

**An Analysis of  
IDRC-Funded  
Projects  
Relevant to  
Desertification**

**MIDDLE EAST AND  
NORTH AFRICAN  
REGION**



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# 1. INTRODUCTION

Canada's International Development Research Centre's (IDRC) Office for the Middle East and North Africa (MERO) is pleased to present the following synthesis of twenty-five selected research projects. All the projects were sponsored by IDRC in North African/Middle Eastern Countries, over the past twenty years, related to desertification.

All of the 25 projects took place in fragile ecosystems such as grasslands, watersheds, and desert areas. The studies cover various aspects of the following fields: ecology, sociology, economics, and history.

Each project is placed within a geographical and ecological context. The objectives, as well as the results of the study, are written in brief without elaborating on the experimental and methodological protocols. Numerous findings have been drawn from the success and failure of these projects. The topics cover a wide range of themes, with various objectives.

The projects include the following topics:

- Methods and tools for the inventory, survey, analysis and characterization of the major components of fragile ecosystems (soil, water, vegetation, population). These projects have used modern techniques, which provide comprehensive and integrated data on different environments and interactions between their diverse components. These include technologies such as remote sensing by satellite, radar, geographical information systems and simulation models. Special efforts have been made to train national staff to use these new techniques.

Since 1975, the projects have evolved from research on specific system components to increasing the integration of the various ecosystem components. The sociological, economical and environmental aspects, as well as gender and other related components have increasingly gained importance and priority. The multidisciplinary requirements were met by linking national specialists from different institutions with scientific specialists from foreign institutions. The high level of cooperation offered by Canadian institutions, which provided equipment, scientific background and training facilities, often resulted in a positive outcome to these projects.

- Methods and techniques for the control of erosion and desertification such as windbreaks, water harvesting techniques and rangelands.
- Specific development and management-related activities regarding fragile ecosystems (dry grasslands, mountains, desert areas) such as afforestation, soil conservation and farming systems.
- Techniques for improving agricultural, pastoral or forestry productions.

All of the projects are in compliance with the priorities of the principal program identified by the 1992 United Nations Conference on Environment and Development (UNCED), more specifically, those stated in Agenda 21, which address fragile ecosystems, drought and desertification control.

IDRC has been playing a pioneering role since the 1970s in supporting research projects that assist developing countries in creating their own long term solutions to pressing development problems. IDRC plays a catalytic role in responding to the needs of national programs in developing countries, by providing them with knowledge on the fragile ecosystems and the techniques of improving control over the desertification process.

## **2. REVIEW OF PROJECTS**

### **LAND RECLAMATION**

**Research institution:** Agricultural Research Corporation, Sudan

**Project numbers:** 74-0029 Phase I, 82-0194 Phase II

#### **Background:**

With the construction of several dams on the Nile and its tributaries, seasonal floods have disappeared and farming has been restricted to the banks of the river. To reclaim more land for agriculture, the Sudanese Government has drilled deep wells in the basins of the Nile. Although water was provided by the wells, farmers soon abandoned their areas because their crops and irrigation channel were buried by creeping sand. It was urgent and vital to tackle this problem to save the costly investments made in the region and to stabilize agricultural activities. The use of biological protection like shelterbelts; appeared to be the cheapest and one of the most sustainable technique to achieve this goal.

#### **Phase I:**

The objective of the first phase was to find ways to recover abandoned agricultural land, and to protect existing farm land adjacent to desert, by planting trees as shelterbelts. The specific objectives were:

- to investigate the best design of shelterbelt that will protect land and crops from desert encroachment and hot dry wind effects;
- to examine differences in yield and quality of agricultural crops whether protected or not;
- to study the effects of biological protection on microclimate and water economy within the protected area; and
- to make a preliminary evaluation of the economics of land reclamation and desert farming under protective tree plantations.

The first phase started in April 1975 and lasted for 5 years. It was extended until June 1983. The project was carried out in a desert zone with less than 75 mm rainfall. Irrigation of both crops and trees were essential and all the experiments relied on the supply of water from deep wells situated within the trial blocks.

**Research achievements:**

A total of approximately 3.5 km of shelterbelt were established on the trial site, containing two, three, four or five rows of trees and planted with different species. Six meteorological stations were established within the trial site; five of them were built behind shelterbelts, while the sixth was built in an unprotected area to compare the conditions.

Significant differences were found between conditions behind the shelterbelts and in the open. Windspeed was reduced by an average of 40% by trees and evaporation by 22%. Air and soil temperatures increased behind the shelterbelts, but the temperature range was reduced.

