Final Report

Tadla Resources Management

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TADLA RESOURCES MANAGEMENT

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TABLE OF CONTENTS

Acknowledgements		i
Executive Summary		iii
Résumé Analytique		vii
Lessons of Use to Future Projects		xi
SECTION I	INTRODUCTION AND PROJECT BACKGROUND	I-1
	A. Morocco: Accelerating Pressure on Resources	I-1
	B. The Tadla Resources Management Project	I-1
	C. The Project's Partnership with ORMVAT	I-3
	D. Overview of the Tadla Region	I-3
SECTION II	WATER VOLUME SAVINGS	II-1
	A. Improving Canal System Management	II-1
	B. Improved On-Farm Management	II-10
SECTION III	WATER POLLUTION REDUCTION	III-1
	A. Groundwater, Soil, and Water Quality Management	III-1
	B. Soil and Water Quality Monitoring Networks	III-1
	C. Groundwater Resource Model	III-2
	D. Nitrogen Fertilizer Management	III-2
SECTION IV	INTEGRATED PEST MANAGEMENT PROGRAM	IV-1
	A. Purpose and Goals of the Program	IV-1
	B. Program Methodology	IV-1
	C. Program Implementation	IV-2
	D. Agro-chemical Management	IV-3
	E. Program Sustainability	IV-4
SECTION V	WATER USER ASSOCIATION STRENGTHENING	V-1
	A. Water User Associations in the Tadla Irrigated Perimeter	V-1
	B. Background of Water User Associations in Morocco	V-1
	C. Overview of TRM's Approach to Water User Associations	V-2
	D. TRM Water User Association Activities	V-2
	E. Program Benefits	V-4
SECTION VI	DISSEMINATION OF TECHNOLOGIES	VI-1
	A. Technologies Disseminated Under TRM	VI-1
	B. Activities to Disseminate Technologies	VI-1
SECTION VII	PROGRESS IN WATER POLICY AND INSTITUTIONAL REFORM	VII-1
	A. Water Policy in Morocco	VII-1
	B. The TRM Project's Role in Supporting Reform	VII-1
SECTION VIII	TRM PROJECT ACHIEVEMENTS	VIII-1
	A. Overview of Project Achievements	VIII-1
	B. Achieving the Project Goal, Purpose, and Results	VIII-1
	C. Project Achievements in Six Areas	VIII-2
ANNEX A	PROJECT TARGETS AND PERFORMANCE BY INDICATOR	A-1
ANNEX B	TRM OBJECTIVE TREE	B-1
ANNEX C	TRM PROJECT REPORTS	C-1

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Executive Summary

Conceived by USAID/Morocco in cooperation with the Moroccan Ministry of Agriculture and implemented by Chemonics International, the Tadla Resources Management project (TRM) was designed to improve water management and protect the natural resource base supporting the agricultural sector in Morocco. From 1993 to 1999, the project helped ORMVAT — Office Régional de Mise en Valeur Agricole du Tadla — improve water management in Tadla's irrigated zone. In carrying out this mandate, the TRM project introduced new technologies, strengthened water user groups, and served as an effective advocate for policy and institutional reform within Morocco's agricultural sector. The project focused on achieving six results:

- Saving water through improved water management
- Reducing pollution through a reduction in excess nitrogen fertilizer use
- Protecting the environment through a program of integrated pest management
- Increasing public participation in water management through water user associations
- Producing environmental impact by disseminating appropriate technologies
- Developing institutional reforms through policy change

Project Achievements

TRM achieved significant results in all of the above areas. In addition, it introduced innovative technologies to improve Tadla's water management. Highlights of project achievements:

Increased water savings. TRM enhanced canal and on-farm water efficiency through irrigation planning models, geographic information systems, real-time weather and water-flow monitoring networks, and portable flow-measurement weirs. By increasing ORMVAT's computational capacity and linking it to real-time data collection, these tools enhanced the office's canal-management capabilities and saved 82 million cubic meters of water a year — enough to irrigate 10,000 hectares or supply 55 percent of Casablanca's annual municipal consumption.

Assisted by the TRM project, Tadla farmers can look forward to a future of improved water management.

The volume of water saved represents a value of $1.5 million annually at current ORMVAT irrigation prices ($.018/m^3). The potential irrigated land area represents a value of $20 million annually when comparing the difference between rainfed and irrigated productivity ($2,000/ha). When compared with the TRM project funding by USAID of $10.4 million over six years, the

benefits provide a most significant return on investment, and this applies to only one of several project benefits.

TRM's introduction of level-basin irrigation technology through laser-assisted leveling equipment increased yields, saved labor, and enhanced salt and nitrate management. The team trained two local firms to conduct laser land leveling. Now actively serving farms, the firms are developing 1,200 hectares of level basins a year. With 30 percent of Tadla's area suitable for the technology, on-farm annual water savings could reach 52 million cubic meters if level basins were installed whenever possible.

Reduced water pollution. High levels of nitrate in the groundwater have been attributed in part to heavy and untimely application of nitrogen fertilizer for crop production. The project diagnostic studies revealed an excess application of 1,800 tons in the Tadla irrigated perimeter. Changes recommended by TRM on fertilizer management at the farm level have greatly contributed to the reduction of excess nitrogen, which is a potential source of nitrate pollution of the groundwater. Excess use of nitrogen has been drastically reduced for both wheat and sugar beet crops. The total reduction of nitrogen for both crops amounted to 981 tons, a 54.5 percent reduction of the baseline value of excess nitrogen and more than double the established project target of a 25 percent reduction. Furthermore, reducing fertilizer applications has lowered costs for Tadla's farmers.

Integrated pest management. The project initiated integrated pest management to help Tadla's citrus and paprika farmers reduce pesticide use, helping to lower grower costs and reduce pest resistance. TRM provided pheromone insect traps and instructions on linking pesticide spray use to insect densities. Adopted by 198 citrus farmers, the techniques significantly reduced pesticide use on 50 percent of Tadla's citrus. Most farmers are now purchasing their own traps from businesses established under a private sector initiative. For paprika farmers, an endemic mildew, *Phytophthora capssici*, has kept many farmers from cultivating this high-value crop. TRM developed farming-practice guidelines to control the mildew, convincing 38 farmers to adopt the new practices. Other crops in the Tadla perimeter will be addressed by the Regional Agricultural Research Institute through an agreement with ORMVAT to expand IPM practices.

Water user associations. Working closely with ORMVAT's extension service, the project helped form water user associations that provide farmers with greater autonomy in managing resources. In the project's pioneering strategy, water quotas are determined each year according to crop area and water availability, with each farmer free to use his quota as he sees fit. This approach — much like a checking account that allows spending choices as long as an overall spending limit is respected — has increased local input in water management and encouraged billing transparency.

Technologies disseminated to other perimeters. TRM introduced 14 technologies/methodologies, including:

- Models for hydrologic, groundwater, hydraulic, and irrigation-demand forecasting
- Networks that track agro-climatic, groundwater, soil quality, and farm data
- Improved fertilizer application and integrated pest management

- Geographic information systems that integrate data to facilitate decision making
- Farm-level tools: level-basin irrigation, laser leveling, and portable weirs
- Water user associations that increase farmer participation in managing water

Other ORMVAs have already adopted portable measurement weirs, laser-leveled basins, geographic information systems, and the irrigation and hydrological planning models. The Repogle weirs have enjoyed particular success, with seven ORMVAs following Tadla's example and using the portable measurement devices. Strengthened through training and shared activities during the project, ORMVAT continues to actively disseminate many TRM-introduced technologies to other ORMVAs, ensuring their long-term sustainability.

Improved water policy framework. The team worked to improve the policy, regulatory, and institutional framework for ORMVAT activities. Project studies advanced understanding of water-pricing issues and paved the way for Morocco's decision to adopt a decentralized, water-basin approach to managing resources; TRM's water user association work also built support for decentralized resource management. The project also examined institutional efficiency issues, prompting ORMVAT to increase operational efficiency and financial autonomy.

Résumé Analytique

Le projet de Management des Ressources du Tadla (MRT), qui a été conçu par l'Agence Américaine du Développement International et le Ministère de l'Agriculture du Maroc pour améliorer la gestion des ressources irriguées au Maroc, a été mis en œuvre par la société américaine Chemonics International en collaboration très étroite avec l'Office Régional de Mise en Valeur Agricole du Tadla (ORMVAT) de 1993 à 1999. Afin d'améliorer la gestion de l'eau an niveau du périmètre irrigué du Tadla, le projet MRT a introduit de nouveaux outils technologiques, a renforcé la création d'associations d'irriguants, et a été un défenseur effectif des réformes politiques et institutionnelles dans le secteur agricole au Maroc. Le projet a focalisé ses activités en vue de réaliser ce qui suit:

- Un volume accru d'eau épargnée à travers une amélioration de la gestion de l'eau d'irrigation
- Une pollution réduite à travers la réduction des excès d'engrais azotés
- Une amélioration de l'environnement à travers l'adoption des pratiques intégrées de lutte contre les ennemis des cultures
- Une participation élargie du public dans la gestion des ressources en eau à travers le renforcement des associations d'irriguants
- Un impact environnemental accru à travers la dissémination des technologies appropriées
- Un progrès dans les réformes politiques et institutionnelles du secteur de l'eau.

Résultats du projet MRT

Des résultats significatifs ont été réalisés par le projet MRT conformément aux objectifs escomptés décrits ci-dessus. En plus, plusieurs technologies nouvelles ont été introduites et/ou développées par le projet en vue d'améliorer la gestion des ressources d'eau dans le périmètre d'irrigation du Tadla. Quelques résultats importants du projet MRT sont résumés dans les points suivants:

Grâce au projet MRT, les agriculteurs du Tadla peuvent anticiper un avenir de gestion d'eau amélioré.

Volume accru des économies d'eau. Le projet a contribué à l'amélioration de l'efficience du réseau d'irrigation à travers le développement des modèles de planification d'irrigation, du système d'information géographique (GIS), des réseaux de surveillance agro-météorologique et de mesure des débits en temps réel, et des déversoirs portables de mesure des débits. L'intégration de ces outils dans la gestion du système d'irrigation a rehaussé la capacité

de l'ORMVAT à améliorer la gestion de l'irrigation pour répondre de manière efficace aux demandes de plus en plus complexes des agriculteurs du périmètre. La capacité informatique puissante associée à une collecte de données en temps réel et les capacités de réponse rapides ont contribué à la réalisation des résultats ciblés du projet en matière d'économie de l'eau, qui est estimée à 82 millions de m^3 d'eau d'irrigation par an. Cela représente, par exemple, 55 pour cent de la consommation annuelle de la ville de Casablanca ou l'équivalent des besoins en eau de 10 000 hectares de cultures irriguées. A l'heure actuelle, ces économies sont allouées à une dotation d'irrigation supplémentaire des champs existants afin d'améliorer le taux d'intensification cultural. En appliquant le prix actuel de l'eau d'irrigation à Tadla (0.18 DH/m^3), on peut estimer que le volume d'eau économisé représente une valeur financière d'environ 15 millions de Dirhams par an. En utilisant la différence des valeurs de production entre l'irrigué et le bour, qui est estimée à 20 000 Dirhams/ha, on peut déduire que la valeur ajoutée par l'irrigation potentielle de 10 000 hectares supplémentaires représente une valeur économique de 200 millions de Dirhams par an. Ces économies, qui ne représentent qu'une partie des bénéfices réalisés par le projet MRT, constituent un revenu très significatif du don investi par l'USAID dans les activités du projet, notamment 10,4 millions de dollars américains (104 millions de Dirhams) durant six ans.

L'introduction par le projet MRT de la technologie de l'irrigation par bassin à fond plat par l'utilisation d'un équipement de nivellement assisté par laser a donné des résultats considérables au vu des économies d'eau réalisées, de l'amélioration des rendements, et des économies en intrants et en main d'œuvre. Les économies d'eau ont atteint une moyenne de 20 pour cent dans les parcelles où les bassins à fond plat ont été installés. En raison du grand intérêt suscité chez les agriculteurs, qui a dépassé la capacité de l'ORMVAT à offrir ce type de nivellement du sol, le projet a de ce fait aidé l'ORMVAT à développer le secteur privé pour fournir des services de nivellement par laser requis dans l'irrigation par bassin à fond plat. Il y a actuellement deux entreprises privées qui opèrent dans le Tadla avec des plans pour mettre en œuvre 1200 hectares de bassins à fond plat par année. Plus de 30 pour cent de la superficie du périmètre irrigué du Tadla est facilement adaptable à l'application des bassins à fond plat, ce qui engendrait des économies d'eau de plus de 52 millions de m^3 avec la généralisation de cette technologie à l'échelle du périmètre.

Réduction de la pollution de l'eau. Les niveaux élevés de nitrate découvert dans la nappe phréatique ont été attribués en partie à l'application massive et inopportune d'engrais à base d'azote pour la production agricole. Les diagnostics réalisés par le projet ont révélé des applications excessives d'engrais azotés, estimées à 1800 tonnes par an à l'échelle du périmètre. Les changements recommandés par le projet MRT pour la gestion des engrais au niveau des exploitations agricoles ont contribué à la réduction des excès d'azote pouvant polluer la nappe phréatique. L'utilisation excessive des engrais azotés a été réduite de manière radicale pour le blé et la betterave à sucre. La réduction totale de l'azote a atteint pour les deux cultures un total de 981 tonnes, ce qui constitue une diminution de 54 pour cent de la valeur de base de l'azote en excès. Cela a doublé la valeur de 25 pour cent qui constituait la cible prévue par le projet. La diminution de l'application des engrais a aussi contribué à la diminution du coût des intrants, qui est à l'évidence d'une grande importance pour les agriculteurs.

Lutte intégrée contre les ravageurs des cultures. Le projet MRT a introduit la technologie de la lutte intégrée contre les ravageurs des cultures dans le Tadla en vue de réduire le nombre

d'application des pesticides, réduire le coût des traitements par les produits chimiques, et retarder le développement de la résistance aux pesticides chez les ravageurs. Le programme du projet MRT comportait la distribution de pièges à phéromone et les instructions pour déterminer le seuil critique où le traitement est recommandé. Adoptée par 198 agrumiculteurs, la technique de lutte intégrée contre les ennemis des cultures a permis une diminution des applications de pesticides sur 50 pour cent des 7600 hectares d'agrumes cultivés à Tadla. Pour les producteurs de niora (piment), un mildiou résidant dans le sol, Phytophthora, a posé des grands problèmes et a limité le nombre d'agriculteurs adoptant cette culture rentable. Le projet MRT a développé des solutions culturales pratiques pour lutter contre le mildiou et a encouragé un total de 38 agriculteurs à adopter ces nouvelles approches. Il y a de bonnes raisons de penser que le programme de lutte intégrée contre les ennemis des cultures commence à prendre pied et continuera à se répandre dans les années à venir. La preuve réside dans la mise en œuvre d'une initiative privée locale pour la vente des pièges aux agriculteurs intéressés, le nombre accru d'agriculteurs qui ont acheté leurs propres pièges, et l'accord signé par l'ORMVAT avec l'Institut National de Recherche Agronomique pour poursuivre cet effort en vue de couvrir d'autres cultures.

