga and Fez, it became clear that government institutions are generally reluctant to move toward progressive pricing policies. In the Souss-Massa area, however, we found a greater willingness to pay for water services than in other parts of the country. In general, Moroccan institutions should work to raise awareness of the long-term consequences of continuing to subsidize water prices.

Application of the "polluter pays" principle. The polluter pays principle is applied under the Water Law 10-95. Based on certain norms and standards, River Basin Agencies can impose fines on entities that pollute the public hydraulic domain. Our experience with the Dokkarat chromium recovery project made it clear that, as long as norms and standards are not enforced, industry will not voluntarily pay for the pollution it generates. In Fez, tanners are opposed to paying RADEEF, the local water utility, for their pollution. They are willing, however, to purchase recycled chromium, provided the recycled product does not affect leather quality.

One important obstacle to the polluter pays principle is that, in the context of the Water Law, it only applies to discharges in fresh water bodies. Discharges to the sea are not covered by the law. Thus, a tanner in Fez will be subject to pollution fines, whereas a tanner in Casablanca will not. Since most of the industrial activity in Morocco is located in coastal areas, the majority of water pollution is not covered by the polluter pays principle. It is, therefore, imperative for the Moroccan government to address coastal area protection through legislation similar to the Water Law. Otherwise, there will be a perverse incentive for industrial facilities located in the interior (e.g., Fez, Marrakech) to relocate to coastal areas, where there are no pollution charges.

Proper enforcement of the polluter pays principle also requires Moroccan institutions to develop the human and financial resources necessary to issue permits, conduct sampling and analysis, and establish a system of fines and the means to implement them. River Basin Agencies should start preparing themselves for the enforcement actions, even before the application decrees related to the polluter pays principle are passed.

Use of environmental impact assessments. Morocco recently passed legislation on environmental impact assessments (EIAs). The Ministry of Environment is committed to begin requiring the systematic use of EIAs on large projects or projects that could potentially harm the environment. Under WRS, we prepared two EIAs, one for the Drarga project and one for the Dokkarat project.

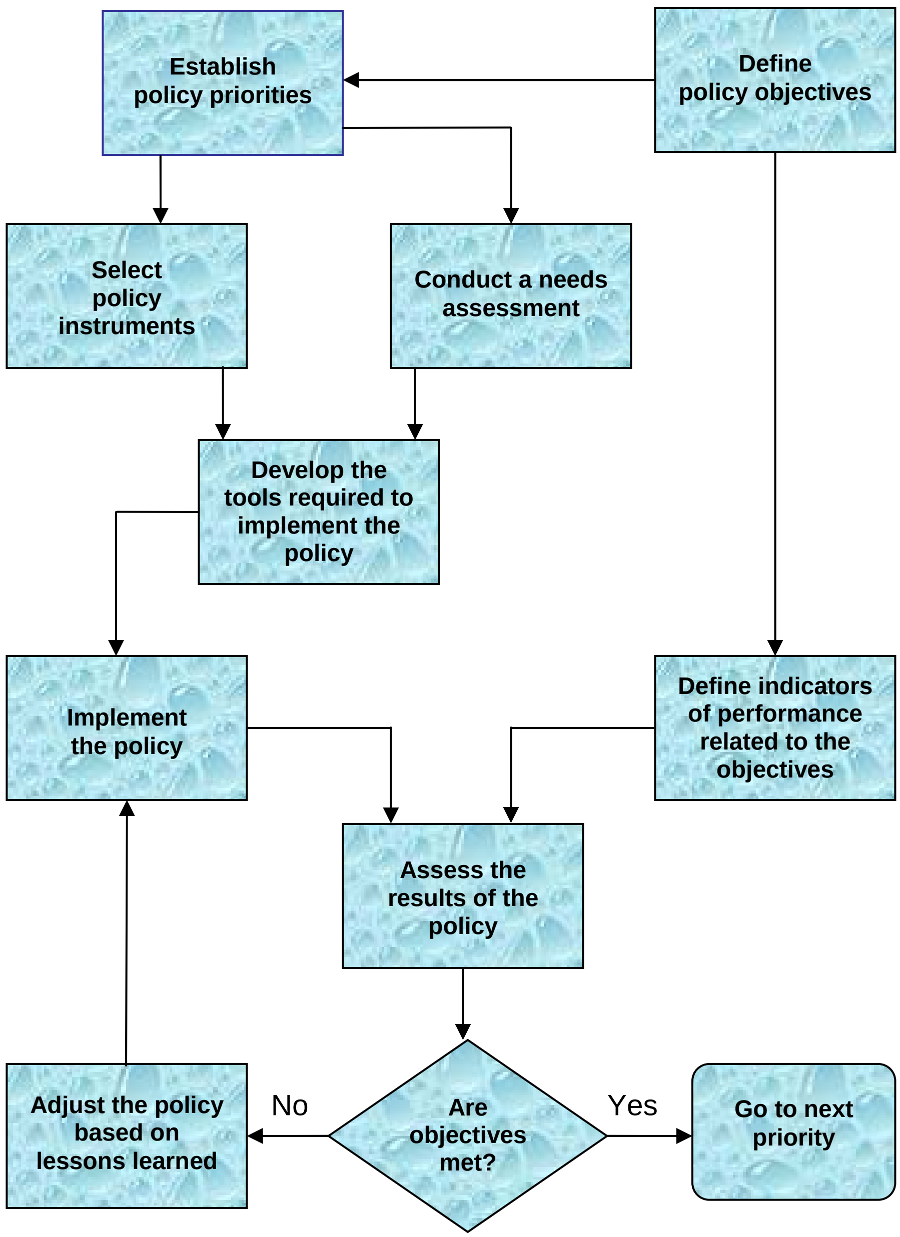
The EIA for the Drarga project recommended widening Oued Laarba to protect the site from floods and constructing a system to eliminate the production of nitrates. Both of these recommendations were implemented by the project.

In Dokkarat, the EIA recommended special precautions for construction of the piping network to prevent contamination of the aquifer. In this case, although the contractor's terms of reference called for pipes capable of handling chromium, the pipes ended up leaking and were not waterproof. To solve this problem, we implemented an alternative system to transport the chromium by tanker truck.