Due to inadequate and irregular irrigation, the success of the shelterbelts has been erratic. However, in certain areas, trees have reached a fairly uniform height of 5 to 10 m and offered effective protection from wind and sand-drift.

Because of the same irrigation problems, it was not possible during the first phase to carry out the planned study of agricultural crop production under protection. For the same reason, the evaluation of the economics of land reclamation and desert farming was not completed.

In spite of these difficulties, the project had received full support from the Government of Sudan, which provided more than half of the project's cost and gave a noticeable priority for the purchasing of equipments in order to improve the irrigation systems. Although the shelterbelts were established and designed primarily for testing, the project echoed the interest of both the peasant farmers and the government officials in Northern Sudan.

**Phase II:**

This phase started in 1984 more than one year after the termination of Phase I. The completion date was June 30, 1986. The main objective had not changed and the specific objectives were:

- to continue to evaluate tree growth within phase I shelterbelts;

- to characterize the efficiency of the existing shelterbelts by studying their effects on microclimate and water economy within protected areas;
- to examine the effects of the shelterbelts on yield and quality of different agricultural crops; and
- to make a preliminary evaluation of the economics of land reclamation and desert farming under protective tree plantations.

**Research achievements:**

The results summarized below were based on the limited information available from the two annual reports up to 1985, as the final report has not been submitted.

Height measurements of species within selected sections of shelterbelts were recorded up to 1985 and growth was considered satisfactory by the researcher team. Meteorological data was collected for the two reporting years and analyzed. Three winter crops were raised on leeward and windward sides of the shelterbelts at least once, but no data was presented .

**Conclusion:**

This project was carried out under extremely harsh environmental conditions and it thus provides experience in tree planting and cropping under desert conditions. However, some administrative and organizational problems, in addition to political disturbances, were major negative factors, which restrained the orderly progress of the project.

Furthermore, the remoteness of the project site from Khartoum did not permit adequate monitoring and supervision of activities by senior members of the project team. The situation became worse when the project leader along with many assistants left the project and were not replaced. The difficulties of recruiting and retaining qualified personnel continued throughout both phases.

## RESTORING PRODUCTIVITY AND PROTECTING SITES: THREE PROJECTS

Two approaches are commonly used in dealing with the problem of desertification: 1) control measures and 2) restoration measures. The work summarized here deals with restoring the productivity of desert land and the protection of restored sites. Desert agriculture is a major component of desert development systems, which leads eventually to changing unproductive, degraded (desertified) land into a productive.

Agricultural development in the deserts begins by improving the productivity of poor sandy soil, increasing water use efficiency and optimizing other inputs. All of these activities need proper protection mainly by establishing shelterbelts around farms and new settlements in the desert. The following three projects — Casuarina, Forest Tree Culture, and Desert Farming Systems — all deal with this issue.

### CASUARINA

**Research institution:** Faculty of Agriculture, University of Alexandria, Egypt

**Project number:** 75-0048 Phase I, 80-0027 Phase II

#### **Background:**

The establishment of shelterbelts is a prerequisite for the successful reclamation of land on the fringe of the desert, for the protection of existing farmland against soil erosion and for the prevention of desert encroachment. It has been demonstrated in the region that increases of as much as 40% in yields of certain food crops can be obtained when they are adequately protected with shelterbelts. Several tree species can be used for shelterbelt plantations, among them *Casuarina* spp is the most common used for shelterbelts in the land reclamation areas in Egypt. More than 14,000 km of windbreaks have been planted in Egypt in the past. More plantations are expected in line with the Desert Development Programs. By planting superior trees, which have identical characteristics and quality, it should be possible to obtain greater economic benefits from the investment made in plantations. Improvement of the adaptability and yield is possible through individual selection and control breeding of *Casuarina* species.

#### **Phase I:**

The objective of this project was to obtain genetically improved material for use in shelterbelt and woodlot plantations. The research aim was to provide



fast-growing and drought-resistant trees that in the long term would offer better protection to cultivated areas in the desert and generate additional income to small-scale farmers.

The specific objectives were:

- to initiate a breeding program for the improvement of the Casuarina species;
- to develop vegetative propagation methods such as grafting techniques for these species; and
- to provide training to agricultural officers involved in afforestation and extension activities.