Associations d'irriguants. Le projet MRT a aidé l'ORMVAT à former des associations d'irriguants afin de prendre un rôle plus grand dans la gestion du réseau d'irrigation. Une des spécificités de la stratégie adoptée réside dans le fait que l'ORMVAT met un volume d'eau prédéterminé à la disposition de chaque agriculteur appartenant à l'association pour l'affecter librement en cas de besoin. Ce volume est basé sur la superficie des cultures pratiquées et la disponibilité d'eau annuelle. L'approche de "carnet de chèques", qui permet aux utilisateurs de surveiller les quantités d'eau qui leur sont livrées, a en outre l'avantage de contribuer à l'instauration d'un esprit de confiance et de transparence concernant les questions relatives à la facturation de l'eau.

Technologies disséminées aux autres périmètres irrigués. Le projet MRT a introduit un total de 14 technologies/méthodologies, qui comprend:

- Modèles d'analyses hydrologiques, de la dynamique des eaux souterraines, de simulations hydrauliques, et de planification et de programmation des irrigations

- Réseaux de suivi des données sur l'utilisation des produits agro-chimiques, la qualité des eaux souterraines, et la gestion au niveau des exploitations agricoles

- Utilisation rationnelle des engrais azotés et des pratiques de lutte contre les ravageurs des cultures

- Système d'Information Géographique pour faciliter l'intégration et l'analyse des données

- Technologies au niveau de l'exploitation agricole: Bassins à fond plat, nivellement au laser, déversoirs portatifs de mesure de débits

- Formation d'associations d'irriguants pour renforcer la participation des agriculteurs dans la gestion des ressources en eau.

Parmi les technologies/méthodologies introduites au périmètre du Tadla, cinq ont été déjà adoptées par d'autres ORMVA. Ils ont inclus les déversoirs Replogle, les bassins à fond plat nivelés par laser, le Système d'Information Géographique, ainsi que les modèles hydrologiques et de planification des irrigations. Le déversoir portatif Replogle a connu un très grand succès avec des prototypes distribués à sept autres ORMVA afin de suivre l'exemple de Tadla et l'utiliser pour vérifier et contrôler l'eau livrée aux agriculteurs. Les diverses technologies ont été placées dans les mains capables du personnel de l'ORMVAT, qui ont été très bien formés et associés par le projet MRT à toutes les phases du développement de ces technologies. Ce personnel est capable d'utiliser ces technologies d'une façon très efficace et d'assurer davantage leur large dissémination, ce qui confirme la durabilité des réalisations du projet.

Amélioration de l'aspect institutionnel. Le Projet MRT a apporté l'assistance nécessaire à l'ORMVAT et au Ministère d'Agriculture à travers des études spécifiques visant à faciliter la formulation et l'application de réformes institutionnelles pour améliorer la gestion des ressources en eau au Maroc. Ces études comprennent des sujets en rapports avec la tarification progressive de l'eau, la décentralisation de la gestion de l'eau, le renforcement des associations des usagers d'eau agricole, et l'amélioration de l'efficacité opérationnelle et financière de l'ORMVAT.

Lessons of Use to Future Projects

TRM produced several lessons of use to future projects:

1. The key to success is local staff ownership of results.

TRM taught us that the single most significant sign of success is a local staff's enthusiastic use of project technologies and techniques. During TRM's final seminar, ORMVAT staff skillfully explained the technical aspects of technologies introduced under the project and fielded a number of questions, often complex in nature. Clearly, TRM had succeeded where so many other projects had failed: in passing a sense of investment and ownership from expatriate staff to local staff and counterparts. The enthusiasm that ORMVAT staff demonstrated for expanding project activities did not come about by magic. Rather, ownership of results was built day by day during project implementation, cemented by the project's attention to the details of training, close working relationships, and a strong foundation of mutual trust. The result: sustainable results beyond the life of the project.

2. Projects need time to produce sustainable results.

TRM's six-year duration was essential for building the technical and managerial skills necessary to sustain results over the long term. Early on, team members spent significant time developing strong working relationships with key staff; as the project progressed, TRM staff concentrated on building skills, understanding local issues, and reaching consensus on priorities and strategies with project counterparts. Momentum built gradually, with a critical threshold of technical skill, managerial expertise, and mutual understanding achieved in the project's fourth year. This process paved the way for achieving solid results during the project's final two years, with most significant achievements occurring in the project's last year. Achieving sustainable results is a time-intensive endeavor, built on training, relationships, and lessons learned from the failures and successes that take place along the way during implementation.

3. Projects benefit from an integrated expatriate and local staff.

Under TRM, a combination of American and Moroccan consultants worked with ORMVAT staff to carry out project activities. Most of the project's local consultants came from Morocco's university system — in particular, the country's agricultural institutes in Rabat, Meknes, and Agadir — and possessed great familiarity with local issues, culture, physical environment, and institutions. These consultant/professors, many with U.S. training, possessed a strong understanding of TRM-proposed techniques and technologies that was enhanced by the presence of world-class expatriate specialists on the project team. By blending local and expatriate expertise, a cross-fertilization took place that enhanced the quality of project outputs and provided the strong human-resource foundation required for truly sustainable results.

4. Productivity is enhanced through joint planning, management, and implementation activities.

TRM's four long-term team members worked side-by-side with ORMVAT staff in the organization's offices, an arrangement with benefits for both the project and ORMVAT. Sharing work space provided the team with immediate access to Moroccan colleagues, encouraging joint activities on a regular basis. For example, project and ORMVAT staff met weekly to clarify objectives, plan tasks, and establish priorities, thereby greatly improving project management. The close relationships that resulted from frequent joint activities facilitated major project tasks like annual work plan preparation. ORMVAT staff also realized benefits in the form of continuous on-the-job training over the project's six years, increasing technical expertise and boosting the staff's sense of ownership of project results.

5. Providing assistance in agriculture and resource management sustains economic growth.

With urbanization increasing worldwide, many donors and governments have shifted attention away from agriculture to focus on the problems and opportunities found in young, rapidly growing cities. While these issues are important, we believe that agricultural projects should continue to receive donor attention and funding. Agriculture plays a pivotal role in the world's economy, and sustained economic growth requires proper resource management. Therefore, developing more projects like TRM is essential for raising living standards over the long term.

For most low-income countries, agriculture remains the single most significant sector from both the economic and social perspective. Agriculture — usually the largest contributor to national economies — often employs a significant proportion of the population; in addition, agricultural products have allowed many developing countries to gain a strategic foothold in foreign markets. While efforts to diversify economies will continue, the agricultural sector generates economic and employment benefits that should not be ignored, lest they disappear.

Government and donors should pay particular attention to water management's critical role in sustaining agricultural sector profitability. The TRM project's focus on strong, effective water management should be repeated in future projects, both in the arid Middle East and worldwide. With agriculture the single biggest consumer — and polluter — of water, a healthy agricultural sector requires developing effective water-management practices and rationalizing the use of farm chemicals. Such improved practices will produce real benefits downstream, including stronger national economies, reduced water-treatment costs, and protected ecosystems.

The success of the TRM project is a testament to the fundamental importance of sustaining agricultural production through improved water management and environmental protection. The USAID/Morocco mission and the Government of Morocco are to be commended for designing the project and supporting it for six years to its successful conclusion. In our view, the technologies, techniques, and approaches that were so successfully used under TRM should be integrated into the design of USAID/Morocco's Souss-Massa project in Agadir as well as in water resource management projects worldwide.

SECTION I

Introduction and Project Background

SECTION I

Introduction and Project Background

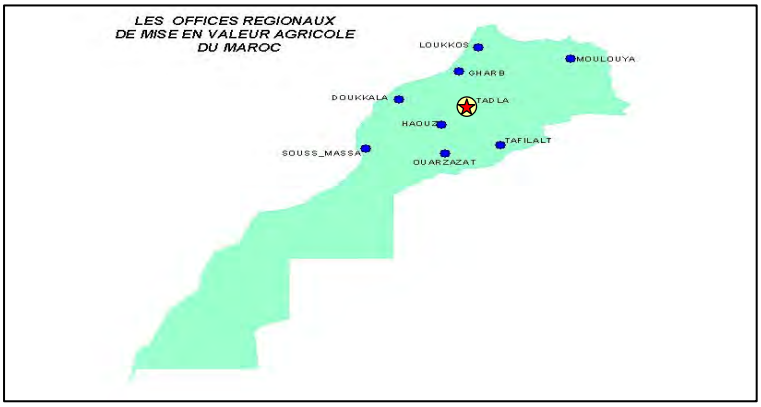
This report provides a final resume of achievements produced by the Tadla Resources Management (TRM) project. In addition to addressing all contractually determined tasks and results, it provides lessons learned during the six-year effort that may be applied to future projects.

A. Morocco: Accelerating Pressure on Resources

Like many countries, Morocco is passing through a crucible of technological, social, and economic change. New technologies, increasing competition, and a high degree of uncertainty characterize Morocco's markets, now firmly situated in the world economy. At the same time, the country's rapidly increasing population exerts constant pressure on its agricultural and ecological systems.

Such economic and population pressures — coupled with labor force changes and growing consumer expectations — have had a profound impact on natural resource and environmental management in countries like Morocco. These countries are learning that effectively responding to the challenges of rapid development and social change requires new approaches to managing natural resources. This is especially true in the case of water, traditionally viewed in Morocco as a sacred resource that must be shared.

Morocco's efforts to develop a national strategy for sustainable resource use should be based on the creation of an irrigated agricultural sector that is productive and competitive – and, at the same time, preserves the environment for the use of future generations.



TheTadla perimeter is one of nine major irrigation zones in Morocco.

B. The Tadla Resources Management Project

Conceived and developed by USAID/Morocco in cooperation with Morocco's Ministry of Agriculture, the TRM project was designed to improve water resource management and protect the environment in Morocco's critical agricultural sector. The project's geographic location was Morocco's second largest river basin, the Oum Er-R'bia.

Lasting from 1993 to 1999, the project had a budget of more than $14 million, with $10.6 million contributed by USAID. To ensure the sustainability of results, TRM activities involved the active participation of the project's institutional partner, the Tadla Regional Office for Agricultural Development (Office Rϑgional de Mise en Valeur Agricole du Tadla), widely known as ORMVAT.

After a competitive bidding process, Chemonics International was selected to provide technical assistance under the effort. Several subcontractors provided crucial assistance in carrying out project activities: Resource Management International, the University of California at Davis, Agridec, and the National Cooperative Business Association.

The goal of the TRM project was to promote the long-term competitiveness and environmental sustainability of Moroccan irrigated agriculture, while the project purpose focused on increasing the efficiency, economic yield, and environmental sustainability of irrigation resource management and use in the Tadla perimeter. To achieve this purpose, the project provided an integrated program of technology transfer, research and demonstration, institutional and private sector strengthening, and policy analysis. Project activities were designed to arrive at the following end-of-project results:

- Improved Tadla irrigation resources, conservation, and production practices
- Greater environmental sustainability of resource management and use in Tadla
- Increased private participation in Tadla resource allocation, management, and use
- Improved Moroccan irrigation resource management policy

Under USAID/Morocco's reengineered program, TRM was re-classified in 1995 as an environmental project, supporting strategic objective 2 (SO2): "Improved water resources management in the agriculture, urban, and industrial sectors."

Reengineering requires that projects develop appropriate, reliable, measurable indicators and realistic, achievable targets. For a project already two years old at the end of 1995, hard choices were made from the broad range of activities that served as deliverables in the Chemonics contract. After reengineering, project resource deployment focused on those activities that supported the SO2 objective of improved water resource management, as well as produce measurable results over the remaining life of the project. As a result, several planned or current activities were cancelled or modified due to time limitations or the need to focus on activities producing measurable results. Cancelled activities included:

- Addressing soil and water salinity
- Developing a dynamic groundwater model
- Addressing drainage problems
- Continuing private sector development for agricultural product marketing

Corresponding to the ethos of managing for results, the TRM project focused on achieving six specific results:

1. Saving water through improved water management
2. Reducing pollution through a reduction in the excess use of nitrogen fertilizer
3. Protecting the environment through a program of integrated pest management
4. Increasing public participation in management through water user associations
5. Producing environmental impacts through the dissemination of appropriate technologies
6. Developing institutional reforms through policy change

C. The Project's Partnership with ORMVAT

The project delivered technical assistance to ORMVAT, the responsible institution for irrigation in the Tadla plain, and one of nine large-scale irrigation schemes in the country. The project also provided significant assistance to other ORMVAs through training and the transfer of appropriate technologies.

ORMVAT, established in 1966, is a financially autonomous public enterprise under the supervision of the Ministry of Agriculture. ORMVAT is governed by an administrative council and a technical committee. Management responsibilities are undertaken by a director, assisted by five department heads, and a staff of 1,200 technicians and extension agents. ORMVAT's mission is to supply water to area farmers and manage the extensive canal network, as well as provide agricultural extension services to farmers.

D. Overview of the Tadla Region

D1. Geographic and General Characteristics

The population of ORMAT's zone of action is 560,000 inhabitants, according to 1994 census figures, of whom 120,000 are urban and 440,000 are rural. The irrigated zone includes 27,000 farms.

The Tadla irrigation perimeter is a gravity-fed system covering an irrigated area of 117,500 hectares.

The Oum Er-R'bia River runs through the entire length of the Tadla Plain, dividing it into two independent hydraulic regions: the Béni Moussa on the left bank and Béni Amir on the right. The average annual flow of the river is 37.4 m^3/sec., with a maximum of 1,700 m^3/sec. and a minimum of 7.6 m^3/sec.

The largest tributary of the Oum Er-R'bia is the El Abid River whose average annual flow is 32 m^3/sec., with an average maximum of 77 m^3/sec., and an average minimum of 10 m^3/sec. The perimeter of Béni Amir is irrigated by the deviation dam on the Oum Er-R'bia at Kasba Tadla which was constructed in 1929. The Béni Moussa perimeter is irrigated by the large Bin El Ouidane catchment dam on the El Abid River, which has a total capacity of 1,500 million m^3 with an effective storage capacity of 1,100 million m^3. Average annual rainfall is 350 mm. Groundwater consists of two aquifers: one near the surface and a second located much deeper. The total available water from this source is 440 million m^3, of which 132 million m^3 is now used.

On the next page, Exhibit I-1provides an overview of Tadla's general characteristics. As shown in the exhibit, a significant portion of Tadla's agricultural land is irrigated — some 117,500 hectares — with large-scale irrigation making up most of this total. Even so, rain-fed agriculture represents the majority of farmland.

Exhibit I-1. Characteristics of the Tadla Perimeter

Land Use in Tadla (in hectares)	
Irrigated land:	
Total irrigated area	117,500 ha
Large-scale irrigation	97,700 ha
Small- and medium-scale irrigation	5,000 ha
Wells	12,000 ha
Pivot	2,800 ha
Non-irrigated land:	
Rain-fed agriculture	137,500 ha
Forest	17,000 ha
Grazing land	28,000 ha

D2. Irrigation System, Farm Size, and Principal Crops

The irrigation system in Tadla is gravity-fed. However, pivot and micro-irrigation systems have been introduced in the perimeter requiring pumping. The length of the irrigation canal network is almost 3,000 kms in length and serves approximately 27,000 farmers working an area of 97,700 hectares.

Exhibit I-2 below provides data on farm size in the perimeter; as indicated in the exhibit, farms of five hectares or less account for the vast majority of holdings.

Exhibit I-2. Farm Size in the Tadla Perimeter

Farm Size	Percentage of Total Farms
0 – 5 ha	82%
5 – 10 ha	11%
> 10 ha	7 %

Exhibit I-3, found below, shows hectares planted in the region's major crops.