C. Conceptual Policy Framework

Based on the policy work carried out under the WRS project, we developed a water policy framework, presented in Exhibit IV-1 below. Under this framework, development of the tools required to implement the policy is the central linkage between defining broad policy objectives and achieving expected results. The principal elements of this framework include policy formulation, implementation, and evaluation activities.

Exhibit IV-1. Water Policy Framework



Policy formulation. The first step in formulating sound water policy is to determine the key objectives of that policy. Significant discussions on this topic have already taken place through the Superior Water Council (CSE), and key Moroccan objectives can be found in documentation from the last CSE meeting in 2001. Once policy objectives are defined, they can be used to establish policy priorities and performance indicators for achieving desired results. In Morocco, the policy priorities are to:

- Provide potable water to meet the needs of all citizens
- Develop sufficient water resources to ensure food security

- Support the water needs of the growing industrial and tourism sectors
- Preserve the quality of Morocco's fresh water resources
- Ensure that the poor are not left out of wastewater service delivery
- Reduce losses and unaccounted-for water

Specific performance indicators should then be developed for each policy objective. These should be measurable and monitored on an ongoing basis. Some indicators are easy to develop and monitor (e.g., percent of households with access to potable water, unaccounted-for water), while others are more difficult to measure (e.g., food security indicator). Furthermore, some objectives may require several indicators. For example, measuring water quality depends on end use of the water resource. That is, indicators for water destined for human consumption are not necessarily the same as indicators for water used in agriculture.

The Moroccan government will have to make a concerted effort to create clear and measurable indicators related to key water policy objectives. Developing the human and technical resources to measure the indicators will also be an important issue.

Once policy priorities are established, two steps are necessary to start affecting policy changes: (1) selecting policy instruments and (2) conducting a needs assessment. The Moroccan government should follow these steps to determine what policy instruments are necessary (e.g., regulations, incentives, subsidies) and what it needs to do to apply those instruments (e.g., draft and pass regulations, prepare questionnaires, change the tax code).

Policy implementation. Based on the selection of policy instruments and the needs assessment, effective implementation of water policy requires the development of specific tools to achieve desired results. Effluent charges, user charges, subsidies, and market incentives are among the instruments available to policy makers to effect changes in water demand. Certain tools are available for each policy option. In Morocco, Water Law 10-95 advocates two fundamental policy principles: polluter pays and user pays. As previously mentioned, the main challenge in Morocco lies in the application and enforcement of these principles.

To enforce the polluter pays principle, River Basin Agencies (RBAs) could develop the following tools:

- Questionnaires for major polluters so they can report pollution levels to the RBAs on a periodic basis
- Audits of polluters conducted by the RBAs to assess effluent releases into water bodies
- System of penalties to match the level of fines to the extent of pollution generated
- Publication of a "black list" of companies that cause significant threats to human health and the environment
- Spot sampling and analyses of water bodies to identify levels of contamination and link pollution levels with potential polluters
- Information for major polluters on techniques, environmental management systems, and technologies to reduce pollution

To facilitate compliance with the user pays principle, RBAs can do the following:

- Conduct surveys of private wells and collect information on well size, depth, and maximum pumping rate
- Install locked meters at private wells to monitor water withdrawal rates
- Require permits for digging new wells
- Establish a system of fines for users of unmetered private wells

It is important to note that the application of both principles constitutes a major shift from traditional ways of doing business. For farmers and many industrial concerns, water is considered a free or nearly free resource that should not be taxed. In addition, polluters have become accustomed to releasing polluted effluents into water bodies with no threat of fines. Adjusting to new systems of tariffs and fines will be disruptive for many. But as water resources become increasingly scarce, there is no alternative to enforcing these principles.

Some farmers and the private sector have already started to adopt better water management practices. For example, under the Morocco Watershed Protection and Management (WPM) activity, the COPAG dairy in Taroudant, a major polluter, has entered into a partnership with various institutions, including the Souss-Massa RBA, to embark on a massive pollution prevention and control program. COPAG is investing in pollution prevention and control systems on a voluntary basis, and the RBA, along with USAID, is providing technical assistance. This is an important example of a public-private partnership that can be replicated to ensure that the Water Law serves as an incentive to polluting industries and that common ground is reached.

Policy adjustment. Once water management and protection policies are implemented, they must be continuously evaluated and adjusted. The RBAs should monitor indicators that measure water availability, water quality, and the efficiency of water use. If targets are not reached, policies should be revisited and amended as appropriate. Information systems are particularly useful in this regard. For example, the water data management system developed under the Souss-Massa Integrated Water Management project should be used and updated to ensure that the impacts of Water Law implementation are properly monitored and that adjustments are made as necessary. Once specific objectives are met, the RBAs can move to the next priorities while continuing to monitor previous objectives.

SECTION V

Communication, Marketing, and Dissemination Strategies

SECTION V

Communication, Marketing, and Dissemination Strategies

Throughout the course of project implementation, the WRS team developed communication, marketing, and dissemination strategies to publicize the project's accomplishments and ensure sustainable replication of successful pilot activities.

A. Communication Activities

From its inception, WRS made a concerted effort to involve targeted communities in pilot projects. Our public awareness activities helped promote acceptance of new technological solutions introduced by the project and adoption of required changes in practices.

Finalized in 2000, our communication strategy guided design and implementation of programs to replicate the pilot projects, providing guidelines on basic tasks such as how to identify target audiences and develop communication materials. We used a wide range of communication channels and tools to generate publicity about the project's activities and accomplishments, including:

- *Meetings with stakeholders.* For each pilot project, the WRS team held meetings with stakeholders, including community members and institutional partners, to validate each step of project development.

- *Training programs and reference materials for partners.* As discussed in Section III, "Capacity Building," we sponsored various workshops and seminars to train project partners and provide reference materials on the pilot projects.

- *Press releases and media events.* We organized high-profile events at all three pilot sites with Moroccan ministers, provincial governors, the U.S. Ambassador, the deputy chief of the USAID Mission, and other senior officials. These events generated intensive coverage in the broadcast and print media, and articles about the project appeared regularly in Moroccan newspapers.

- *Project videos.* Early on, the audiovisual center at the Meknes National Agricultural College started filming project activities, from the feasibility study stage, through implementation, to project results. The center produced one video providing an overview of the entire project, which was shown at our close-out workshop, and a series of videos for each of the pilot projects. These videos are useful dissemination tools as they provide a visual record of the project's approach, activities, and results.