**Research achievements:**

The three year project began in the fall of 1975 and a one-year extension was authorized at the end of 1978. A great deal of work was accomplished during this period. The foundation of a breeding program was established, many superior trees were selected, several seed collection areas were identified and lines of research were initiated. Before starting the improvement research program, the team had to solve the taxonomical problems related to the identification of Casuarina species grown in Egypt. Studies revealed three distinct species of Casuarina and a hybrid between two species.

The main activities of the breeding program pertained to the mass and individual plus (superior) tree selection. Germination tests were carried out on seed samples from plus trees and from mass collection. A study conducted on vegetative propagation, including cutting and grafting, was encouraging and a clonal seed orchard were established in 1977.

A study tour of Australia by the project tree breeder resulted in the introduction of 10 new species of Casuarina for into Egypt. Several local provenances of Casuarina were also tested.

Concerning training, two MSc students completed theses on subjects related to the Casuarina Project.

**Phase II:**

The commencement date of Phase II of the project was in July 1980. The project was completed on March 31, 1984, which means that the research activities lasted for almost 8 years.

Besides the objectives indicated in Phase I, two more activities were added during the second phase:

- the evaluation of the biomass yield and wood volumes in Casuarina species plantations; and
- the assessment of the nutritive value of Casuarina branchlets as animal feed.

**Research achievements:**

Several species and provenances of Casuarina were introduced in three locations to test their performances. The results obtained, clearly indicated that the best performances were achieved by the three species already existing in the country, after a long period of adaptation to local ecological conditions. This leads to the conclusion that many species, provenances or ecotypes of Casuarina were introduced into Egypt over a long period of time and varieties present today are those that survived the hard and variable conditions of the country.

The best example of adaptation is the local hybrid that is the most drought resistant among the different provenances and which also yielded the best performance under irrigation.

The biomass of different tree components was measured and results were compared for two of three locally grown species. Results did not indicate significant differences between species. Some trials were designed to select Casuarina species as a source of fuel and showed that *Casuarina glauca* is the most productive woodfuel due to its vigorous coppicing potential, which allows the cutting of trees at the age of one year, resulting in an intensive production of biomass.

The production of Casuarina seedlings in Egypt increased steadily during the decade 1980–1990. Parastatal companies and agencies, as well as the private sector, produce Casuarina seedlings which are sold to farmers. Although full information on production of each nursery is not available, it is noteworthy that some of them doubled their annual production in the seasons of 1985–86 and 1986–87, when compared with previous years. In addition, their net income increased four to five times during the same period.

A socioeconomic survey of Casuarina shelterbelt planting in Northwestern Egypt gave precise data on the trends. The large spread of shelterbelt plantations occurred only after the end of the second phase of project when the farmers became convinced of the benefits of using improved Casuarina

seeds, as well as its good survival and growth, under harsh conditions. The high survival rate of Casuarina on private farms indicates that peasants can grow and care for their shelterbelts. It should be noted that it took sustained efforts to transfer the technical recommendations to farmers, particularly as relates to planting and maintenance practices.

The majority of the farmers (81%) planting shelterbelts used Casuarina. They planted this species as they realized its protecting role. Some of them, however, planted trees to obtain a more direct economic gain, for example, from timber. Most of the land protected by shelterbelts belonged to smallholders, farming 5-10 feddan. As a result, the impact of the project mostly benefitted small-scale farmers.

### **Conclusions and comments:**

As was indicated, the shelterbelt techniques initiated in the two phases-project were slowly integrated by farmers into their agricultural management practices. Only when results and benefits were absorbed by the farmers did nurseries develop across the region and peasants incorporated shelterbelts more systematically into their agricultural practices.

At the completion of the second phase, research had too little impact on farmers to be measured because it was too early to demonstrate the commercial benefit of utilizing improved seeds of Casuarina in shelterbelts.

However, measurements of most trials were continued after the end of the project and showed the positive results of shelterbelt plantations techniques in desert regions. These positive outputs motivated the development of a "Forestry tree Culture" project in 1988, aiming at enhancing research and improving integration with desert farming systems.

Thus the three projects (Casuarina 1975-1988, Forest Tree Culture 1989-1993 and Desert Farming Systems (1979-1989)) share the common objective of trying to improve the farming systems of small-scale farmers in marginal areas (i.e. on the desert fringes). Furthermore, the three projects helped make agricultural and husbandry activities more sustainable, productive and diverse.