Exhibit I-3. Principal Crops in the Perimeter

Principal Crops (1998-99 Crop Year)	
Principal Crop	**Hectares Planted**
Fall Cereals	42,000 ha
Fodder Crops	21,000 ha
Sugar Beets	18,774 ha
Vegetables	6,542 ha
Olives	14,200 ha
Citrus	7,610 ha

SECTION II

Water Volume Savings

SECTION II

Water Volume Savings

The TRM project carried out two primary tasks under this indicator: upgrading Tadla's canal system and improving on-farm water management in the perimeter.

A. Improving Canal System Management

ORMVAT provides irrigation water to approximately 27,000 active farmers cultivating some 30 crops over an irrigated area of 97,700 hectares. To do this, ORMVAT relies on a 3,000-kilometer network of open, half-round irrigation canals, including 830 kilometers of principal and secondary canals. Given the large number of farmers served and the system's size, efficient water delivery requires advance programming, including estimating crop water needs and simulating water demand at the canal level.

The watershed of the Bin el Ouidane reservoir provides most of the TADLA perimeter's water.

At the project's inception in 1993, Tadla's irrigation system was hindered by numerous physical limitations as well as outmoded, inefficient operating procedures. TRM team members carried out several diagnostic studies to identify key constraints and focus project attention on pressing issues. The first of these studies, "Diagnostic Study of the Tadla Irrigation Perimeter" (Report 9), conducted in October 1994. The report, a system-wide diagnostic, provided the team with a thorough analysis of Tadla's existing irrigation system, pinpointing management and operational constraints.

Responding to the study's findings, ORMVAT undertook remedial measures that addressed shortcomings in physical maintenance. With project assistance, the office also developed management tools to improve the efficiency of canal system management.

Technologies introduced to the perimeter under the TRM project have significantly improved the operation of the perimeter's canal system. These technologies include:

- A computerized hydrologic model to analyze water-supply data
- Computerized irrigation planning and scheduling
- A real-time telemetric network that gathers agro-meteorological data
- Automated flow-monitoring stations linked to ORMVAT's central office

- Mobile monitoring units to provide on-site measurement of farm-level flows
- A computerized model to simulate canal hydraulics
- Geographic information systems that improve data analysis capabilities

Described in detail below, these technical innovations helped improve water delivery flexibility, reliability, and timeliness within the perimeter's canal system.

A1. Hydrologic Analysis of Water Supply

Upstream water resources play a key role in water management within the perimeter. Project team members quickly realized that improvements in hydrologic data management — including frequency analysis capabilities — were needed to accurately evaluate water availability in Tadla. Furthermore, analyzing water availability at different probability levels would help define critical water levels upstream in the perimeters of Béni Amir and Béni Moussa.

To achieve this end, a study conducted in the project's first year lay the foundation for the design of a computerized program to manage flow data related to the Bin El Ouidane dam and the Oum Er-R'bia river at Kasba Tadla.

When developed, the computerized program proved an effective, rapid tool for managing Tadla's hydrologic database. The interactive program — initially written in DOS format but later adapted to Windows — allows staff to update and edit data with ease; the program also supports the frequency analysis of average annual and monthly water flows. ORMVAT technicians quickly mastered the program, which has the further advantage of a structure in the form of independent modules, permitting future improvements. The program consists of two linked parts:

- The program's first part — a hydrologic data management program — is as an important tool for monitoring the upstream sources of the Béni Amir and Béni Moussa perimeters. It provides access to four databases: daily and monthly data for Bin El Ouidane, and daily and monthly data for Kasba Tadla. Several drop-down menus permit database manipulation. After selecting a database, the user can rapidly execute desired operations — e.g., update, edit, delete, and search a file — and print.

- The second element, a frequency analysis program, allows user to adjust monthly and yearly flow rates under various probability levels. The user can select the probability most applicable to the data or allow the program to choose the best fit automatically. The resulting analysis provides the following information:

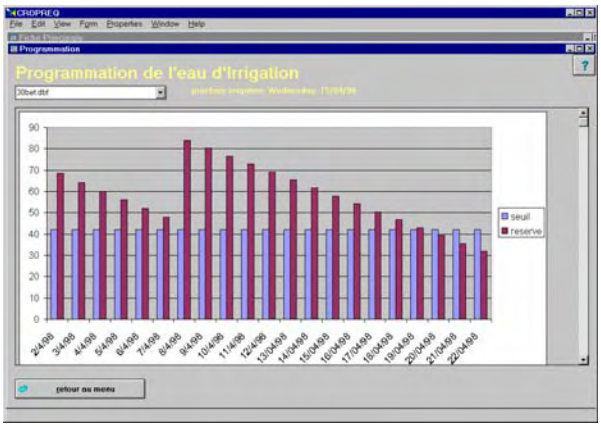
    - Statistical parameters for the observed series of flows
    - A graphic illustrating the degree of adjustment
    - A summary table of simulated flows for certain characteristic probabilities, with the corresponding confidence interval

When integrated into the perimeter's irrigation management modeling system, the hydrologic database program allows users to determine water intake frequency each month throughout the

irrigation season. Technicians can compare this result with observed intakes, providing information to optimize water use for the remainder of the season.

A2. Computerized Irrigation Planning and Scheduling

Working with ORMVAT, the TRM project developed the CROPREQ computer model to facilitate irrigation programming and scheduling. Based on Visual Dbase, CROPREQ was developed to estimate the water needs of specific land parcels under cultivation as an aid to irrigation planning, both before and after the irrigation season.



A computer model analyzes crop water needs, maximizing efficient, well-timed water delivery to farms.

The program identifies weekly and monthly crop water needs at the head of each irrigation system branch, determines the water flow necessary to satisfy those needs, and tabulates the effective flow of water in canals. To carry out analyses, CROPREQ relies on data files with the following information:

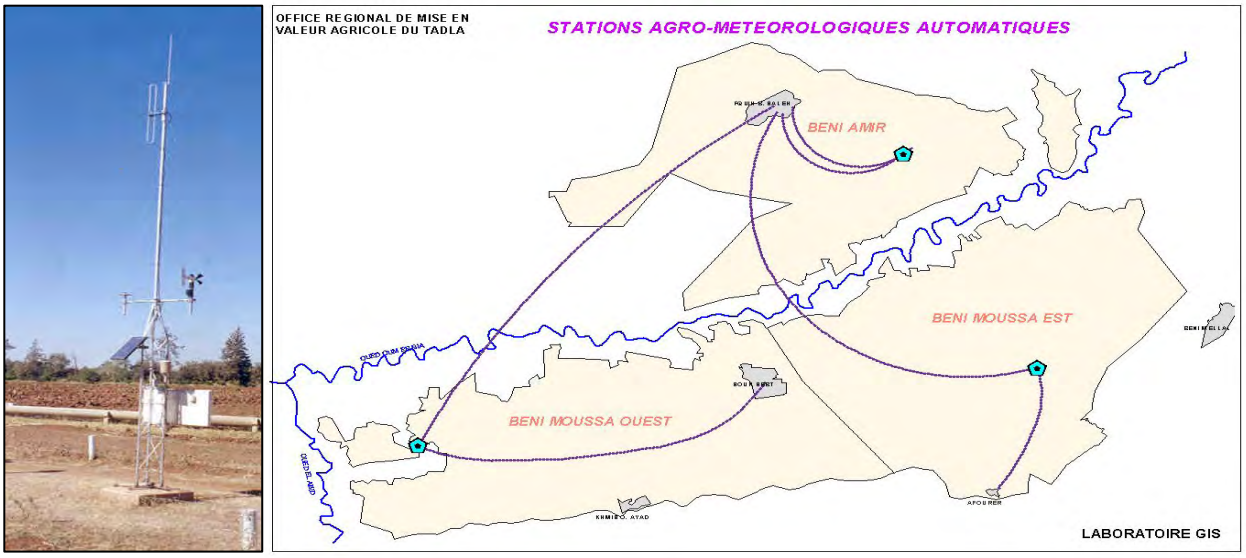
- Identification of each perimeter parcel, along with size and farmer's name
- Description of the crops and area planted on each parcel
- General agronomic information on crops, including crop water demand coefficient, vegetative periods, root depth, and date of seeding
- Daily and monthly weather data
- Actual and nominal capacities of irrigation canals

This program has helped ORMVAT improve water service and efficiency by delivering water when it is most needed. With the program, ORMVAT can develop water management plans at the beginning of each crop year that correspond to water availability, basing irrigation programs on crops' water needs and the soil's hydrologic properties. A program interface with the project's geographic information system – also developed by the TRM project – allows managers to compare calculated needs to actual consumption. As an additional benefit, the

program provides information that water user associations need to develop their own cropping plans.

A3. Agrometeorological Monitoring Network

In an area as vast as Tadla, estimating the water needs of crops requires accurate, up-to-date information on weather parameters. TRM project assistance in this area began with a study on climate spatial variability in the Tadla zone (Report 16). The project then installed three weather stations to automatically transmit real-time data by radio to the base computer in ORMVAT's



Three weather stations provide real-time data to assist technicians in calculating crop water needs.

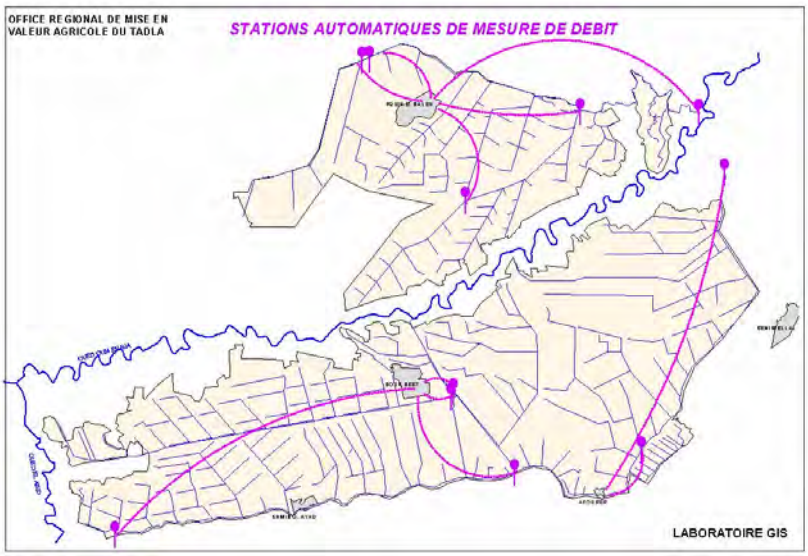
central office, as well as base computers in the perimeter's three management *arrondissements*. Functioning since 1996, these stations provide data that is used in several ways:

- Feeding data to the CROPREQ model to calculate crop water needs, thus allowing for more precise irrigation planning and programming
- Providing critical information for calculating degree-days, needed to control pests that damage crops
- Developing a database for use in agro-climatic studies, with data on climate information assessment, the influence of climate parameters on crop development, and other information

A4. Automated Flow-Monitoring Stations

Tadla's irrigation system moves large volumes of water, with flow that varies from 14 m^3/s at the main canal in Béni Amir to 42 m^3/s at the system's two principal canals, D and GM, located in Béni Moussa. ORMVAT officials charged with monitoring canal flow must coordinate activities with various partners; these include public works officials, National Office of Electricity managers in Béni Amir and Béni Moussa, and Haouz irrigation district officials.

To effectively control flow rate and coordinate management tasks, a reliable measurement system is needed to check the volume of water entering and leaving the system, as well as flow rate at key points along the canals. By increasing water savings through improved water management and transport efficiency, good measurement helps ensure stable, adequate water delivery; it also allows water managers to divide resources equitably among users of the Bin El Ouidane dam and Zidania basin.



Flow monitoring stations automatically send data to help engineers carry out efficient canal operations and water delivery.

To achieve accurate flow monitoring, the TRM project installed 11 automated flow-measurement stations, with 5 stations placed in Béni Amir and 6 in Béni Moussa. Through these stations, canal flow-rate data are automatically gathered and transmitted to a computer in ORMVAT's central office, as well as to base computers in the three management *arrondissements*.

As a flow-measurement tool, the stations use broad-crested weir measurement devices. Among its many advantages, this device creates a critical flow, allowing flow rate to be determined by simply reading a water height measurement above the crest, shown as pre-established tables. With a measurement error of 2 percent or less, the device provides real-time information on water flow transiting different nodes.

This information allows ORMVAT managers to better control the release of water for irrigation in Tadla and Haouz, while assisting National Office of Electricity officials in releasing controlled volumes of water for energy production. Automatically measuring water flow has improved water transport efficiency and reduced water losses downstream by reducing discharges and allowing safety siphoning. As a result, the project-installed devices have saved significant volumes of water.

ORMVAT has used this highly effective tool in managing Tadla's irrigation system since 1996. With the system, system managers can evaluate irrigation programs by comparing water volume data noted by on-the-ground personnel with measurements automatically recorded as water transited the canal system.

A5. Mobile Monitoring Units

Before the TRM project, farmers and ORMVAT water distribution personnel often disagreed on water-flow rate in the system's tertiary canals. To address the problem of accurate water-flow measurement at the farm level, the TRM project developed a portable-measuring device in 1994, basing the device's design on the broad-crested weir. This device offers several key advantages to farmers and water managers:

- Light, portable, and easy to use, it can be adapted for canals of different dimensions.
- It is accurate, with less than 2 percent error for flow rates higher than 10 liters/sec.
- The device is inexpensive and can easily be manufactured locally.

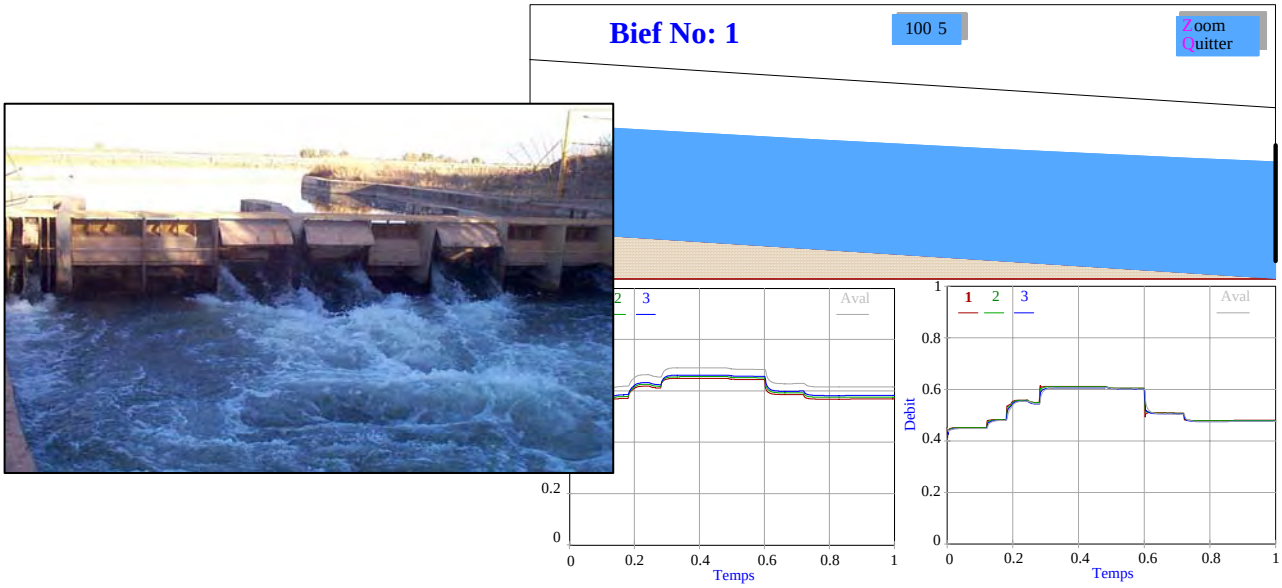
Replogel weirs — mobile water monitoring units — measure water volumes with precision, ensuring farmers receive allocated water.