- *Public talks.* The WRS chief of party delivered presentations about the project at a number of public fora, including roundtables, conferences, and seminars, helping us gain visibility among various audiences.

- *Brochures and posters.* We developed several communication materials, including pamphlets on each pilot project and a general brochure describing project activities and results, which was distributed at our close-out workshop. The Ministry of Environment is making extensive use of these tools to communicate the project's achievements.

- *Field visits.* Our team organized field visits to project sites for different groups, including government officials and technical staff, students, foreign visitors, seminar attendees, and potential beneficiaries of future projects. We expect such visits to continue under the aegis of our partners.

- *Project website.* We created a project website (www.proprem.com) capturing WRS project activities and results. It is linked to the websites of the Ministry of Environment, ECODIT, and Chemonics International.

B. Marketing Strategy

In January 2002, our team developed a marketing strategy for replicating WRS pilot projects. Our approach focused on identifying a single organization capable of carrying out the functions of the WRS team in conceiving, designing, and implementing other projects. In other words, the goal was to identify the "engine" or catalyst that will drive the replication process.

Using this strategy, we determined that the Moroccan Center for Clean Production (CMPP) should be the facilitator/dealmaker for replicating the Dokkarat chromium recovery project. CMPP is the leading advocate for pollution prevention and clean technologies in Morocco and is familiar with the Dokkarat pilot project. As an NGO, it is well placed to establish linkages between public and private sector agencies, and has developed working relationships with Moroccan industries, government agencies, and international donors. The center is associated with the United Nations Industrial Development Organization, which can provide technical and managerial guidelines for various industries, and with the United Nations Environmental Programme, which can share environmental standards and a wide range of other environment-related information. CMPP is thus uniquely suited to take over the work performed by WRS on the Dokkarat pilot project.

The Ministry of Environment, WRS' primary partner, has a good working relationship with CMPP and has many talented staff members who have much to contribute to the replication program. Consequently, we anticipate that the Ministry will be involved with CMPP in replicating the Dokkarat pollution prevention project. The roles envisioned for Ministry staff include conducting environmental assessments, monitoring pollution, and providing technical advice. CMPP should particularly draw upon Ministry staff who have already worked on the Dokkarat pilot project with WRS. The Ministry of Environment is also expected to serve as an advocate and to provide technical support to the replicated projects. CMPP could establish an advisory board including the Ministry of Environment, the Ministry of Commerce and Industry, financial institutions, and other key stakeholders that could provide advice and support to the replicated projects.

Using the same strategy, the WRS team determined that the National Potable Water Agency (ONEP) was best suited to facilitate replication of the Drarga wastewater treatment and reuse project. ONEP is a parastatal organization that, among other duties, is responsible for water and wastewater programs for small and medium-sized communities. ONEP was involved in the Drarga pilot project and presided over the project's technical committee. The commune of Drarga has requested that ONEP take over management of the wastewater treatment plant. As an autonomous body, ONEP utilizes many private sector practices and approaches. In some cases, the agency sells the water it buys to local water utilities, and sometimes actually sets up and operates the local utilities.

Although ONEP has technical capabilities among its own staff, it will also need to draw upon the Ministry of Environment and other ministries as needed. As with the Dokkarat project, the Ministry of Environment has been the primary partner of the WRS team and is expected to work with ONEP to replicate the Drarga wastewater treatment and reuse project. In this case, the Ministry's primary role will be to conduct environmental assessments, monitor pollution, and provide technical advice.

With regard to the Nakhla soil erosion control project, we identified the consulting group from the National Agricultural School at Meknes as the most suitable facilitator for the replication process. The group has worked on the Nakhla pilot project from the beginning and is interested in establishing a center for land and water resources management that would take over the role of the WRS team. The center would function like a private consulting company, but would actually operate under the university umbrella or as an NGO.

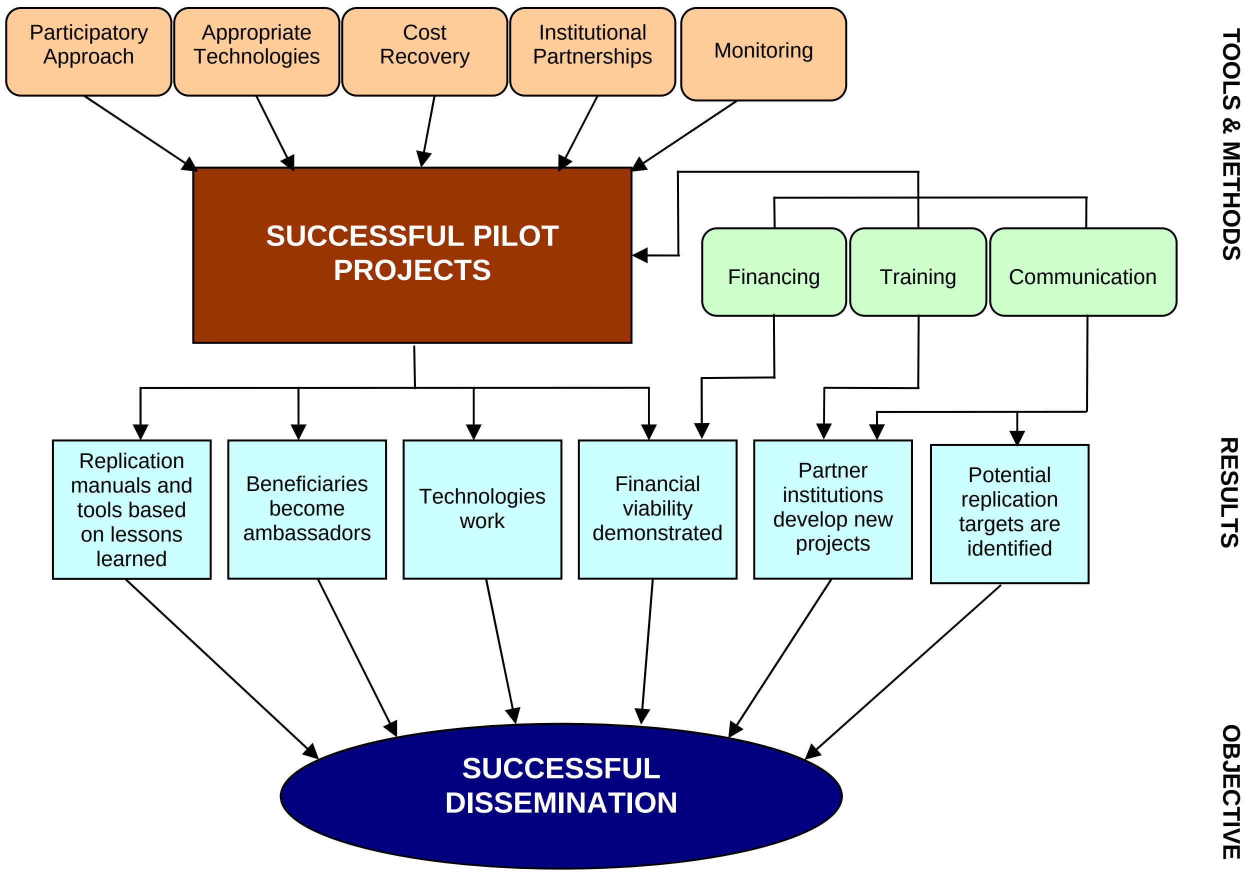
We envision that the Ministry of Environment will also be involved with the Meknes center in replicating the Nakhla soil erosion control project. The center should draw upon the resources of Ministry staff who worked on the Nakhla project with WRS since they are particularly qualified to serve as advocates for the replicated projects and to provide technical support as needed.