## **FOREST TREE CULTURE**

**Research institutions:** Alexandria University, Alexandria, Egypt  
American University in Cairo, Egypt  
Suez Canal University, Ismailia, Egypt

**Project number:** 3-P-88-0293

### **Background:**

Previous research studies have shown that proper crop protection from wind and sand is essential for agricultural activities in desert areas. The establishment of shelterbelts and windbreak has been an integral part of desert reclamation schemes in Egypt. It is estimated that between 9 to 10 million forest tree seedlings are needed annually for windbreaks in the newly reclaimed areas. In addition, there is a growing interest in establishing woodlot of multipurpose tree species throughout the country.

Although tree resources of Egypt are very limited, they are extensively exploited. The size of the wood industry is increasing in order to reduce the level of dependency on the imports of timber and wood products. Currently, it is very dependent on wood extracted from windbreaks, threatening to destroy this resource. In the newly reclaimed desert areas, moving sand dunes are threatening settlements, roads and agricultural lands.

Based on the above, there was an urgent need to increase the number and size of tree plantations. Since little was known about the performance of forest trees in Egypt, planting programs must be accompanied or preceded by properly designed and executed research. IDRC was committed to resolving this problem by funding a research study on forestry in Egypt.

In 1975, IDRC funded the Casuarina project (3-P-75-0048) in collaboration with the Department of Forestry, Alexandria University. The objective of the research was to provide fast-growing, drought resistant trees that have the desirable characteristics for windbreak establishment. This project was granted a second phase in 1980 in order to complete the research undertaken earlier and to test selected material, as well as to train junior staff.

### **Objectives:**

The objective of the Forest Tree Culture project was to provide a solution to the problem of the growing demand for trees for the protection of crops and human settlements, as well as to meet the needs for wood, fodder and fuel in Egypt.

The specific objectives were:

- to review and evaluate research conducted in the past on forest tree planting in Egypt;
- to complete the Casuarina improvement program initiated in 1975;
- to develop nursery practices suitable for different environmental conditions in the country;
- to carry out trials on different provenances of selected multipurpose tree species;
- to establish a Forest Seed Centre and pilot plantations for the purpose of testing, demonstration and extension;
- to study variations in biomass properties for different tree species for wood, fodder and fuel purposes;
- to conduct short training courses for agricultural officers and technicians; and
- to measure the socioeconomic benefits of tree planting.

**Research achievements:**

The project commenced in March 1989 for 36 months. A twelve month extension was granted without additional funding. Since the project activities have just been completed, only the progress achieved during three years of research undertaken by the Universities involved will be mentioned.

Under the second phase of the Casuarina project, seeds of 17 provenances of *C. cunninghamiana* and nine provenances of *C. glauca* were collected in Australia and tested in a desert site at South Tahrir in 1982–1983. The above mentioned plantations are being maintained by the Desert Development Centre (DDC) where the site is located. Their measurements have produced very valuable information related to the adaptability of these two species in such a hard environment as well as to their productivity. For each species, three specific provenances are performing very well. They can be used to either supply seeds for plantation programs or be introduced in to a grafted seed orchard where improved seeds can be collected and distributed to nurseries in Egypt and other similar desertified areas.

In addition to the Casuarina species, the project has introduced several other forest tree species for testing in six different locations belonging to the three universities. As plantations occurred recently (1990–1991), it is premature to draw final conclusions and/or recommendations about the performance of species and their ranking at this stage.

### **Biomass evaluation:**

#### *Nutritive value and feeding experiment*

Desert agroforestry is the focus of one of the farming systems studied at the DDC in South Tahrir. In this agrosylvopastoral system, *Acacia saligna* is grown under drip irrigation to provide fodder and wood. Results show the remarkable adaptability of this shrub to desert environment. *A. saligna* is well adapted to desert conditions and can be integrated into desert agroforestry systems as a multipurpose shrub.

#### *Root studies*

Forest trees are grown in Egypt primarily as windbreaks to protect fields, orchards and farmsteads, or as multipurpose woodlot for fuel, timber or fodder. While the beneficial advantages of tree windbreaks are recognized, farmers often complain about competition between the trees and crops for water and nutrients. To answer this question, the root systems of six years old *A. saligna*, *C. cunninghamiana*, *C. glauca* and *Eucalyptus camaldulensis* trees grown in plantations irrigated with sprinkler or drip systems were investigated at DDC.

It was concluded that both *A. saligna* and *E. camaldulensis* can be grown satisfactorily under sprinkler or surface irrigation, while *C. cunninghamiana* and *C. glauca* can make better use of drip irrigation systems.