Sets of the broad-crested weir — designed for flow measurement in semi-circular canals of 40, 50, 60, 70, 95, and 110 cm in diameter — were locally manufactured according to plans provided by the project, with prototypes of the device given to other ORMVAs. The project organized training sessions on using the device for managers and technicians from all ORMVAs.

Through these activities, the project created mobile brigades at the local management level — consisting of flexible, easy-to-use devices and trained operators — to control flow-rate fluctuations in the canal system. The project's work in this area has greatly contributed to improvements in water delivery through accurate measurement of water received by farmers.

A6. Computerized Canal Hydraulic Model

To improve water service, managers must possess a thorough understanding of a canal network's hydraulic functioning, including good data acquisition and modeling tools. In the case of Tadla, modeling principal canals provides useful information for managing the perimeter's overall network. This information is particularly useful when combined with automatically acquired data on the system's functioning — for example, by pairing hydraulic information with real-time data on water level at specified points in the system.



Canal flow modeling helps engineers verify flow and improve delivery efficiency.

Responding to water managers' clear need for better modeling tools, the TRM project adapted an existing, off-the-shelf model to Tadla's needs: the CanalMan model, developed by Gary Merkley at Utah State University. CanalMan — recommended by the TRM project's mid-term evaluation — proved to be an effective tool for simulating flow in regulated canals.

However, adapting the model to simulate Tadla's variable conditions required overcoming several challenges. For example, principal and secondary canal hydraulic functioning in Tadla is not completely under the system manager's control. With automatic regulators in the canals influencing water flow, substantial losses can occur as water flows through the system.

To fully account for the system's more unusual aspects — including the dependence of flow at the head of two of the system's principal canals, D and G — the project engaged a Moroccan expert to design a revised model to realistically simulate canals D and G. ORMVAT staff worked with the short-term Moroccan consultant to collect required data on the physical and operational characteristics of the system's three principal canals, D, GM, and G. A simulation model of canals D and G was developed in April 1999.

With the model, water managers can develop profiles of the water line and transit flows in each section of a canal; the model can also provide information on canal water regulators to verify functioning. The model can simulate flow-variation curves at the head of a 2,500-meter-long canal and the flow at the tail, as well as describe water elevation at either extreme.

The model allows canal system managers to optimize their use of real-time information on water volumes pumped into the system and flow divisions between the system's principal canals and lateral branches. With water consumption better quantified, perimeter water managers can organize and monitor water distribution more efficiently. ORMVAT plans to continue working

with the local consultant on calibrating the model to improve the canal system's hydraulic efficiency.

A7. Geographic Information Systems

ORMVAT possesses a large quantity of diverse spatial data on irrigation planning and programming, canal maintenance, and soil and water quality monitoring; this information requires continuous maintenance to meet users' needs. The difficulty involved in managing this spatial database by conventional methods justifies using new technologies to gather data and carry out analyses more efficiently and rapidly.

One such technology is the geographic information system (GIS), a geo-referenced computer tool that allows analysis of a rapidly changing relational database that is both spatial and tabular; the system also facilitates analysis of cartographic elements. Creating a GIS capability for ORMVAT — a TRM objective since the project was designed — was achieved in 1995 when a system was installed for the office.

Tadla's GIS hardware configuration consists of a network of two Sun Unix workstations (Sparc 20 and Sparc 5) and two Windows NT workstations, two summagraphic digitizing tables, two HP plotters, and two printers. The project installed the following software:

- For UNIX platform: ARC/INFO (2 licenses), GRID (1 license),TIN (1 license), and ArcView (1 license)
- For WINDOWS NT platform: ArcView (3 licenses), Spatial Analyst (1 license), Network Analyst (1 license), and 3D Analyst (1 license)

A powerful tool, Tadla's GIS laboratory supports water management decision making.

To ensure the system's continuous functioning, two full-time ORMVAT agricultural engineers and a computer technician run the office's GIS laboratory. In addition, a GIS working group within ORMVAT participates in designing databases and developing applications. ORMVAT uses the system to facilitate planning and rationalize water delivery to farmers. In addition, it helps planners monitor and evaluate the impact of agricultural activities on the environment, including tracking changing groundwater levels and soil and water quality.

Under TRM, GIS assistance included procuring and installing computer equipment and organizing short-term training programs for ORMVAT managers on the system's operation and uses. Training courses included:

- Introduction to UNIX
- Introduction to ARC/INFO/GIS
- The concept of database
- Data digitalization and production
- Introduction to AML programming
- UNIX system administration
- Introduction to ArcView/GIS
- Introduction to programming with ArcView (AVENUE)
- Introduction to Spatial Analyst/ArcView
- Introduction to Network/ArcView

Given the volume of existing data and the complexity of applying GIS methods to perimeter-wide irrigation planning, the project decided to first develop the application in a pilot zone. The zone selected, CDA 536, consists of 3,500 hectares and 1,079 farms. After developing a methodology for digitalizing the database by blocks, parcels, and networks in the pilot area, the project subcontracted digitalization of perimeter-wide data to a private GIS laboratory in the United States. All available data — relating to some 80 percent of the irrigated perimeter's total area — was digitized under this effort, making use of the methodology, results, and analyses already carried out in the pilot zone.

The GIS laboratory at ORMVAT has extended this work, developing programs that makes analytical and visual use of data to determine changes in groundwater and soil quality. The spatial and temporal analytical programs — developed to increase understanding of changing resource patterns under different environmental parameters — have resulted in maps that assist ORMVAT managers charged with tracking and allocating the perimeter's water resources.

The GIS team at ORMVAT has digitized the following databases: the perimeter's management and administrative boundaries, soil types within the irrigated perimeter, and a monitoring network for tracking groundwater movement and water and soil quality. For database applications on cropland use, soil characteristics, climatic factors, crop data, and irrigation system characteristics, the project developed an ArcView-based interface. The interface facilitates spatial visualization of the distribution of crop water needs, increasing user understanding of spatial variations by superimposing layers of other data. In addition, the interface helps planners carry out analysis of planned and completed water deliveries.

Developing GIS capabilities within ORMVAT was a highly successful part of the TRM project, demonstrating the important role that GIS can play in supporting irrigation planning and environmental monitoring. The following actions contributed to the success that GIS technology has enjoyed in Tadla:

- The project's decision to install state-of-the-art hardware and software and newer upgrades to accommodate rapid changes in technology

- Delivery of comprehensive training to ORMVAT personnel to ensure the appropriate use of GIS technology

- Project assistance in developing a competent GIS team within ORMVAT
- TRM's assistance in digitalizing and editing a spatial database covering the entire perimeter to support the work of ORMVAT's GIS group
- ORMVAT management's interest in GIS applications and support for project initiatives

B. Improved On-Farm Management

B1. Farm Enterprise Inventory, Typology, and Baseline Data

When well designed, farm enterprise surveys provide valuable information on the impact of development interventions and new technologies on rural economies. Farmers' access to production inputs — including irrigation water — affects farm management decision making. Farmers must consider such factors as the availability of canal water, access to groundwater, crop profitability, input cost and availability, and access to information on current agricultural and irrigation practices.

During TRM implementation, project personnel found that field studies on factors affecting decision making at the farm level strengthens water management in several ways. First, field studies supply information useful in developing targeted interventions to solve the problems impeding the adoption of new technologies. In addition, studies increase institutional awareness of farmers' needs, supporting ORMVAT's efforts to improve service.

The TRM project carried out agricultural field studies from the project's start. The first, a diagnostic study (Report 20), identified constraints to improving resource management at the farm level. In the study, a representative sample of 201 farms in the perimeter provided baseline data that TRM staff used to select project monitoring and evaluation indicators; the study also helped identify potential short-term improvements, useful in developing early project interventions. The study provided information on irrigation systems and planning, farming practices, vegetable and animal production, agricultural product marketing, and the role of women in farming activities.

The project selected a smaller sample of 30 farms for further interviews, producing a farm typology that included the following elements:

- General characteristics of categories of farmers in the perimeter
- Major constraints affecting each category of farmers
- Strategies employed in each category to overcome constraints and achieve potential

In conjunction with the 30-farm in-depth survey, the project conducted a special study on Tadla women's role in agriculture (Report 21). The study covered the emerging role of rural women in the region's agricultural economy and helped ORMVAT identify opportunities for enhancing women's participation in water resource management.

At the project's mid-point, TRM staff carried out another field study involving 150 farmers, producing information needed to evaluate the project's strategic performance indicators (Report 49).

Agricultural studies carried out over the life of the project strengthened team members' understanding of the management practices of Tadla farmers and produced a baseline of information on specific issues. The studies also provided the project with an opportunity to deliver on-the-job training to ORMVAT personnel in field study and analysis, a strong feature of TRM monitoring and evaluation.

B2. On-Farm Pilot Demonstration Activities

The project's early diagnostic studies revealed poor water efficiency at the farm level. In Tadla, inefficient water use primarily stems from the widespread use of the Robta irrigation method, which is practiced on 97 percent of Tadla's total irrigated area. Most Tadla farmers are forced to turn to Robta irrigation — which involves furrow flooding over a series of small basins — due to the poor state of field leveling.

Level-basin irrigation, developed with larger assisted levels, has produced average water savings of 20 percent and 30 percent yield increases in the irrigated perimeter.

The drawbacks of Robta irrigation include low water use efficiency, which ranges around 50 percent, far below an acceptable goal of 70 percent. In Robta irrigation, the duration of water flow into a parcel is 12 to 15 hours, at least 50 percent longer than ORMVAT's goal of 8 hours. Finally, Robta irrigation results in a 10 percent loss of available cropping area, due to the numerous furrows and berms needed to conduct the water; in another drawback, these furrows pose an obstacle to farmers who might otherwise consider mechanizing certain farming tasks.

To solve these problems, TRM project personnel worked with ORMVAT to introduce level-basin irrigation, increasing in-field efficiencies to as high as 80 percent. The approach taken by TRM team members involved minimal modifications to existing Robta micro basins: Under project supervision, existing basins were enlarged and leveled to a zero slope.

By introducing level-basin irrigation to Tadla, the project helped realize significant water savings through a low-cost technology, well suited to local skills, that farmers can readily understand and maintain. After four years of project trials on some 50 farms — and on all crops widely planted in Tadla — the following results were achieved:

- A 20 percent water savings
- A 30 percent increase in yield by uniformly distributing irrigation water on fields
- A 50 percent labor savings and 10 percent savings on inputs
- Protection of the environment by limiting fertilizer distribution to plant roots

To satisfy the growing demand for laser leveling in Tadla, the project supported the creation of two private land-leveling enterprises by former ORMVAT technicians. After furnishing the firms with the required laser equipment, TRM facilitated an agreement between ORMVAT and the enterprises to carry out laser leveling on 1,200 hectares a year. The two companies – AFRIT Nivellement and NAJIMI Nivellement — are currently carrying out land leveling in Tadla. By encouraging the private sector to provide laser-leveling services, the project helped sustain the water efficiency improvements that level-basin irrigation has brought to Tadla's farms.

B3. Information Dissemination and Outreach Program

To communicate information on new technologies and TRM activities, the project organized a number of meetings with Tadla farmers over the life of the project, covering virtually every aspect of the project. Other information dissemination and outreach program activities included:

- Workshops and field days organized by the project for farmers, extension agents, and professional organizations

- Visits paid by project personnel to other perimeters to explain and demonstrate selected technologies

- Project reports on a variety of topics, made available to all interested parties

- A technology report, brochure, and video produced to sustain information dissemination on project activities and new technologies

SECTION III

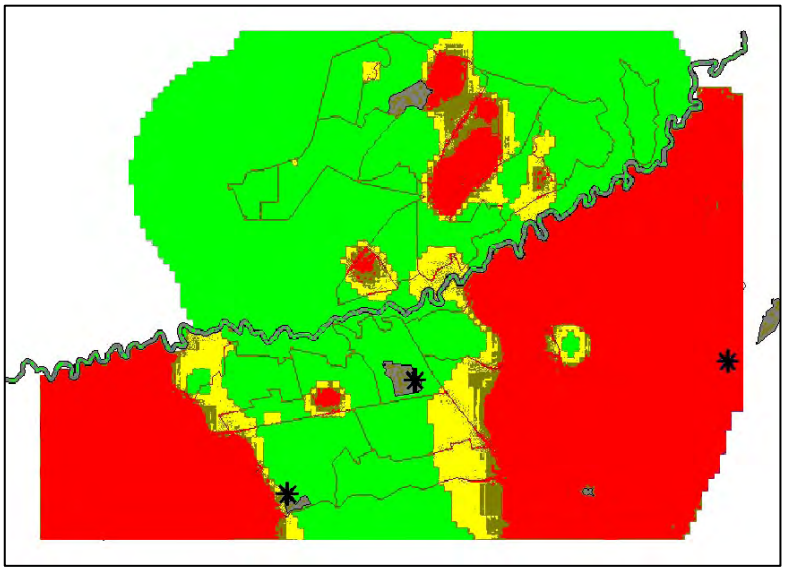
Water Pollution Reduction

SECTION III

Water Pollution Reduction

A. Groundwater, Soil, and Water Quality Management

In Tadla, increased surface and groundwater use, coupled with intensified farming and chemical pollution, has led to deterioration in soil and water quality. Tadla's natural resources have suffered the effects of increasing salinization, silting, soil structure deterioration, engorgement, and nitrate pollution.



A GIS map showing pollution "hot spots" provides support for farm management decision making.

To address these issues and reduce water pollution in the perimeter, TRM project activities included developing soil and water quality monitoring networks, creating a groundwater resource model, and managing nitrogen fertilizer use.

B. Soil and Water Quality Monitoring Networks

In 1994, TRM carried out a diagnostic study on Tadla's environmental characteristics; the project also evaluated ORMVAT's system for monitoring groundwater levels and water and soil quality. Responding to recommendations that emerged from the studies, project personnel introduced an integrated network to allow ORMVAT to track groundwater levels, monitor nitrate and salinity levels in groundwater, and evaluate the impact of agro-chemicals on soil quality. Monitoring points for the network were selected to ensure full spatial, agro-pedological, and hydro-geological representation. The network included:

- 100 wells geo-referenced to measure groundwater depth and chemical quality
- 40 sites for monitoring soil quality
- 47 typical farms to analyze quantitative and qualitative agro-chemical use

After the network's installation in 1995, ORMVAT Environment Office staff began periodic sample collection and network data analysis. As part of the process, staff members enter monitoring data on water and soil quality, including groundwater nitrate levels, into the ORMVAT geographic information system database. The office's geographic information system laboratory, established by the TRM project, produces temporal and spatial analyses of

monitoring data in the form of maps, including the cartographic boundaries of vulnerable zones. The completed maps — which describe the current status as well as trends for various environmental parameters — are provided to personnel charged with interpreting network data for ORMVAT managers.