C. Dissemination Strategy

Knowing full well that the experience gained from the pilot projects would serve as a model for replicating successes in other areas of Morocco, the WRS team made a concerted effort to carefully document all phases of implementation from the very beginning. For each pilot project, we kept records documenting our participatory approach, the use of appropriate technology, the incorporation of cost-recovery elements, the establishment of institutional partnerships, and mechanisms to monitor progress.

In 2000, we prepared a comprehensive dissemination strategy designed to replicate the results of WRS pilot activities. The framework for this strategy is presented in Exhibit V-1 below.

Exhibit V-1. WRS Dissemination Strategy



D. Replication and Extension of WRS Activities Through the WPM Project

Our successes in the Nakhla watershed have provided a significant impetus for the replication of soil erosion reduction activities. This momentum is sustained by the continued interest among villagers to carry on implementation activities and the commitment of USAID, government agencies, and NGOs to build on the project's results.

In 2001, USAID/Morocco launched a new activity, the Watershed Protection and Management (WPM) project, to expand water management efforts in the Nakhla watershed and the Souss-Massa basin. The WRS team began implementation of this new project in October 2001. In the Nakhla watershed, the goal is to expand successful soil erosion control activities to the entire watershed, thereby reducing siltation of the Nakhla reservoir and prolonging its life. In Souss-Massa, our efforts focus on identifying, designing, and implementing new watershed protection activities to control soil erosion, reduce the spread of desertification, and protect water quality.

Nakhla watershed. Under WPM, we prepared a three-year plan for the extension of WRS activities to the entire watershed. We expect that the Agency for the Development of Northern Provinces will match the USAID implementation budget in the Nakhla watershed at a level of 1:1.

Souss-Massa basin. One of the components of the WPM project in Souss-Massa focuses on integrated watershed management. WPM will establish a pilot project to replicate the WRS project in the Bigoudine sub-watershed of the Abdel Moumin watershed. The Bigoudine sub-watershed was selected after two survey teams visited and evaluated several candidate sites in the upland regions of the Souss-Massa river basin.

The watershed management activity in the Bigoudine sub-watershed uses methodologies developed by WRS for soil erosion control in the Nakhla watershed. These methods include multi-disciplinary, multi-agency participatory approaches, direct involvement of farmers and villagers, rapid implementation of activities that directly or indirectly reduce soil erosion and increase water conservation, implementation of activities that generate additional income for participants, including women, and careful monitoring of indicators to assess progress.

SECTION VI

Lessons Learned

SECTION VI

Lessons Learned

From the start of the project, the WRS team documented lessons learned in the preparation, implementation, and dissemination phases of the project. In addition, we engaged project partners in workshops to discuss lessons learned from the pilot activities. The goal of these workshops was to share the perspectives of different partners and to help develop guidelines for replication.

A. Lessons Learned Workshops

Dokkarat. In May 2001, we held a workshop in Fez on lessons learned from the Dokkarat chromium recovery pilot project. The stakeholders, including representatives from the Ministry of Environment, the Wilaya of Fez, RADEEF, the Regional Directorate of Hydraulics-Fez, ONEP, the Ministry of Commerce and Industry, and the Urban Agency, reviewed project activities, successes, and failures, and formulated recommendations for successfully replicating the Dokkarat experience. A report documenting lessons learned will be made available to groups interested in replicating the pilot project.

Stakeholder participation was critical to successful design and implementation of pilot activities. Formal agreements with our partners helped clarify the specific roles of project stakeholders, including management and financial responsibilities. Strong political support from government officials, including the Wali of Fez, helped facilitate the cooperation of project beneficiaries.

Despite its successes, the Dokkarat project experienced significant delays in getting the plant up and running. This was mainly due to leaks in the sewage networks that were discovered after construction of the plant. After a few months of operation in the summer of 2001, we discovered that the chromium reaching the plant was diluted.

Drarga. We hosted a similar workshop in Agadir in May 2001 to formulate recommendations for replicating the Drarga wastewater treatment and reuse pilot project. Participants included representatives from the Ministry of Environment, the commune of Drarga, RAMSA, ERAC-Sud, Majestic (the subcontractor that built the plant), the Department of Health, and the ORMVA/Souss-Massa. A report documenting lessons learned will be made available to groups interested in replicating the project.

Community ownership, participation, and contribution were critical to successful design and implementation of pilot activities. As with the Dokkarat project, partners and stakeholders signed formal agreements detailing their specific roles and responsibilities. We received strong political backing from the Wali of Agadir and other government officials. This support helped our team promote the pilot project to beneficiaries as well as secure their trust and cooperation.

Nakhla. In November 2000, we held a workshop on the Nakhla soil erosion control pilot project, bringing together partners, stakeholders, and beneficiaries to review and discuss accomplishments and shortcomings, and to devise revised approaches so the replication process would be more successful. Information from the workshop, combined with input from the WRS team and consultants, was integrated into a lessons learned report, which will be made available to groups interested in replicating pilot activities.