#### *Nursery practices and pilot plantations*

The two state model nurseries at El Nahda and Sadat City have been functioning satisfactorily. A total production of 300 000 of *Acacia* and *Casuarina* seedlings were produced in 1991–1992, most of them distributed to farmers free of charge. During the first year of the project, two private nurseries were initiated. Their production increased by ten folds as a result of the improved seeds they received from the project.

Pilot plantations were established by the Alexandria group, using five species. The trees are less than two years old. A current assessment of the plantation shows that the growth of different species and provenances are good.

**Socioeconomic studies:**

The information collected by the Alexandria University group from the different locations is being examined and analyzed.

**Training:**

Training was undertaken by Alexandria University and DDC in the first and second year of this project. In the third year of the project, one training course was undertaken by the Faculty of Agriculture, Alexandria University, with the participation of fifteen trainees for a five-day period. A second training course was undertaken by the DDC jointly with Alexandria University, which was attended by sixteen trainees for four days.

**DESERT FARMING SYSTEMS**

**Research institution:** The American University in Cairo, Egypt

**Project numbers:** 79-0120 Phase I, 83-0097 Phase II, 85-0193 Phase III

**Background:**

Desert accounts for approximately 96% of the land area of Egypt and the balance is insufficient to support the country's rapidly growing population. In 1981, the Egyptian Government announced plans for reclaiming 1.2 million ha of desert over the next 20 years. The expansion of cultivable land through reclamation from the desert continues to be a major objective in development plans. However, reclamation is slow and costly. Agricultural production on newly developed areas is often constrained by such factors as poor soils, insufficient and poor quality water and inadequate infra-structures. In addition, there is only a very short agricultural tradition in desert areas compared to the Nile Valley. Research on these ecosystems has also been neglected.

The Desert Development Centre (DDC) receives support from several donors in addition to IDRC in an attempt to ensure a holistic approach to desert development. The IDRC research project, which was carried out in three phases, effectively starting in 1980 and terminating in 1990. It was conducted parallel to a Ford Foundation project that examined related socioeconomic conditions.

The objective of this project since its inception in 1980 and throughout its three phases has been to improve the productivity of the virgin desert sandy soils and develop suitable desert farming systems.

The research program focused on introducing and testing crops and crop varieties adapted to desert conditions, adopting proper crop rotations and implementing ecologically compatible culture practices. These factors were correlated with irrigation and water management techniques, different tillage techniques and fertilizers. In addition, special attention was given to identify the most economically and socially acceptable farming systems.

**Phase 1:**

The first stage of this project (Phase I), which started in 1980, concentrated on improving the production of sandy soils by applied research in forestry (windbreak and multipurpose trees), crops (green manure) and animal husbandry.

The objective was to develop farming systems suitable for light texture desert soils with an emphasis on the establishment of productive desert farming systems for management by small-holders and cooperatives. Specifically, this phase aimed to:

- test and evaluate different systems of on-farm water management;
- introduce and assess different tree species for use as windbreaks and other purposes such as firewood, fodder, etc.;
- evaluate different cropping patterns;
- evaluate the role of the animal component in the farming systems; and
- evaluate the socioeconomic aspects of the integrated desert farming systems.

Although the objectives for the first phase were somewhat ambitious and broad, trying to cover several disciplines in a fragile ecosystem, the DDC researchers have done a good job in building an effective multidisciplinary team.

During the first phase, major infrastructures were built or made available, including animal sheds, nurseries, stores, agricultural and irrigation equipment. A considerable amount of data was produced. Following every cropping season, the development of the soil's physical and chemical properties was assessed and compared to virgin soil characteristics.



The data collection and the observations were followed by identification and testing of appropriate methodologies for desert farming systems, irrigation and water management, forestry and animal husbandry.

Research results revealed the difficulty of developing production systems for previously uncultivated sandy desert soils, resulting in very low yields. For the above mentioned reason, AUC and IDRC agreed to pursue the investigations during a new phase.

### **Phase II:**

While a large amount of data had been collected and experiences were gained in phase I, a proper assessment of the most appropriate crop rotations and the evaluation of integrated approach could not be achieved during the period of three years (Phase I). A period of six or seven years was needed for obtaining reliable recommendations. Accordingly, the long-term rotation demonstrations were continued, after modifications, during Phase II. An alternative approach based on the application of zero or minimum tillage techniques were introduced and tested.