By analyzing network data, ORMVAT technicians can identify water pollution sources as well as pinpoint zones most at risk. A powerful management tool, the geographic information system has a variety of other applications that ORMVAT staff members are currently exploring.

C. Groundwater Resource Model

The intensive agriculture practiced in the Tadla plain has had a profound impact on aquifer recharge and quality. Factors contributing to the degradation of aquifer water quality include the following:

- Use of water from the Oum Er-R'bia river, with a natural salinity exceeding 1.7 g/L
- The recycling of groundwater fed by agricultural drainage
- The rise of groundwater levels

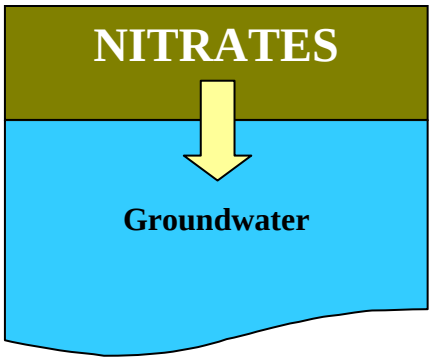
Given the prominent role of groundwater degradation in Tadla's water pollution, TRM staff concluded that improving ORMVAT's decision-making capabilities required an effective tool for modeling the impact of groundwater degradation. In early 1996, the project took the MODFLOW hydro-geologic model, originally developed in the United States, and adapted it to local conditions. The model evaluates the aquifer's response to such irrigation practices as pumping, irrigation, precipitation, and infiltration. It can also be used to preview the impact of management actions on groundwater levels, making it easier for water planners to plan strategies for addressing the problem of rising groundwater.

ORMVAT has used the model to determine aquifer hydro-geologic parameters, including transitivity and storage co-efficiency; office technicians have also used it to visualize groundwater levels at given moments within a steady state. ORMVAT engineers are continuing the model's development: By expanding the model's capacity for incorporating data and extending its capability to simulate transient conditions, ORMVAT is working to improve the tool's accuracy and usefulness within Tadla's complex hydro-geologic environment.

D. Nitrogen Fertilizer Management

Tadla's industrial and agricultural sectors have both contributed to environmental deterioration. Industrial pollution tends to be more spatially localized than agricultural pollution, which is often difficult to trace back to specific farming practices due to its diffuse nature. Manufactured fertilizers and new plant varieties have improved agricultural production worldwide; to achieve and sustain these increases, farmers have turned to the intensive use of agricultural inputs like water, fertilizer, and pesticide. The negative ecological effects that have appeared in Tadla and other places as a result of intensive input use are a cause for concern.

Agriculture's negative impact on the environment is exacerbated by a lack of understanding of proper input use among many farmers. Assuming that "more is better", farmers often add extra



Improved fertilizer application rates have resulted in significantly reduced groundwater pollution and increased yields for selected crops in the irrigated perimeter.

fertilizer or irrigation water in an effort to boost production. Heavy applications of nitrogen fertilizers — required when crops are over-irrigated — causes excess nitrates to leach into groundwater, worsening pollution. This is precisely the scenario that has unfolded in Tadla, where households that depend on local well water are subject to the potentially toxic effects of nitrate, which is especially dangerous for infants.

To counteract practices that waste resources and pollute the environment, TRM project personnel worked with ORMVAT's technical services to develop a strategy for disseminating a series of on-farm fertilizer management practices that improve crop yields while reducing the danger of nitrate groundwater pollution. A program of research and extension produced the following results:

- Recommendations on fertilizer use for Tadla's dominant crops of wheat and sugar beets, based on the crops' nitrogen fertilizer requirements
- Field trials, conducted on volunteer farms, comparing the profitability of crops receiving recommended fertilizer dosages with crops grown under typical conditions
- Extension of trial results throughout the perimeter

The project field trials, carried out from 1996 to 1997, demonstrated that crop nitrogen requirements could be reduced 20 to 30 percent by the judicious application of nitrogen-based fertilizer. At the same time, the trials indicated that controlled fertilizer dosing increased crop yields and reduced available nitrate that could leach into groundwater. The trials provided clear evidence that controlling fertilizer use produced important benefits for farmers — namely, increased crop yields and reduced input costs.

ORMVAT extension services extended the fertilizer management program in the 1997-1998 season to reach 1,048 sugar beet and wheat producers, cultivating 1,423 hectares of sugar beets and 2,350 hectares of wheat. Nitrogen use was reduced by 180.6 tons — in other words, 10.1 percent of total excess nitrogen in the perimeter. At the same time, farmers experienced a 24 percent increase in yield for sugar beets and a 35 percent increase in yield for wheat.

With project assistance, ORMVAT extended these results throughout the perimeter during the 1998-1999 season; project and ORMVAT personnel focused on sugar beet producers, covering a total of 18,685 hectares. To carry out this program effectively, the project helped broker an agreement between ORMVAT, the Sugar Factories of Tadla, and the Sugar Beet Producers Association to put a new fertilizer formula into the hands of Tadla's sugar beet farmers. The new formula — di-ammonium phosphate: 18-46-0 — was applied as a pre-planting fertilizer to the perimeter's entire sugar beet acreage.

During the 1998-1999 season, total nitrogen reduction for wheat and sugar beets totaled 981 tons, 54.5 percent of the baseline value of the perimeter's total excess nitrogen. This result was more than twice the project's performance indicator of 25 percent, an established project target.

SECTION IV

Integrated Pest Management Program

SECTION IV

Integrated Pest Management Program

A. Purpose and Goals of the Program

Integrated pest management — known as IPM – is a series of pest-management methodologies that reduce pesticide applications and lower chemical control costs in farming. Curbing excess pesticide use also reduces the incidence of pest resistance and favors natural processes in regulating pest populations. An important project component was TRM's work with ORMVAT to develop sustainable environmental management practices within Tadla's irrigated perimeter.

By allowing farmers to reduce pesticide use, integrated pest management has reduced pollution and raised farm incomes.

At the project's inception, mounting pest problems had led farmers to relay heavily on pesticides to grow Tadla's principal crops. As pesticide resistance increased and new pests appeared, pesticide use continued to climb, but the effectiveness of many sprays declined. By introducing IPM technology to Tadla in 1996, the project aimed to reduce pesticide applications, reduce chemical control costs, slow pesticide resistance, and promote a natural equilibrium among the perimeter's pest populations.

B. Program Methodology

Under the program, project IPM specialists targeted two crops: citrus and sweet red peppers, locally known as niora. Citrus is produced on 7,600 hectares in Tadla, farmed by 833 producers. For citrus growers, pest-control priorities are the California red scale, known locally as *pou de Californie*, and to a lesser extent, the Mediterranean fruit fly, known as *cératite*. As for niora, up to 12,000 farmers devote at least some land to this crop, which covers 4,500 hectares within the irrigated perimeter. Major niora pests are aphids, which trigger viral infections, and *Phytophthora capssici*, a mildew that can destroy entire crops.

The IPM methodology is based on the careful monitoring of pest populations by means of pheromone traps to determine if a critical threshold is reached that requires spraying. In the case of the California red scale, IPM uses the degree-day method to determine when the insect is most

vulnerable to pesticide. By tracking degree days, ORMVAT can gather information it needs to issue agricultural bulletins advising farmers to start spraying if their traps show that the insects have reached a critical threshold.

C. Program Implementation

Highlights of IPM program implementation included:

- Each citrus and paprika farmer participating in the project's IPM network received enough traps to monitor pest populations over two hectares. At first, extension agents supervised trap installation, population monitoring, and insect identification, with agents teaching the new techniques to farmers. However, project staff soon realized that the extension service lacked the staff to carry out day-to-day trap installation and monitoring, while carrying out its primary task of disseminating technology to all producers in the area. The project's decision to stress farmer self-sufficiency allowed agents to focus on technology dissemination, increasing environmental benefits.

- The project's IPM program was supported by activities in communications and information dissemination, including several informational programs on IPM practices organized by the project for farmers and ORMVAT technicians.

- To provide technical support to farmers and extension agents in the field, the TRM project published two technical guides, which were widely distributed. One guide, written in French, provides information on identifying and managing citrus pests. The other, in Arabic, walks farmers through the trapping and surveillance process, emphasizing the need to wait for ORMVAT's notice before starting to spray.

- During the 1997-1998 season, TRM surveillance traps for monitoring California red scale populations helped reduce pesticide applications by one or more treatments on 70 percent of participating citrus farms. During the 1996-1997 season, the project IPM network covered 37 percent of citrus within the irrigated perimeter. During the 1997-1998 season, this figure reached 57 percent.

- For Tadla's paprika producers, pest control is complicated by the widespread presence of the mildew *Phytophthora capssici*, a major phytosanitary problem for this crop. To fight the mildew, found in soil throughout the perimeter, the project recommended changes in farming practices, including limiting irrigation, to correct conditions encouraging the development of this disease.

- During the 1997-1998 season, 105 farmers participated in the TRM-sponsored citrus and paprika networks. In 1998-1999, involvement in the program increased to more than 230 farmers.

To assist in implementing the program and gain competency in IPM methodologies, 34 ORMVAT extension agents carried out pest-management activities and received project training in IPM methods. ORMVAT appointed three coordinators to supervise agents' work in Béni

Amir, Ouled M'barek/Afourer, and Souk Sebt/Dar Ouled Zidouh. The number of agents increased to 41 during the 1998-1999 season.

D. Agro-chemical Management

In addition to posing a serious hazard to the ecosystem, farm chemicals endanger farmers' health when used improperly. In 1994 the project evaluated agro-chemical practices, including practices relating to the distribution, storage, and use of chemicals. While noting a lack of hard data on agro-chemical practices in the area, the study found significant weaknesses in the enforcement of regulations on agro-chemical labeling, storage, and handling (Report 17).

In 1995 the project formed a network, composed of farmers and other interested parties, to monitor the agro-chemical distribution chain, with a special effort to identify precautions needed to safeguard human health and protect the environment (Report 33). The project carried out training sessions and field demonstrations to educate extension agents and farmers.

E. Program Sustainability

Three solid indications demonstrate that project efforts to disseminate and sustain IPM technology have met with success.

- First — and most important — was the establishment of Agro-Spray in Béni-Mellal in 1999. Providing traps and pheromones, Agro-Spray was established by a former graduate student of the project's IPM expert who had assisted TRM staff in carrying out IPM field research in Tadla. With the establishment of Agro-Spray, producers need no longer depend on the TRM project or ORMVAT to procure traps.

- In 1999 nine producers purchased additional traps to cover all of their acreage, amounting to 2,000 traps and pheromones to cover 600 hectares. This totals nearly twice the number of traps that the project provided during its IPM program.

- ORMVAT signed an agreement with INRA to continue and extend applied IPM research in Tadla. This effort, funded by the World Bank-funded PSDA project, will include maize, olives, alfalfa, and sugar beets, as well as citrus and niora.

SECTION V

Water User Association Strengthening

SECTION V

Water User Association Strengthening

A. Water User Associations in the Tadla Irrigated Perimeter

To meet a TRM strategic objective, team members worked with ORMVAT staff to increase farmer participation in viable water user associations — that is, water user groups that help maintain and manage irrigation systems. Effective water user associations are clearly needed in Tadla, a region characterized by the following features:

- Designed for collective use, the structure of Tadla's irrigation system requires extensive dialogue with users to implement the government's new crop-selection policies.

- In the absence of associations, Tadla's large number of irrigation water users — 27,000 farmers — makes consultation with individual farmers impractical.

- The region's 2,630-kilometer irrigation system — a complex, government-held enterprise that requires concentrated technical management — leaves little room for micro-managed water delivery on the plot level.

B. Background of Water User Associations in Morocco

In Morocco, water delivery has traditionally fallen under the purview of each region's ORMVA (Office Rϑgional de Mise en Valeur Agricole), which maintains sole responsibility for allocating and delivering water from the system's main canal to the fields of individual farmers. Charged with operating, maintaining, repairing, and rehabilitating entire irrigation networks, many regional offices have been reluctant to share management responsibilities — even when faced with the complexities of supervising water delivery down to the field level.

Morocco's centralized framework has relegated the farmer to the role of user, with little or no participation in resource management decisions — a situation commonly found in countries that lack institutional frameworks to support dialogue between institutions and individuals.

During implementation of the World Bank-financed Improvement of Large-Scale Irrigation project (PAGI), a legal foundation for establishing user associations was provided by the adoption of Law No. 02-84 (Dahir No. 1-87-12 of 3 Joumada II, December 21, 1990). After passage of the law, which authorized the formation of water user associations, regional ORMVAs began to experiment with increasing stakeholder participation in water management by organizing water user associations. But these attempts were thwarted by inconsistent national policies and a deeply ingrained reluctance to alter traditional roles.

C. Overview of TRM's Approach to Water User Associations

TRM's well-timed water user association activities — which coincided with national policy changes that included crop-selection liberalization and a central government decision to disengage from local-resource decision making — succeeded where other efforts had failed. Morocco's recent efforts to decentralize resource management received a significant boost from the project's activities.

The pioneering strategy developed by TRM and ORMVAT involves the following steps:

- Water planners determine the water quotas of individual farmers by crop area and water availability during a yearly cycle.

- Water user association members use a water "checkbook," which allows each farmer to draw down his quota as he sees fit. Through this approach, farmers are directly involved in scheduling and delivering irrigation water to individual parcels.

- To formalize relationships, a water sales contract detailing rights and responsibilities is drawn up between each association and ORMVAT.

During TRM implementation, ORMVAT evolved into a firm supporter of increasing farmer participation in resource management through water user associations. Assisted by TRM-sponsored activities and training, ORMVAT has since assumed a leadership role in association development among Morocco's irrigation perimeters.

D. TRM Water User Association Activities

D1. TRM Assistance in Association Formation

Association formation in Tadla was preceded by a TRM diagnostic study of the entire perimeter, including hydraulic, technical, and ethnic factors, to define water user association boundaries. The study found that association boundaries should correspond to homogeneous hydraulic units — that is, areas serviced by secondary canals. Guided by the study, project and ORMVAT personnel calculated that Tadla's 97,700-hectare irrigated perimeter would eventually require 49 associations.

After helping define the nature and reach of associations, TRM project personnel worked with ORMVAT staff to develop an annual work plan for creating the associations. The TRM program was based on several key elements: a campaign to build awareness among farmers, informational meetings for farmers and ORMVAT staff, and training for agents charged with guiding the nascent associations. The project also helped ORMVAT officials lay out a transparent process for creating individual associations: electing representatives from the tertiary canals, convening a general assembly, creating a board of directors, and electing an administrative council.

So far a total of 23 water user associations have been created in Tadla; other associations are still forming. Tadla's water user associations comprise 7,098 producers, farming 38 percent of the irrigated perimeter.

D2. Water User Association Activities

Through the implementation of numerous activities, TRM made significant progress in creating and strengthening water user associations. Project activities included:

- Early in the project, TRM personnel carried out a diagnostic study of farmer organizations in Tadla, surveying water user associations and a variety of other farmer organizations (Report 7). The study, completed in August 1994, showed that water user associations had the potential to improve water use efficiency in Tadla; it also found that successful association development would require improvements in Morocco's policy framework and supporting legislation. The study offered recommendations on strengthening associations to equip the groups to actively participate in managing and distributing water and maintaining the canal system.

- A comprehensive assessment of agribusiness interests and marketing channels in Tadla region, conducted by the project in 1994, identified constraints to improved agricultural product marketing. The assessment recommended products and activities with increased value-added potential (Report 10). It also provided suggestions on increasing farmer participation in the marketing chain to increase their share of marketing margins and improve farm income.