At the institutional level, workshop participants agreed that project partners had gained valuable experience and confidence in implementing project activities. The project's multi-disciplinary, multi-institutional approach helped foster a spirit of cooperation among partners in several ways. For instance, involving stakeholders in the selection of project interventions facilitated their participation in actual implementation and made their joint financing easier to accept. Partly because project objectives were consistent with Moroccan priorities, WRS partners regularly engaged in joint financing of pilot activities. A good example of this congruity is money provided by DPA for labor costs associated with constructing cuvettes around planted olive trees, and by ADPN for the purchase of improved goats and beehives introduced in the Nakhla watershed.

However, our team encountered a number of difficulties in implementing the project, most notably the inability to restore any degraded public matorral lands and to institute rotational grazing management practices. These shortcomings were largely due to the fact that animal grazing in the matorral involves public lands, and villagers were unable to reach a consensus on how to improve management of those lands. There were also problems with the beekeeping program as a result of disease and lack of food caused by drought conditions.

B. Summary of Lessons Learned

The overall lessons learned across all three projects can be divided into four categories: (1) promoting participation, (2) conducting the feasibility study, (3) implementing the pilot project, and (4) disseminating results.

In *promoting participation* among project partners and stakeholders, our successes largely depended on the ability to:

- Convince local-level political leaders of the value and benefits of the project so they can become active supporters
- Involve relevant national institutions from the beginning of the project to facilitate coordination with local structures
- Ensure the local project partner has a strong interest in the success of the project
- Encourage the involvement of water users' associations, farmers, and the private sector whenever possible
- Prepare collective agreements that spell out in detail the roles and responsibilities of each partner

- Organize workshops, study tours, and site visits to showcase similar projects
- Take into account the role played by women in the areas of intervention
- Identify a common vision for the project among partners
- Ensure continuous capacity building through training programs

In *conducting the feasibility study* for each pilot project, our experience emphasized the need to:

- Analyze and use existing data to the extent possible
- Identify implementation options that are adaptable to local needs and to the capabilities of local institutions
- Conduct a cost-benefit analysis and retain those options that minimize costs with respect to benefits
- Conduct an additional analysis to optimize the costs of the selected option
- Perform a detailed assessment of cost recovery
- Include cost-recovery mechanisms in project design
- Conduct an environmental impact assessment and incorporate the recommendations of the assessment during project implementation
- Involve beneficiaries in the selection of project interventions
- Optimize the selection of the project site based on specific constraints (e.g., land ownership status, available space, type of soil, and whether pumping is required)
- Organize study tours to showcase similar projects
- Establish an institutional, financial, and technical framework for project implementation
- Develop indicators of performance and assess baseline conditions to measure the success of the project

In *implementing the pilot projects*, we learned that the following elements were critical for success:

- Prepare a detailed design of the pilot project
- If possible, engage the services of a local engineering firm to work with the U.S. design engineer on project design
- Validate the design with project partners prior to launching implementation activities
- Develop a realistic calendar for the execution of activities, taking into account local and cultural realities (e.g., holidays, Ramadan)
- Prepare a request for proposals tailored to local procurements and select local contractors; prepare a separate procedure for selecting U.S. equipment suppliers
- Prepare detailed and clear terms of reference
- Interview finalists to ensure they are qualified for the job
- Closely supervise the performance of the contractor
- Engage an independent engineer paid by the project to supervise the construction
- Develop training materials, operations manuals, and financial management guides
- Develop and implement a management plan with the key partner institution

In *disseminating results*, our experience stressed the need to:

- Develop a comprehensive dissemination strategy
- Document lessons learned during project implementation
- Develop training documents
- Prepare communication tools (e.g., posters, radio, television, brochures)
- Ensure that partner institutions are involved in disseminating best practices
- Use project beneficiaries as “ambassadors” for dissemination
- Prepare an orientation guide and provide training on financing options and fundraising

SECTION VII

Conclusion

SECTION VII

Conclusion

Between 1996 and 2003, the WRS project successfully implemented three pilot projects: a wastewater treatment and reuse project in Drarga; a chromium recycling facility serving the tanneries of Dokkarat in Fez; and a soil erosion control project in the Nakhla watershed in northern Morocco. As a result of these interventions, environmental conditions have considerably improved in the targeted areas.

In Drarga, more than 175,000 m^3 of wastewater is being treated and reused, resulting in reduced pollution of the Souss river and increased water savings for local farmers. Despite difficulties in setting up the chromium recycling plant, environmental conditions in Dokkarat have also improved due to reduced chromium discharges into Oued Fez. And in the Nakhla watershed, the efforts of the WRS team and its partners have significantly lowered soil erosion rates.

The WRS project has met or exceeded its goals with respect to the performance indicators set forth in its terms of reference. Moreover, it has ensured the success of its activities by actively seeking input from various stakeholders, including government ministries, communities affected by the pilot projects, NGOs, and the private sector. For each pilot project, our team used appropriate technologies and incorporated cost-recovery mechanisms to enhance sustainability.

Other efforts to promote the sustainability of pilot interventions included capacity building for local institutions through workshops, study tours, and a wide range of manuals, reports, and guidelines promoting better water management. Communication, marketing, and dissemination strategies developed by WRS will also contribute to successful replication of the pilot projects in other areas of Morocco.

The follow-on Watershed Protection and Management (WPM) activity, managed by Chemonics International, will add to our sustainability and replication efforts. Launched in October 2001, WPM focuses on disseminating best practices in the Souss-Massa area and on extending soil erosion control activities in the Nakhla watershed. Dissemination activities under WPM include an industrial pollution prevention and control project with the COPAG dairy in Taroudant, a wastewater treatment and reuse project in the commune of Sidi Bibi, and a watershed management project in the Bigoudine watershed. The early successes of these activities are largely due to the application of methodologies and lessons learned from WRS. In addition, the successes achieved under WRS helped secure early buy-in from WPM project partners and increased levels of partnerships and participation on the part of stakeholders.

WRS also made progress in the area of environmental policy reform. Our team helped the Ministry of Environment develop norms and standards for wastewater reuse and the release of chromium effluents in water bodies. In addition, our environmental impact assessment work with the Ministry of Environment led to the drafting of the National Law on Mitigating Environmental Impacts, which was approved by the Moroccan Parliament in 2002.

The WRS experience clearly demonstrates that the success of future projects will largely depend on active community and government participation, thorough feasibility studies, and careful project design. Even when project implementation requires a break from traditional ways of doing business, communication and dissemination strategies tailored to specific audiences can effectively convey the benefits to be derived from project activities, promoting buy-in from all relevant partners and stakeholders.

ANNEX A

Project Expenditures

ANNEX A

Project Expenditures

This annex presents the expenditures incurred by the WRS project from June 1996 to April 2003. Exhibit A-1 breaks down expenditures by contract line item (CLIN), which is the way the WRS contract was structured. As expected, most expenditures were for the implementation of pilot projects (CLIN 1) and for project management (CLIN 15). WRS implemented three pilot projects: the Nakhla soil erosion control project, the Drarga wastewater treatment and reuse project, and the Dokkarat chromium recycling project. On the project management side, expenditures cover the fielding of the long-term technical assistance team, support staff, office expenses, including office make-ready, the purchase and maintenance of five project vehicles, travel expenses for long-term staff, other direct costs, Environmental Alternatives Unlimited (EAU)'s general and administrative expenditures and EAU's fee.

Exhibit A-2 shows the breakdown of project expenditures between project implementation (44 percent), project management (36 percent), and consulting services (20 percent). The breakdown of non-management expenditures is illustrated in Exhibit A-3. The largest category of expenditures was for implementation of the Drarga wastewater treatment and reuse plant, which cost $2.6 million, including the feasibility study, environmental assessment, engineering design, and implementation. The Dokkarat chromium recycling project cost $1.9 million, and the Nakhla soil erosion control project cost $970,000. In other project areas, we spent $415,000 on policy issues; $500,000 on capacity building; $190,000 on dissemination activities; and $180,000 on public participation activities.

Exhibit A-4 shows the breakdown of consulting services undertaken by WRS. The largest expenditures were for feasibility studies (35 percent), short-term technical assistance (21 percent), professional development (12 percent), and community-based public awareness programs (9 percent).

Finally, Exhibit A-5 summarizes WRS expenditures by year. The first two years of the project (1996-1997) focused on project start-up and feasibility studies. In 1998, we engaged primarily in project preparation activities, and we organized three study tours to the United States. From 1999 to 2000, our efforts were mainly devoted to project implementation, where we incurred the highest levels of expenditures. In 2001 and 2002, we prepared dissemination and marketing strategies, reports on lessons learned, manuals and guidelines for the pilot projects, and policy support documents. In 2003, all project expenditures were devoted to completing the Dokkarat chromium recycling project.

Exhibit A-1. WRS Expenditures by CLIN

CLIN	Description	Total Expenditures	Percent
1	Project implementation	$4,723,579	44.00
2	Feasibility studies	$736,925	6.86
3	Environmental assessments	$65,679	0.61
4	Site-specific norms and standards	$81,692	0.76
5	Manuals and guidelines	$50,452	0.47
6	“Lessons leaned” reports on demonstration activities	$41,320	0.38
7	Marketing strategy	$29,682	0.28
8	Community-based public awareness programs	$182,078	1.70
9	Policy assessment study and report	$55,671	0.52
10	Policy framework and associated procedures	$13,179	0.12
11	Professional development plan	$252,713	2.35
12	Training materials	$137,617	1.28
13	Reports	$1,325	0.01
14	Short-term technical assistance	$449,343	4.19
15	Project management	$3,914,843	36.46
	TOTAL	**$10,735,843**	**100.00**