- In November 1995, a short-term TRM consultant conducted a presentation on the U.S. experience with water user associations for the National Symposium on Participative Irrigation Management. In 1996, the consultant developed recommendations and guidelines on transferring selected operational and maintenance functions to water user groups in the Tadla perimeter (Report 30).

- The project sponsored a study tour to Portugal in September 1995, followed by a study tour to the United States in 1997; the tours included visits to water user associations.

- A water policy and management tour, organized by TRM in June 1996, provided an opportunity for ORMVAT's director and Ministry of Agriculture officials to visit water user associations in irrigation districts in California, Arizona, and Mexico. The role and management of water user associations was a major focus of the tour.

- In June 1996, project personnel developed a plan for implementing water user associations in the Tadla irrigated perimeter (Report 41).

- The project prepared an institutional reorganization plan for ORMVAT in June 1997 (Report 55). The study's recommendations supported and reinforced ORMVAT's decision to gradually increase water user association responsibility for water distribution and irrigation system maintenance.

- TRM carried out an evaluation of existing water user associations, analyzing barriers still blocking their effective participation in irrigation water management in the Tadla perimeter (Report 70). The report, prepared in July 1998, provided recommendations on ORMVAT and association task sharing.

E. Program Benefits

The involvement of water user associations in water resource management in Tadla has brought about a number of benefits. These include:

- By providing each association with an annual allocation of irrigation water to manage as it sees fit, ORMVAT has facilitated active user participation in irrigation scheduling.

- The ORMVAT-introduced water checkbook permitting each user to measure water consumption had contributed to billing transparency and strengthened user confidence in the system's management.

- Associations are now involved in defining irrigation programs and setting canal maintenance priorities.

- Associations now participate in monitoring and approving the rehabilitation work that ORMVAT carries out.

With TRM's work now successfully completed in Tadla, the next step for water planners is to introduce effective water user associations to Morocco's other large irrigated perimeters, thereby improving ORMVA management and performance throughout the country.

SECTION VI

Dissemination of Technologies

water resource management. During implementation, TRM personnel turned to the following training-based activities to disseminate technologies introduced by the project:

- Internal workshops for personnel involved in project implementation
- Field days, seminars, and demonstrations in Tadla
- In-country short courses and training
- Study and information-exchange tours
- Outreach and technical support for extension agents
- National workshops and seminars
- Report development and dissemination
- Outreach via the mass media

B1. Internal Project Workshops

To carry out annual work planning, the project held internal project workshops to approve detailed activities within each project work plan. More than 70 people — representing all of the project's principal actors — participated in TRM's start-up workshop, organized in 1994.

During implementation, the project team conducted year-end work planning sessions with designated ORMVAT staff to review the year's performance and develop a work plan for the next year. Involving ORMVAT in the sessions increased the office's sense of ownership and participation in TRM activities.

During the project, more than 60 consultants provided services. The findings of each consultant were disseminated by means of a workshop, presented to ORMVAT and USAID, with comments incorporated into the consultant's final report.

B2. Field Days, Seminars, and Demonstrations

The project organized seminars, field days, and demonstrations in Tadla to present project results and tools to farmers and technical staff. These events included participants from other irrigation perimeters, the Ministry of Agriculture, and international donor organizations. Technologies highlighted included:

- Geographic information system applications
- Integrated pest management
- Improved nitrogen fertilizer management
- Use of the CROPREQ model in irrigation planning and scheduling
- Use of the HYDRO model in simulating upper-basin water flow
- Use of the CanalMan model to simulate canal flow
- Automated flow-measurement stations
- Automated weather stations
- Laser leveling and level-basin irrigation

- Use of the groundwater model in groundwater management
- Water user association development
- Water and soil quality monitoring networks

B3. Short Courses and Training In-Country

Under the project's University of California at Davis subcontract, 11 formal training modules were organized in Tadla; the modules, each 15 days in length, provided training to more than 160 people. Based on a training needs assessment conducted by a university training specialist, the UC Davis training courses were organized in cooperation with ORMVAT's director and staff. In-country training followed the project's training plan, with a focus on strengthening the skills needed to sustain new technologies and continue the process of dissemination. Participants from other ORMVAs took part in project training programs, helping to spread the technologies to Morocco's other irrigated perimeters.

Courses included:

- Groundwater modeling
- Canal modeling
- GIS/ArcInfo applications
- Safe use of pesticides
- Small-scale postharvest technologies designed for rural women
- IPM theory and practices
- Extension methods applied to integrated pest management
- On-farm irrigation
- Flow-measurement methods

B4. Study and Information-Exchange Tours

The project organized three study tours to the United States and one tour to Portugal for ORMVAT managers and Ministry of Agriculture officers. During the tours, officials visited water management agencies that use technologies similar to those introduced in Tadla by the project.

In June and September 1998, project staff and ORMVAT engineers visited ORMVAs in Haouz, Doukkala, Souss-Massa, Gharb, and Moulouya. TRM team members and ORMVAT staff conducted presentations on technologies introduced to Tadla under the project.

The activities described above generated substantial interest in technologies introduced to Tadla under the TRM project. Some participants were already familiar with the benefits of several of the technologies, usually as an indirect result of the technology's introduction in Tadla.

B5. National Seminars and Workshops

Tools and technologies developed in Tadla were demonstrated to staff at the Ministry of Agriculture and other ORMVAs during national seminars and workshops. Events included the following:

- A national workshop on irrigation system management developed by each ORMVA on October 28, 1996
- A presentation on harmonizing ORMVAs' information systems on June 26, 1997, at ORMVAT
- An international symposium on integrated pest management from May 6-7, 1997, in Agadir
- A seminar on ORMVAT strategic planning on December 22, 1997, at ORMVAT
- A national symposium on participatory irrigation management from November 13-16, 1995, in Marrakech

A final TRM project seminar was held in late November 1999 with participants from almost all ORMVAs as well as the Wali of Béni Mellal, Ministry of Agriculture staff, and interested Moroccan agencies. During the seminar, ORMVAT staff presented highlights of project achievements and overviewed technologies introduced under TRM.

The presentations were a testament to the enthusiasm and dedication of ORMVAT staff, demonstrating that new technologies had been placed in capable hands and would be used to benefit the people of Tadla. This transfer of technology and skills serves as a prime indicator of the sustainability of TRM's accomplishments.

B6. Report Development and Dissemination

The TRM project published 92 reports, including more than 60 technical reports. The complete list is provided in Annex C of this report. Project staff ensured that USAID, other ORMVAs, IAV Hassan II, and the Ministry of Agriculture received copies of the reports.

The project completed a final project technical report on TRM technologies and achievements in June 1999, with 300 copies produced (Report 83). The report, distributed during the final project seminar in October 1999, summarized each technology introduced and refined during project implementation.

B7. Outreach Via the Mass Media

In June 1999, team members produced a TRM project film for the project's final seminar. The 13-minute video, produced in French, provided highlights of TRM project activities and achievements, and is suitable for broadcasting on national television.

The project also developed and produced 1,000 copies of a brochure. Entitled “Pérennité de l’eau — une voie vitale,” the brochure was designed to deepen public awareness on the importance of water as a resource and the need for conservation.

SECTION VI

Dissemination of Technologies

The TRM project was placed within ORMAT as a pilot project to improve the management and use of irrigation resources in Tadla's irrigated perimeter. The ultimate goal of the project, however, was to contribute to the long-term competitiveness and environmental sustainability of irrigated agriculture throughout Morocco. TRM's nationwide objectives were achieved by disseminating project results to Morocco's other irrigated perimeters.

A. Technologies Disseminated Under TRM

By late 1999, the TRM had disseminated the following five technologies to other ORMVAs:

- Portable, broad-crested weirs, distributed to other ORMVAs to help field staff verify and control water delivered by regional canal irrigation systems to farms
- Level-basin technology, demonstrated in Doukkala and developed on the feasibility-study level for adoption in the perimeter of Haouz
- Geographic information systems, introduced in Moulouya through the provision of a computer and software
- A hydrologic model (HYDRO), installed in Moulouya to facilitate water supply analysis
- An irrigation planning and scheduling model (CROPREQ), installed in Moulouya to assist in estimating crop water needs

B. Activities to Disseminate Technologies

Early on in implementation, the TRM project learned that the human factor is essential in the successful adoption and application of new technologies. Technicians, administrators, farmers, and other resource management collaborators need high-quality training, in addition to a strong desire to learn and the motivation to stay abreast of technical developments.

The TRM project hosted numerous training sessions and field demonstrations to disseminate a range of project technologies.

The project emphasized training as a means to raise awareness of the complex issues involved in sustainable

SECTION VII

Progress in Water Policy and Institutional Reform

SECTION VII

Progress in Water Policy and Institutional Reform

A. Water Policy in Morocco

ORMVAT is at a crossroads. In the past, its task was to administer irrigation system maintenance programs and provide technical guidance to producers. Now, with Morocco's internal and external environment in rapid change, the role of ORMVAT is in flux.

As Morocco's economy liberalizes, ORMVAT has helped facilitate the transition between an old-style, centralized approach to crop planning to a new system based on free crop selection. At the same time, Moroccan markets are increasingly opening up to foreign imports, subjecting farmers to relentless competition in national and international markets.

Changes are also taking place at the regional level. With state financial support no longer guaranteed, financial autonomy is the order of the day for entities like ORMVAT. New players are appearing in the water management arena — such as the basin agencies, the Ministry of the Environment, and water user associations — requiring ORMVAT to function in a climate of cooperation and compromise.

B. The TRM Project's Role in Supporting Reform

The TRM project prepared detailed studies on a variety of resource management-related topics, helping ORMVAT and the Ministry of Agriculture formulate and apply reforms to improve water resource management in Morocco. These studies — conducted by Moroccan specialists as well as international experts — focused on subjects that included the following:

- Encouraging progressive increases in water prices
- Decentralizing water management authority
- Strengthening water user associations
- Increasing the efficiency of regional irrigation authorities

Highlights of the project's work in these four areas are provided below.

B1. Encouraging Progressive Increases in Water Prices

The project addressed the issue of water pricing through a number of water-economics based studies. Tying water prices to real costs is a step needed to encourage farmers to become more efficient water users. The challenge, then, is to develop water-pricing policies that balance supply and demand. The project's efforts to encourage cost-based water pricing were fruitful: The price of irrigation water in Tadla was 0.18 dirham per cubic meter at the end of 1999 – a 20 percent increase over the price at the project's start at the end of 1993.

B2. Decentralizing Water Management Authority

In August 1996 the project provided technical assistance to the Ministry of Agriculture to examine existing legislation relating to Morocco's water sector, and evaluate the impact of the water law of 1995 on ORMVAs (Report 42).

According to water law of 1995, the Ministry of Public Works will assume a wide array of water management functions; these functions will be carried out through basin agencies, based on the country's drainage basins. TRM's assistance helped lay the foundation for identifying overlapping functions and potential conflicts between ORMVAs and the newly created basin agencies, assisting policy makers in clearly defining the collaboration needed among resource-management institutions to ensure integrated management within each water basin.

B3. Developing Water User Associations

The TRM project conducted numerous evaluations and diagnostic studies that contributed to ORMVAT's approach to the creation of water user associations in the Tadla perimeter (reports 7, 30, 41, and 70). Toward the end of 1997, an all-encompassing strategy for restructuring ORMVAT was presented to the Ministry of Agriculture; water user associations represented a key element in this strategy.

Through the execution of this strategy, ORMVAT is strengthening producer involvement in irrigation system management, increasing the efficiency of water distribution and use, and reducing administrative and operational costs. Under the strategy, water user associations will be granted full membership in ORMVAT's board of directors, providing associations with the institutional access needed to influence future policy and organizational structure.

B4. Increasing the Efficiency of Regional Irrigation Authorities

To assist ORMVAT in increasing efficiency and responsiveness to change, the TRM project conducted an institutional study of the organization, analyzing ORMVAT's mission and its capacity to carry out its required functions under new circumstances (Report 55).

The study reviewed issues related to water pricing, examined relationships with regional basin agencies and water user associations, explored changing institutional roles, and detailed the legislation needed to sustain reform.

Based on the findings of this study, ORMVAT developed a new institutional strategy that focused on improving the organization's technical and administrative effectiveness and attaining financial autonomy. By developing a comprehensive strategy for achieving successful structural change, ORMVAT has provided a positive model for Morocco's other ORMVAs.

SECTION VIII

TRM Project Achievements

SECTION VIII

TRM Project Achievements

A. Overview of Project Achievements

The Tadla Resources Management project (TRM) was designed to improve water management and protect the natural resource base that provides essential support for the agricultural sector of Morocco's Tadla region. From 1993 to 1999, the project helped ORMVAT — the Office Régional de Mise en Valeur Agricole du Tadla — to improve water management in Tadla's irrigated zone.

In carrying out this mandate, the TRM project introduced new technologies, strengthened water user groups, and served as an effective advocate for policy and institutional reform within Morocco's agricultural sector. Over its six-year duration, TRM achieved striking achievements in improving the management of Tadla's water resources through a broad range of technical, managerial, participatory, and policy activities. Though its successes, the project strengthened the capabilities of Tadla's irrigation authority, ORMVAT, while providing a model of technical innovation and cooperation for water-management authorities throughout Morocco.

The TRM project was managed to achieve specific results. A summary of activities, performance indicators, and results are presented in Annex A. Annex B provides an activity tree for the TRM project, while Annex C contains a list of the 92 reports produced during the project's six-year life.

B. Achieving the Project Goal, Purpose, and Results

By promoting the long-term competitiveness and environmental sustainability of Moroccan irrigated agriculture, the Chemonics-led team achieved the TRM project goal.

The project purpose was also achieved, as Tadla's irrigation management registered increases in efficiency, economic yield, and environmental sustainability through TRM's integrated program of policy analysis, institutional and private sector strengthening, and technology research, demonstration, and transfer.

When USAID/Morocco's program was reengineered in 1995, TRM was re-classified as an environmental project to support the mission's strategic objective 2. The project tightened its scope to focus on achieving six measurable results:

- Increasing water savings through improved water management
- Reducing pollution through a reduction in excess fertilizer use
- Protecting the environment through a program of integrated pest management
- Increasing participation in water user associations
- Producing environmental impact by disseminating appropriate technologies
- Developing institutional reforms through policy change

C. Project Achievements in Six Areas

The TRM project achieved significant results in all six of the areas noted above. In addition, it introduced innovative tools and technologies to improve Tadla's water management. Highlights of the project's achievements:

C1. Increasing Water Savings

To increase water savings, TRM upgraded canal efficiency and enhanced on-farm water use efficiency. The project promoted integrated irrigation management through such tools as a hydrologic analysis model, geographic information systems, an irrigation planning and scheduling model, real-time weather and water-flow monitoring networks, and portable flow-measurement weirs.

By increasing ORMVAT's computational capacity and linking the office to real-time, rapid-response data collection, these tools enhanced ORMVAT's canal management capabilities and achieved the project's targeted water savings results. At the project's start, canal efficiency stood at 75 percent. By the project's end, this figure had climbed to 87.4 percent, an annual savings of *82 million cubic meters of water* — enough to irrigate 10,000 hectares or supply 55 percent of Casablanca's annual municipal consumption.