Exhibit A-2. Project Expenditures by Category

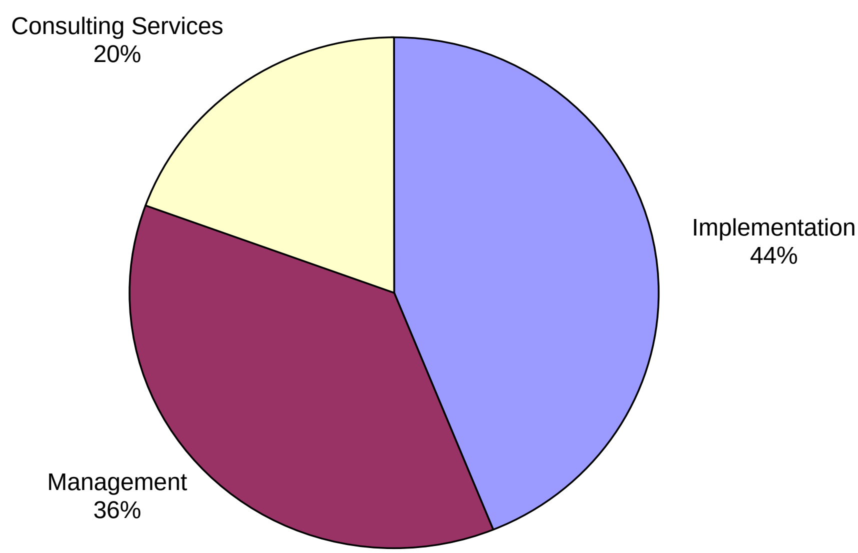


Exhibit A-3. Breakdown of Non-Management Expenditures

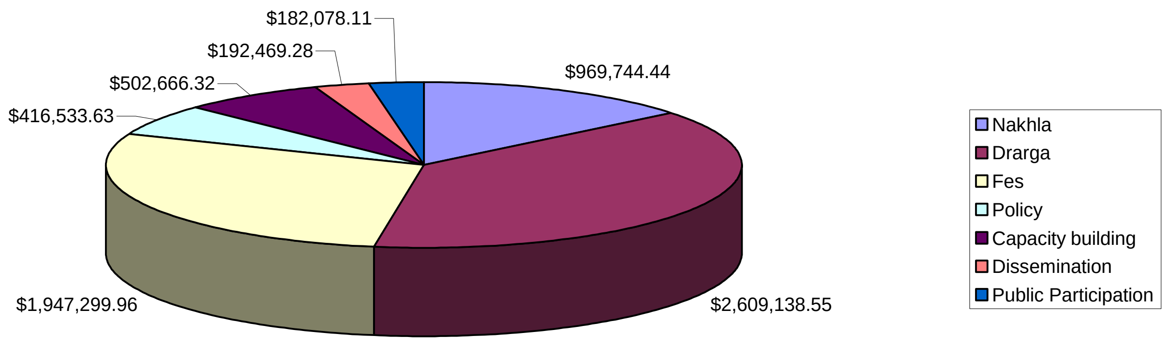


Exhibit A-4. Breakdown of Consulting Services

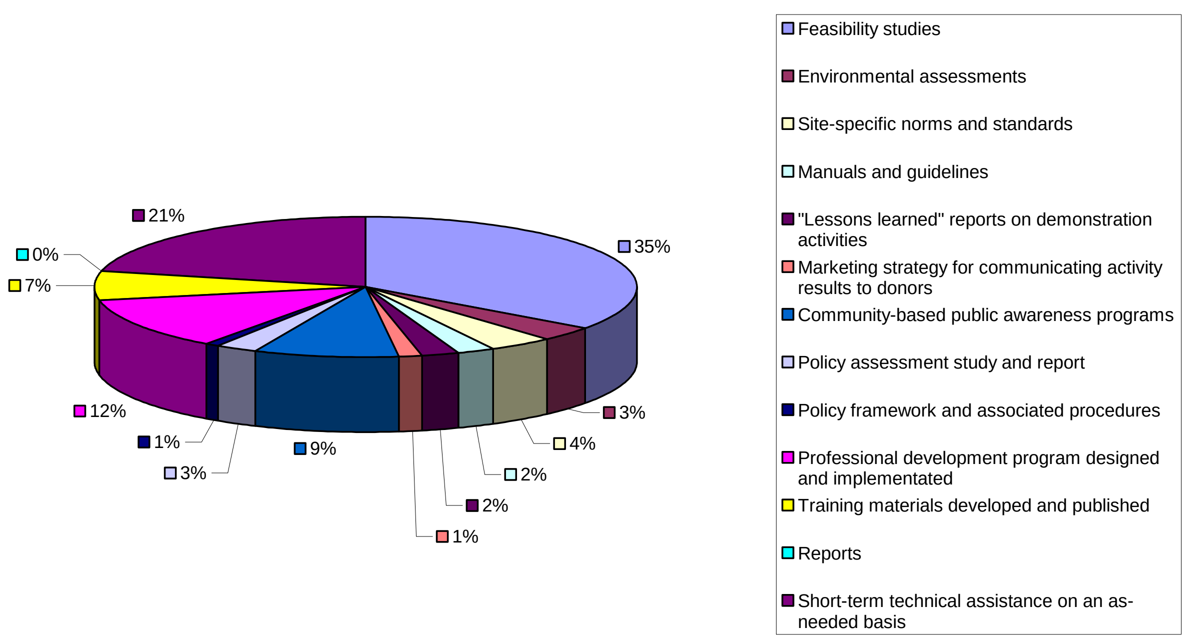
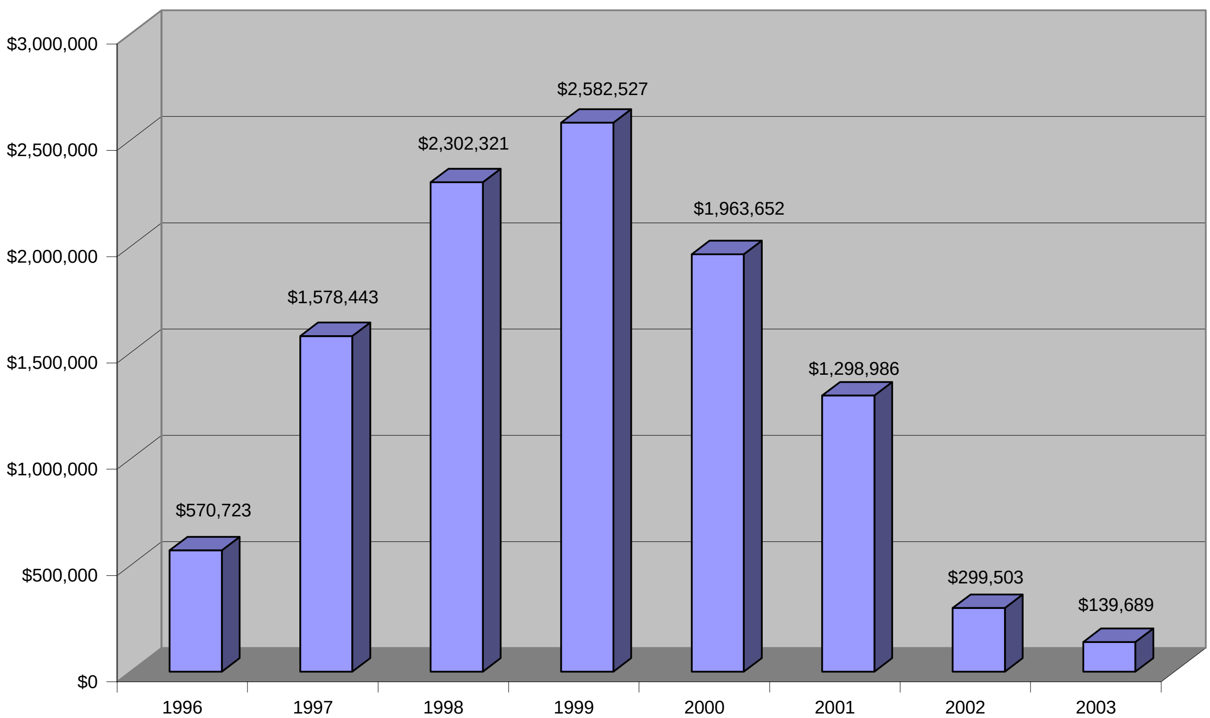