In consideration of the significant water savings incurred, it is revealing to translate these benefits into economic terms. The volume of water saved represents a value of almost $1.5 million at current ORMVAT irrigation prices (82 Mm^3 x $.018/$m^3$). Presuming the saved water is used in an urban setting, such as downstream to Casablanca, the value of water used in an urban setting would be many times higher. If the volume saved were used for expanding the irrigated area or extending the cropping season, then the added value — the difference between irrigated and rainfed productivity — amounts to $20 million/year (10,000 hectares x $2,000/ha). These economic benefits are most significant when compared with USAID's TRM project investment of $10.4 million over six years, and the canal water savings are only part of the overall project benefits.

The Chemonics team succeeded in enhancing the long-term competitiveness and environmental sustainability of Moroccan irrigated agriculture.

To save water at the farm level, the project introduced level-basin irrigation technology through the use of laser-assisted leveling equipment, increasing irrigation efficiency, crop yields, and labor savings, as well as enhancing salt and nitrate management. Farms with level basins have realized water savings of 20 percent.

At least 30 percent of the perimeter's irrigated area is suitable for level basins; if level basins were installed in those areas, water savings would reach an annual rate of 52 million m^3. To expand private capacity to serve this market, Chemonics helped ORMVAT train

local firms to supply laser land-leveling services. Currently two firms provide the service in Tadla, with plans to develop 1,200 hectares of level basins a year.

C2. Reducing Water Pollution

Project diagnostic studies in 1994 and 1995 identified nitrate buildup in Tadla's groundwater as a significant factor in the region's declining water quality, with a potentially serious impact on human health. Tadla's high level of groundwater nitrate is largely the result of heavy, poorly timed applications of nitrogen-based fertilizers on crops.

The project conducted fertilizer trials, revealing an excess application of 1,800 tons of nitrogen used on Tadla wheat and sugar beets, which cover 55 percent of Tadla's total irrigated area. The project's fertilizer specialist developed recommendations for new fertilizer application rates for sugar beets.

By promoting the new rates, the project succeeded in reducing nitrogen applications by 50 kg/ha, for a total reduction of 934 tons over the 18,685 hectares planted in sugar beets in the perimeter. The project's success was aided by the fact that Tadla's sugar beet factories exercise a high degree of centralized control over all aspects of sugar beet cultivation and sales, facilitating the dissemination of the new fertilizer formulas to sugar beet farmers.

For wheat, project efforts resulted in a 20 kg/ha nitrogen reduction over a 2,350-hectare area, totaling a 47-ton nitrogen reduction. This area represents a small portion of Tadla's 38,000 hectares of wheat. However, as extension agents disseminate the new application rates to wheat farmers, total nitrogen reduction for wheat is expected to rise sharply, rivaling the nitrogen savings realized in sugar beets.

Total nitrogen reduction for both crops amounted to 981 tons — more than double the established project target of 25 percent. In addition, reducing fertilizer applications has resulted in impressive cost savings for Tadla's farmers — providing strong motivation to follow the new application rates.

The excessive nitrogen use found in Tadla indicates that a number of other farm chemicals are probably used in excess in the perimeter, including pesticides and herbicides that pose greater dangers to water users than nitrogen. TRM's work has sparked interest in the potential dangers of such chemicals, and is expected to motivate future initiatives to address chemical hazards.

C3. Protecting the Environment Through Integrated Pest Management

The project initiated integrated pest management practice — essentially unknown in Tadla before TRM — to help citrus and paprika farmers reduce the use of pesticides to combat disease. Project success in reducing pesticide applications lowered grower costs, reduced pest resistance, and promoted natural equilibrium among insect populations.

To fight citrus pests, the project provided pheromone insect traps and instructions on linking pesticide spray use to insect population densities. A total of 198 citrus growers, cultivating more than 50 percent of Tadla's 7,600 hectares of citrus, adopted the new techniques.

For paprika farmers, the endemic presence of the troublesome *Phytophthora capssici* mildew in Tadla's soil has limited growing success; as a result of this persistent mildew, many farmers have been reluctant to cultivate this high-value crop. The TRM project developed farming-practice guidelines to control the mildew, convincing 38 farmers to adopt the improved practices.

Indications exist that pest management practices have found a ready market in Tadla. A local private group is now successfully selling pest traps to farmers; in addition, a local research organization has signed an agreement to continue the project's pest management work.

C4. Increasing Participation in Water User Associations

TRM enjoyed significant success in broadening participation in environmental management. A project focus was assisting ORMVAT in forming water user associations to increase farmers' role in managing individual and network water resources.

The water user association concept — which has engendered some controversy in Morocco — has been the subject of several conferences and seminars, the most recent held in December 1999. The project assisted ORMVAT in assuming a leadership role among irrigation perimeters by taking an innovative approach to association creation and strengthening.

In the pioneering strategy that TRM and ORMVAT developed, water quotas of individual farmers are determined each year according to crop area and water availability, with each farmer free to use his quota as he sees fit.

The project's approach — much like a checking account that allows choice in allocating resources as long as an overall limit is respected — has increased local control over water management and encouraged billing transparency. In another sign of progress, water user associations will soon enjoy representation on ORMVAT's board of directors.

C5. Disseminating Technologies to Other Irrigation Perimeters

The team introduced 14 technologies and methodologies to Tadla. Project-introduced tools include:

- Models for hydrologic, groundwater, hydraulic, and irrigation-demand forecasting
- Networks that track agro-climatic, groundwater, soil quality, and farm data
- Improved fertilizer application and integrated pest management
- Geographic information systems that integrate data to facilitate decision making
- Farm-level tools: level-basin irrigation, laser leveling, and portable weirs
- Water user associations that increase farmer participation in managing water

Other ORMVAs have already adopted five technologies: portable measurement weirs, laser-leveled basins, geographic information systems, and the irrigation and hydrological planning models. The Repogle weirs have enjoyed particular success, with seven ORMVAs following Tadla's example and installing the portable measurement devices.

Strengthened through training and shared activities during the project, ORMVAT continues to actively disseminate many TRM-introduced technologies to other ORMVAs, ensuring the long-term sustainability of the project's technical innovations.

C6. Developing Institutional Reforms Through Policy Change

In addition to the technological development that provided a focal point for most TRM activities, team members worked to improve the policy, regulatory, and institutional framework for ORMVAT activities. The project addressed issues like cost-recovery-based water pricing, decentralized management, water user association empowerment, and institutional efficiency.

Highlights of the project's policy efforts include:

- *Increasing understanding of water-pricing issues.* To address the question of water pricing — the subject of national-level debate for several years — the project contributed technical studies that contributed to increased understanding of this pivotal issue. The studies have helped pave the way for a policy shift in favor of locally established irrigation water prices that reflect real operating costs. Since the beginning of the project, irrigation water prices have risen 20 percent, to 0.18 dirhams/cubic meter. According to informed observers, the government is preparing new policies to require cost-based irrigation water pricing.

- *Encouraging water-management decentralization.* Morocco's government has adopted a new approach to water management based on the decentralized authority of regional water basin agencies. The basin authorities — designed with the authority to allocate water among competing interests — represent a major boost to the concept of decentralizing resource management. To support the government's move toward increasing resource-management decentralization, the TRM project carried out a major study on the water-basin approach to water management. Not surprisingly, the government has decided to establish Morocco's first water basin in an area that includes the Tadla irrigated perimeter — the Oum Er-R'bia basin.

- *Establishing and strengthening water user associations.* Through its innovative approach to water user associations, the project realized substantial progress in advancing the role of these associations in the country's water management. TRM's water user association approach — widely seen as the most successful in Morocco — has also built support on the national level for decentralizing resource management. Significantly, Tadla's water user associations have won approval to join the ORMVAT board of directors — a strong indicator of the associations' empowerment.

- *Increasing institutional efficiency.* Through various studies, the project examined a range of institutional efficiency issues, including state subsidies, downsizing, and increased autonomy. With the report's recommendations in hand, ORMVAT has taken steps to increase operational efficiency and develop financial autonomy.

ANNEX A

Project Targets and Performance by Indicator

TABLE 1.1. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

St. Objective # 2: Improved Water Resources Management in the Agricultural, Urban & Industrial Sectors.

INDICATOR: Volume of water savings in target areas

UNIT:
Millions of cubic meters/yr (annual, not cumulative)
(Mm3)

SOURCE:
ORMVAT reports

INDICATOR DESCRIPTION:
See COMMENTS

Performance Data		
Year	**Planned**	**Actual**
1994	Baseline	0
1995	0	2
1996	5	6
1997	10	12.8
1998	30	33.3
1999	70	82.6

COMMENTS:

1- Estimation of water savings for 1999

- Canal system savings:

ORMVAT's estimate of canal system efficiency is based on the ratio of the volume of water delivered to the farmers to the volume of water entering the main canals for the agricultural year (October 1 - September 30).
ORMVAT canal efficiency in 1999 was 87.4%; The baseline efficiency was 75%;
The total volume of water released into the perimeter in 1999 was 658.4 Mm3.
The total water savings = (0.874 - 0.75)x 658.7 = 82.3 Mm3.

- On-farm savings:

The annual surface water applied in Tadla perimeter is around 8650 m3/ha.
Level basin technology is saving around 1730 m3/ha (20% of the water currently applied)
The project installed 50 ha of level basins and the two newly created private companies leveled 100 ha by the end of 1999 (September & October).
Amount of on-farm water savings is 1730 m3/ha X 145 ha = .3Mm3
However, this amount is expected to increase next year due to involvement of private sector.
An area of 1200 ha will be leveled each year by the two private companies.
This corresponds to an addition of 2 million m3/year of on-farm savings.
The level basin practice is now estimated to be eventually applicable to at least 30,000 ha, which will result in a potential water savings of 52 Mm3/year.

Total water savings:

Total water savings = 82.3+ .3 = 82.6 Mm3

2- Contributing activities include:

ORMVAT's management of the irrigation system has been improved by the use of the following set of new management tools developed by the project:
- Real time measurement of water flows at 11 points along the distribution network has been operational since June 1997. Since then, this tool has been used by ORMVAT's field engineers for managing water distribution.
- Computer Irrigation programs & GIS, in place since 1996, were used by ORMVAT to improve irrigation planning and scheduling.
- Agro-meteorological network data , functioning since 1996, has been used to improve irrigation planning & scheduling.
- Mobile flow monitoring system, in place since 1995, has been used to check the water delivered to the farmers.

3- Plan for verification includes

- Use of the 11 project installed monitoring stations for measuring inflow and outflow from primary & secondary canals for verification of ORMVAT's efficiency figures.
- ORMVAT's reports on the measurement of the amount of water used by the farmers compared to the amount of water entering the main irrigation canals.
- The 20 % on-farm savings from laser leveled basins was calculated from project field demonstration results.

TABLE 1.2. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

St. Objective # 2: Improved Water Resources Management in the Agricultural, Urban & Industrial Sectors.

INDICATOR: Reduction in the amount of water pollution in target areas	**Performance Data**		
	Year	**Planned**	**Actual**
DEFINITION: Reduction in the amount of nitrates potentially leached into the ground water in Tadla.	1995	Baseline: 35 kg/ha average excess nitrogen applied in Tadla	
UNIT: Percent reduction in kg/ha of excess nitrogen fertilizer/ha	1996	0%	0%
SOURCE: ORMVAT reports, sample field verification	1997	10%	10.4%
INDICATOR DESCRIPTION: See COMMENTS	1998	15%	35.7%
	1999	25%	54.5%

COMMENTS:

1- Estimation of percent reduction of excess nitrogen for 1998/99:

The TRM project is assisting in the development and dissemination of better nitrogen (N) management practices for sugar beet and wheat crops based on 1996 project demonstrations results.
In 1996, based upon the TRM project diagnostic studies, an estimated 1,800 tons of excess N were applied in the 51,000 ha area (I.e., 38,000 ha of wheat x 20 kg excess per ha + 13,000 ha of sugar beets x 80 kg excess).
In the 1998-99 crop year, growers on small farms totaling 2,350 ha of wheat continued the reduction of 47 tons of excess N applications on wheat (20 kg/ha x 2350 ha), which represents 2.6 % of baseline.
For the sugar beet, the project worked with the Sugar Beets Growers' Association and Tadla Sugar Factories to reduce the N content in fertilizer distributed to all sugar beet farmers. Average rates of excess N fertilizer reduced on sugar beets (50 kg/ha, estimated from farmers surveys) multiplied by the total area planted in sugar beets (18,685 ha, in 1998/99) gives a reduction of excess N of 934.2 tons, which represents 51.9% of baseline.
Adding both the wheat and sugar beets nitrogen excess reductions achieved in 1998/99 gives a total decrease of 54.5 % of excess nitrate applied.

2- Contributing activities include:

- MRT project demonstrations on nitrogen applications that reduce nitrates leaching and improve yields for sugar beets and wheat.
- Field days, field visits, and training of ORMVAT's extension staff.
- MRT dissemination of best nitrogen management practices to the Tadla farmers, ORMVAT's extension agents, and to the Tadla Sugar Beet Production Standing committee.

3- Verification includes

Reports from ORMVAT's extension agents on farmers following the ORMVAT/TRM nitrogen application program for the 1998-99 crop-year, along with surveys.
The excess nitrogen baseline of 18,000 tons was obtained in a 1996 survey which addressed the prevailing practices concerning quantities of fertilizers and the time of application.

TABLE 1.3. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

Program Outcome No. 2.2: Improved Environmental Technologies

INDICATOR: Number of farmers adopting Integrated Pest Management (IPM) practices for targeted crops in irrigated perimeters	**Performance Data**		
	Year	**Planned**	**Actual**
UNIT: Number	1994	Baseline	0
	1995	10	8
SOURCE: ORMVAT reports, sample field verification	1996	40	36
	1997	100	105
INDICATOR DESCRIPTION: See COMMENTS	1998	300	228
	1999	600	228

COMMENTS:

1- Number of farmers adopting IPM in 1999

The TRM project is assisting ORMVAT's extension staff to expand IPM practices for citrus and paprika crops based on the results of previous years. A total of 228 farmers (198 citrus, 30 paprika) adopted the project recommended IPM practices for 1998-99 crop year.
While this number of citrus farmers is 27% of the 833 total citrus farmers, the land area involved is is about 50% of the 7,600 ha total hectares planted in citrus in Tadla.
Based upon our present evaluation, it appears that the target of 600 total participants by the end of 1999, set earlier in the life of the project, is not feasible. The lack of growth in the number of paprika farmers is due to continuing problems with Phytophtora, a mildew residing in the soil, has reduced the quality and quantity of production of the crop. No effective control of the mildew has been found to date.
The TRM project concentrated its effort this year on training the farmers who already adopted the IPM technology in 1998 to make them capable of managing their own traps and making their own decision about spraying in stead of depending completely on the ORMVAT's extension agents.

There are three solid indications that the IPM technology has taken hold and is sustainable:
(i) Agro-Spray, the company that provides the traps and pheromones, established an agency in Tadla perimeter staffed with an IPM specialist (January 1999)
(ii) Several citrus producers are purchasing their own traps to cover all their citrus acreage (in 1999) and are involved in managing their own IPM program
(iii) ORMVAT signed an agreement with local research organization (INRA) for the continuation and extension of applied IPM research in Tadla (September 1999)

2- Contributing activities includes

- Project technical support of the Tadla IPM network.
- Field days, field visits, training seminars, and publications for extension agents and Tadla farmers.