Exhibit A-5. Project Expenditures by Year



ANNEX B

Deliverables and Technical Reports

ANNEX B

Deliverables and Technical Reports

A. Deliverables Required by the Contract

1. Professional Development Plan Outline
2. An Assessment of Water Policy in Morocco and its Implications on the Water Resources Sustainability Project (English and French)
3. 1996 Annual Work Plan
4. 1996 Third Quarter Progress Report, July 15-October 15, 1996 (English and French)
5. 1996 Annual Report, May 1-December 31, 1996 (English and French)
6. Pilot Project for the Reduction of Chromium Discharged by the Tanneries in Dokkarat: Feasibility Study (English and French)
7. Pilot Project for Treatment and Reuse of Domestic Wastewater in Drarga: Feasibility Study (English and French)
8. Pilot Project for Soil Erosion Control in the Oued Nakhla Watershed: Feasibility Study (English and French)
9. 1997 First Quarter Progress Report (English and French)
10. 1997 Second Quarter Progress Report (English and French)
11. Environmental Assessment of the Drarga Wastewater Treatment and Reuse Pilot Project (English and French), Sana Hamady
12. WRS Life-of-Project Monitoring Plan (English and French)
13. 1997 Third Quarter Progress Report (English and French)
14. Environmental Assessment for the Pilot Project to Reduce Chrome in Wastewater Discharged by the Tanneries of Dokkarat, Fez (English and French), Sana Hamady
15. 1997 Annual Report, January 1-December 31, 1997 (English and French)
16. 1998 Annual Work Plan (English and French)
17. 1998 First Quarter Progress Report (English and French)
18. Detailed Engineering Designs of the Wastewater Treatment and Reuse Plant in Drarga, Stearns and Wheeler
19. Detailed Engineering Designs of the Chromium Recovery Plant in Dokkarat, Fez, Bennett & Associates
20. Equipment Procurement Bid Documents for the Drarga Wastewater Treatment Plant, Stearns and Wheeler
21. 1998 Second Quarter Progress Report (English and French)
22. 1998 Third Quarter Progress Report (English and French)
23. 1999 Annual Work Plan (English and French)
24. 1998 Annual Report, January 1-December 31, 1998 (English and French)
25. 1999 First Quarter Progress Report (English and French)
26. Potential for Replication of the Pilot Project and Development of a Handbook of Procedures: Oued Nakhla, David M. Swift
27. 1999 Second Quarter Progress Report (English and French)
28. 1999 Third Quarter Progress Report (English and French)

29. *Élaboration de valeurs limites pour les rejets liquides des tanneries au Maroc*, Avijit Dagupta and Paul Larochelle
30. 1999 Annual Report, January 1-December 31, 1999 (English and French)
31. 2000 First Quarter Progress Report (English and French)
32. 2000 Annual Work Plan (English and French)
33. 2000 Second Quarter Progress Report (English and French)
34. *Manuel d'exploitation et de maintenance de la station de Dokkarat* (English and French)
35. *Manuel d'exploitation et de maintenance de la station de Drarga* (English and French)
36. *Élaboration de valeurs limites pour la réutilisation des eaux usées en irrigation*, Dimitri Xanthoulis
37. Action Plan for Communication Support to the Replication of the Nakhla Soil Erosion Control Pilot Project, John Woods
38. Action Plan for Communication Support to the Replication of the Drarga Wastewater Treatment and Reuse Pilot Project, John Woods
39. Action Plan for Communication Support to the Replication of the Dokkarat Chromium Recycling Pilot Project, John Woods
40. 2000 Third Quarter Progress Report (English and French)
41. *Leçons à retenir du projet pilote de traitement et des réutilisations des eaux usées à Drarga,* Joseph Karam
42. 2000 Annual Report, January 1-December 31, 2000 (English and French)
43. *Leçons à retenir du projet pilote de contrôle de l'érosion des sols dans le bassin versant de Oued Nakhla,* Fouad Rachidi
44. 2001-2002 Work Plan (English and French)
45. 2001 First Quarter Progress Report (English and French)
46. 2001 Second Quarter Progress Report (English and French)
47. 2001 Third Quarter Progress Report (English and French)
48. Marketing Strategy for Dokkarat Chromium Recycling Pilot Project (English and French), John Woods
49. Marketing Strategy for Nakhla Soil Erosion Control Project (English and French), John Woods
50. Marketing Strategy for Drarga Wastewater and Reuse Pilot Project (English and French), John Woods
51. 2001 Annual Report, January 1-December 31, 2001 (English and French)
52. Guidelines for Implementing Pilot Projects to Sustain Water Resources in Morocco (English and French)
53. WRS Completion Report (English and French)

B. Reports Not Required by the Contract

1. *Réduction de la pollution industrielle de la ville de Fès : Rapport des pré-audits des tanneries de Dokkarat,* Said Bouanani and Driss Messaho
2. *Réduction de la pollution industrielle de la ville de Fès : Étude synthétique des données sur la pollution industrielle des tanneries de Fès,* Said Bouanani
3. *Mise en place d'un système de traitement et de valorisation des eaux usées et des boues résiduaires d'une commune pilote de la région d'Agadir : Étude préliminaire de diagnostic,* Brahim Soudi and Khalid Khallaayoune

4. *Mise en place d'un système de traitement et de valorisation des eaux usées et des boues résiduaires dans la commune de Temsia : Étude préliminaire de diagnostic,* Brahim Soudi and Khalid Khallaayoune
5. *Mise en place d'un système de traitement et de valorisation des eaux usées et des boues résiduaires dans la commune d'Oulad Dahou : Étude préliminaire de diagnostic,* Brahim Soudi and Khalid Khallaayoune
6. *Mise en place d'un système de traitement et de valorisation des eaux usées et des boues résiduaires dans la commune de L'Qliaa : Étude préliminaire de diagnostic*, Brahim Soudi and Khalid Khallaayoune
7. *Bassin versant de Nakhla : Caractéristiques physiques, hydrologiques et détermination du taux d'érosion*, M'Hammed Tayaa
8. *Atelier sur les méthodes participatives dans un bassin versant*, November 8-9, 1997, Meknes, Mohamed Mounsif, Fouad Rachidi, and Carla Roncoli
9. *Compte-rendu de l'atelier de formation "Analyse coûts-avantages des projets environnementaux" du 5 au 8 mai 1997,* Joseph Karam
10. *Compte-rendu de l'atelier de formation "Analyse coûts-avantages des projets environnementaux" du 12 au 15 mai 1997,* Joseph Karam
11. Cost-Benefit Analysis of the Chromium Recuperation Unit for the Tanneries in Dokkarat Industrial Park, Christine Bernardeau
12. An Assessment of Community Issues and Practices Related to Water in Two Souss Basin Communes: Drarga and Temsia, Elizabeth Bennour and Carla Boussen
13. *Étude pédologique du basin versant de Oued Nakhla,* Mustapha Naimi and Rachid Bouabid
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