3- Verification includes

Reports from ORMVAT's extension agents on farmers following the ORMVAT/TRM IPM program for the 1998-99 crop-year, along with sample survey.

TABLE 1.4. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

Program Outcome No. 2.3: Broadened Public Participation for Environmental Action

INDICATOR: Number of farmers in viable Water Users Associations (WUA) participating in the management of the water distribution in the Tadla perimeter.	**Performance Data**		
	Year	**Planned**	**Actual**
UNIT:	1994	Baseline	188
Number	1995	188	530
SOURCE:	1996	1,000	1,556
ORMVAT reports, sample field verification	1997	3,000	3,043
INDICATOR DESCRIPTION:			
See COMMENTS	1998	6,000	6,320
	1999	10,000	7,098

COMMENTS:

1- Number of farmers in WUA in 1999:

The TRM project is assisting ORMVAT in its action plan for participatory involvement for the farmers in the irrigation system management and maintenance.
Three additional WUAs were created in 1999 with a total of 778 members: Nahda (238), Takkadoum (302), Alfadl (238).
The total number of farmers in WUAs at the end of 1999 is 7098.
While this number represents 26 % of the 27,000 farmers in the perimeter, the land area covered by WUAs is about 38 % of the 97,700 hectares in the Tadla perimeter.
The reason for not reaching the1999 target was the fact that ORMVAT focused this year on two main activities: (i) strengthening the existing WUAs by training them and getting them involved progressively in the ORMVAT water allocation and management, and (ii) developing the final WUA strategy presented at the national WUAs seminar held in December 1999 (sponsored by the Word Bank).

2- Contributing activities include

- Diagnostic & evaluation of WUAs in Tadla (1994)
- A design for the implementation of WUAs in the Tadla irrigation perimeter (1996)
- Study tours & national seminars (1996)
- Analysis and recommendations for strengthening WUAs in The Tadla perimeter (1998).
- Informational meetings and continuous assistance of ORMVAT agents charged with the creation of WUAs

3- Verification includes

Reports from ORMVAT's WUA Bureau on farmers who are members of the WUAs involved in the Tadla system management and maintenance.

TABLE 1.5. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

Program Outcome No. 2.2: Improved Environmental Technologies

INDICATOR: Number of technologies developed by the TRM project disseminated to one or more ORMVAs in other region of Morocco.	**Performance Data**		
	Year	**Planned**	**Actual**
UNIT: Number	1995	Baseline	0
	1996	1	1
SOURCE: ORMVAs reports & field verification	1997	2	2
	1998	3	3
INDICATOR DESCRIPTION: See COMMENTS	1999	5	5

COMMENTS:

1- Number of technologies disseminated

- Replogle weirs

Replogle weirs were disseminated widely in 1996. A total of 8 other ORMVAs (Doukkala, Haouz, Ghareb Loukkos, Moulouya, Tafilalt, & Ourzazet) received a set of this technology developed by the TRM project. This technology is used for measuring and controlling water delivered by the canal irrigation system to the farmers.

- Laser-level basins

During the 1997-98 crop-year, the project disseminated the level basin technology to the Doukkala perimeter. In October 1998, following a request from the Director of the Haouz perimeter, the project provided two consultants to the perimeter of Haouz to help in the preparation of a feasibility study for the adoption of level basin irrigation at a large scale in Haouz.

- GIS

In December 1998, following project staff visits to other ORMVAs and training seminars in Tadla, the Director of the ORMVA of Moulouya expressed interest in adopting many of the project-developed technologies including the GIS. In 1998, the TRM project helped initiate the establishment of the GIS unit in Moulouya by providing a computer and software, including one license for ArcView GIS.

- CROPREQ & HYDRO models

In November 1999, following an expression of interest of ORMVA of Moulouya in the irrigation tools developed by the TRM project the ORMVAT staff visited the Moulouya perimeter and installed the "Hydro" and CROPREQ models to help in the hydraulic analysis of water supply and in the irrigation planning and scheduling, copies of the two models were also given to the ORMVA of Haouz following their visits and training in the Tadla in the use of the two models.

2- Contributing activities include

- Field days and seminars.
- Dissemination of project technical reports.
- Project staff visits to other ORMVAs to present technologies developed in Tadla with USAID assistance
- Training courses in Tadla with participants from other ORMVAs

3- Verification includes

List of ORMVAs using the TRM project-developed technologies & field verification.

TABLE 1.6. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

Program Outcome No. 2.1: Improved Policy, Regulatory and Institutional Framework

Reform 1: Progressive pricing policy

Definition:
Encourage progressive water pricing policies to bring demand into balance with supply.

	Performance data*							
	'95	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**
Planned		10	25	35	45	65	85	90
Actual		10	30	35	50			

Comments:
Even though there was no water price increase during 1999, ORMVAT already validated its institutional strategy which included a progressive water pricing to reflect the real cost. The new ORMVAT policy which is going to be signed between ORMVAT and the Government in the near future.
a policy change in water pricing. The price of water is going to be decided locally by the board of Directors of ORMVAT based on the real cost of the water (instead of being fixed at the national level).
This constitutes, in part, an implementation of the Project institutional studies recommendations

Contributing activities:
Includes:
- the TRM technical studies on water savings and water pricing policy
- Participation in the continuous dialogue on water pricing at local and national levels.

Reform 2: Decentralization of water management authorities

Definition:
Encourage the implementation of Water Law and formulation of roles of the proposed new institutions and the existing ones.

	Performance data*							
	'95	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**
Planned		10	20	30	40	70	100	100
Actual		10	20	30	50			

Comments
The Director of the Oum Rbia Basin Agency was appointed in 1997. During 1999 there was a continuos dialogue at national and local levels between water users institutions to strengthen the agency and to discuss their financial contribution. The composition of the the board of Directors of the agency was also defined.

Contributing activities:
Includes the TRM study on the existing legislation in the water sector in Morocco in 1996.

* Progress is rated as follows:
Identification : 10% + Formulation: 10% + Validation: 20% + Adoption: 30%; + Enforcement: 30% = 100 %.

TABLE 1.6. TARGET AND PERFORMANCE FOR TRM PROJECT ACTIVITIES

Program Outcome No. 2.1: Improved Policy, Regulatory and Institutional Framework

Reform 3: Water Users Associations empowerment

Definition:
Adoption of steps necessary to support the progressive transfer of irrigation management responsibilities to WUAs in the Tadla perimeter.

	Performance data*							
	'95	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**
Planned	10	20	30	40	60	70	100	100
Actual	10	20	45	50	65			

Comments:

ORMVAT has continued the creation of new Water Users Associations (WUA) and the strengthening of the existing ones.
At the end of 1999, twenty three WUAs have been created.
The ORMVAT's strategy is to progressively integrate farmers into the ORMVAT irrigation water allocation and management.
The WUAs would be given full membership in the next ORMVAT Board of Directors meeting. With this representation, the WUAs will have institutional power to influence ORMVAT policy and organizational structure in the future.

Contributing activities:
Includes the TRM diagnostic & evaluation studies of ORMVAT's WUA program (in 1995, 1996, 1997, and 1998), study tours, and continuous Project technical support of ORMVAT's unit in charge of creating WUAs.

Reform 4: ORMVA's efficiency enhancement

Definition:
Enhance the efficiency of ORMVAs through reduction in state subsidies, downsizing, and increasing their autonomy.

	Performance data*							
	'95	**'96**	**'97**	**'98**	**'99**	**'00**	**'01**	**'02**
Planned		10	20	30	50	70	80	100
Actual		10	30	35	60			

Comments:
In 1997, the project assisted ORMVAT in the development of its new strategy to become an autonomous institution.
The new strategy was promoted and validated at local and national levels through several meetings and presentations.
in 1997 and 1998. ORMVAT's new strategy for structural change is considered a model to be followed by other ORMVAs.
A Contract-Program between the Government of Morocco and ORMVAT has been prepared and is going to be signed in the next few months. This Contract-Program calls for the ORMVAT to become the first ORMVA to have a full autonomous status.

Contributing activities:
Includes the TRM study to assist ORMVAT in its mission statement and strategic plan in 1997.

* Progress is rated as follows:
Identification : 10% + Formulation: 10% + Validation: 20% + Adoption: 30%; + Enforcement: 30% = 100 %.

Indicator # 1 **Volume of water savings in target areas**

Baseline = 700 Mm3 of water used in the perimeter in 1995

I- Improving canal conveyance efficiency

- Average conveyance efficiency = 75%

We assume that half of this loss is attributed to canal maintenance deficiency . The other half, or 87.5 Mm3, could be reduced by 60 % as a result of better system management developed by the project.

Project's potential savings for improvement of canal management = .6 x 187.5 = 52.5 Mm3

II- Improving on-farm maintenance efficiency

Year 1997:

- Average on-farm efficiency = 60%
  Annual water currently used = .6 x 525 = 315 Mm3

- Level basin will save 20% of the water currently applied
  Potential amount of water savings : 525 x 0.2 = 105 Mm3

Year 1997:

Potential **Total water savings** by 1999 = .2 x 105 = 21 Mm3

52.5 + 21 = 73.5 Mm3

Current water savings estimates:

Definition: ORMVAT's estimate of conveyance efficiency is based on the ratio of the volume of water billed for the year (1st of September to 31 October) to the estimates of the volume of water entering the main canals.

Year 1995:
ORMVAT Beni Moussa canal efficiency estimates = 79 %
Total volume of water released in the system = 536.9 Mm3
Total water savings = (.79 - .75) x 536.9 = 21.47 Mm3
We assume that the project related activities in 1995 contribute to 10 % of overall ORMVAT water savings = 2 Mm3

Year 1996:
ORMVAT canal efficiency estimates = 82 %
Total volume of water released in the system = 658.7 Mm3
Total water savings = (.82 - .75) x 464.6 = 32.5 Mm3
We assume that the project related activities in 1996 contributed to 20 % of overall ORMVAT water savings = 6 Mm3

Year 1997:

ORMVAT canal efficiency in Beni Moussa =	82.4%	
Total volume of water released into B. Moussa System =	575.4	Mm3
Total water savings = (.846- .75)x 577 =	42.6	Mm3
We assume that the project related activities in 1997 contributed at least 30 % of the overall ORMVAT water savings		
Project water savings = 42.6 x .30 =	12.8	Mm3

Indicator # 2 **Reduction in the amount of nitrate potentially leached into the groundwater**

Nitrogen application norm for cereals = 120 Kg /ha
Nitrogen application nor rm for sugar beats = 120 Kg/ha

Baseline estimates (1996)

Crop	Area (ha)	Nitrogen applied (kg/ha)	Norm	Excess
Cereals	38000	140	120	20
Sugar beets	13000	300	220	80

Total excess in 1996 = (20 x 38000 + 80 x 13000) / 51000 = 35.3 kg/ha

By 1999, the project contributed to a 50 % reduction in the excess
for the sugar beet and cereals crop area (or 25 % for the whole perimeter)

Source of information:

- Statistics of the number of farmers who adopted project recommendations related to the nitrogen application for sugar beets and wheat crops (Information gathered by ORMVAT extension agents)
- Another source of information is estimates of crop area and nitrogen application from the project's annual survey of a representative sample of Tadla farmers.

Indicator # 3 **Number of farmers adopting integrated pest management (IPM) practices**

Source of information:

- Knowledge of the number of farmers who adopted project recommendations related to IPM practices for the crops selected (information gathered by ORMVAT extension agents)
- Estimates from the project annual survey of a representative sample of Tadla farmers could be used.

Indictor # 4 **Number of farmers in viable water user associations**

Source of information:

Statistics on the number of farmers who participate in each WUA activated by ORMVAT (information gathered by ORMVAT WUA bureau)

Indicator # 5 **Dissemination of technology to other irrigated perimeters**

Source of information:

Statistics on the number of project technologies requested and adopted by other ORMVAs (information gathered by ORMVAT WUA bureau)

	Volume of water billed					Volume of water entering the system	Efficiency*
	Oct-Dec 96	Jan-Mar 97	Apr-Jun 97	Jul-Sep 97	Total		
B. Amir	46.5	36.9	59	67.5	209.9	232.3	90.4%
B. Moussa	96	81.9	141.5	154.9	474.3	575.4	82.4%
Total					684.2	807.7	84.7%

*** Efficiency:** (Volume of water billed / volume of water entering the system)*100

ANNEX B

TRM Objective Tree

ANNEX C

TRM Project Reports

ANNEX C

TRM Project Reports

1. First Annual Work Plan. Tadla Resource Management Project, May 1994.

2. 1994 First Quarterly Report. Tadla Resource Management Project, April 1994.

3. Atelier de démarrage du projet MRT du 13 au 16 mai 1994. Fquih B. Saleh, June 1994.

4. AGIR: Analyse de Gestion, Impact et Résultats (A Performance-Based Tracking System). B. Sensening, June 1994.

5. Rapport du voyage d'étude organisé aux Etats-Unis par le projet MRT au profil du personnel de l'ORMVAT du 2 au 16 Avril 1994. ORMVAT, June 1994.

6. 1994 Second Quarterly Report. Tadla Resource Management Project, August 1994.

7. Tadla Resource Management Project: Diagnostic Assessment of Tadla Farmer Organizations: Water Users Associations and Dairy Cooperatives. Ronald Philips, August 1994.

8. 1994 Third Quarterly Report. Tadla Resource Management Project, October 1994.

9. Diagnostic Study of the Tadla Irrigation Project. D. Oellermann, October 1994.

10. Tadla Resource Management Project: Agribusiness Diagnostic Study. T. Easterling, October 1994.

11. Water Supply Database Management and a Frequency Analysis: Computer Programs. M. Tayaa, October 1994.

12. Flow Measurement Instrumentation for the Tadla Irrigation Project. J. Replogle, October 1994.

13. Etude environnementale du périmètre du Tadla: gestion quantitative et qualitative des ressources en eau et sol des périmètres irrigués de Beni-Moussa et Beni-Amir. A. Debbagh, October 1994.

14. Environmental Assessment: Groundwater and Drainage. R. Stillwater, November 1994.

15. Qualité des sols et des eaux: situation actuelle et méthodes de suivi de paramètres de qualité. B. Soudi, November 1994.

16. Selecting Automated Weather Station Sites and Equipment for the Tadla Irrigation Project. W. Trimmer and A. Ramdani, November 1994.

17. Analyse de la gestion quantitative et qualitative des produits agro-chimiques utilisés dans le périmètre de Tadla. P. Dreckmann and M. Ammati, November 1994.

18. Second Annual Work Plan. Tadla Resource Management Project, January 1995.

19. First Annual Project Report. Tadla Resource Management Project, January 1995.

20. Essai de typologie des exploitations du périmètre irrigué du Tadla. A. Herzenni and F. Mosseddaq, February 1995.

21. Diagnostic des exploitations agricoles du Tadla: résultat de l'enquête. SCET-Maroc, February 1995.

22. Improvement of Surface Irrigation Systems in the Tadla Irrigation Project. A. Dedrick, March 1995.

23. 1995 First Quarterly Report. Tadla Resource Management Project, April 1995.

24. 1995 Second Quarterly Report. Tadla Resource Management Project, July 1995.

25. Mise en place des réseaux de suivi de la nappe phréatique et de la qualité des sols et des eaux du périmètre de Tadla. M. Ammati, B. Soudi and A. Debbagh, September 1995.

26. Rapport du voyage d'étude effectué au Portugal du 12 au 16 September 1995. ORMVAT, September 1995.

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