The specific objectives of this phase remained the same as in phase I. The main results can be summarized as follows:

- In addition to alfalfa (rotation 1), three other rotations provided favourable results.
- Fertilizer experiments indicated that cereals responded more to Nitrogen than P and K. Potassium fertilizer improved the productivity of sandy soils. Response to micronutrient (Mn and Zn) was remarkable in quantity and quality.
- The first water management experiment was implemented, using three different irrigation regimes and having the same total amount of applied water. Preliminary results were not conclusive.
- The forestry program began at the same time as the project was initiated. A tree nursery was established on the site. Windbreaks were planted to protect crops and multipurpose trees were introduced in the region to provide fuel, fodder and other products.
- Animal husbandry research started in the third year of the first phase. An indigenous breed adapted to desert conditions was introduced. Feeding experiments using crops produced on the

site were undertaken, as well as a study of the impact of sheep on the productivity of sandy soil.

### **Phase III:**

The original duration of this phase was 36 months, but this was extended to 48 months. The project terminated in 1989. Phase III emphasized the importance of the dissemination of results, demonstrating successful practices to some neighbouring farmers and improving their participation.

The objective was to improve "Farming Systems" in newly reclaimed desert lands. In addition to the continuation of the ongoing research on water and soil management, crop rotations, conservation tillage, the specific objective of Phase III was to conduct on-farm research and demonstrations on the land of the settlers of South Tahrir.

The on-farm research covered: crop rotations and appropriate varieties and agronomic practices, soil and water management, and conservation tillage.

### **Research achievements:**

Out of five rotations tested over five to six years, three were found to be promising. The most promising livestock production system was found to be the "alfalfa" cereal rotation.

Fertilizer experiments confirmed the results obtained previously that phosphorus, potassium and nitrogen are important for the desert soils of the region. Zero tillage appeared to have doubtful advantages under the prevailing conditions and was also found to increase weed infestation. Minimum tillage was recommended.

The economic analysis of the experimental outputs failed to reach conclusive results mainly due to changing costs of inputs, fluctuating crop prices and government policies.

### **Conclusions and comments:**

This project lasted almost 10 years, during which the researchers involved developed technological packages specific to a very difficult ecosystem. Their work resulted in improvements to the conditions of life for these marginalized people who are fighting to survive in a harsh environment.

Due to the lack of extension services in the project area, the on-farm demonstration was very limited. It only included seven smallholders. This program encouraged farmers to follow certain crop rotations, to grow better varieties, to adopt new and alternative that were more beneficial. The hope was that in the future, the project's outputs would contribute to utilization of improved practices by more farmers.

If certain results need time to mature and gain confidence, one has to admit that long-term experiments on crop rotations require well-designed experiments. These designs should provide enough flexibility to adapt to changes during the long-term evaluation, yet they have to be strict enough to avoid any confounding effects.

The findings of the "On-farm Demonstration Program" confirm that there is a good potential for improving the performance of small-holders. Signs of prosperity were evident in certain households such as building new houses, buying tractors. However, the project shows that there are some major obstacles to agricultural development. These obstacles include the unreliable supply of water due to power failures and insufficient maintenance of pumping stations and are not related to technical or ecological difficulties.

Finally, the DDC staff has made encouraging progress in learning to grow crops in an exceedingly difficult environment. They have acquired agronomic knowledge that was lacking in their formal training and which is considered essential for any strong researcher team working on desert development.

## **CONCLUSION**

These three projects have directly and indirectly contributed to desertification control by introducing usable irrigated farming systems into the desert and by providing for the proper protection of these farms through the establishment of shelterbelts and wind-breaks using selected material, appropriate nursery technology and innovative planting and maintenance methods.

## **AFFORESTATION**

**Research institution:** Forests and Range Department, National Planning Council, Amman, Jordan

**Project number:** 75-0120-00

### **Background:**

In recent years the Government of Jordan has taken steps to give full support and autonomy to the special efforts being made for the improvement of its land resources. A national forest policy has been adopted resulting in the strengthening of forestry services and the launching of a national afforestation program. This program aims to develop an adequate proportion of land in the better rainfall areas for the purpose of wood production and soil protection. Moreover, the program aims to improve the remaining forests that are degraded.

Most of the afforestation work previously carried out in Jordan is concentrated in the northern zone of the country at high altitudes in areas receiving annually between 250 mm and 400 mm of rainfall. In order to bring the benefit of tree planting to inhabitants living in dry zones and to rehabilitate these degraded ecosystems, IDRC undertook investigations on species and techniques suitable for planting under these conditions. The benefits anticipated under this study are the production of fuelwood and fodder on a sustained-yield basis and the provision of a certain amount of supplies for food and shelter from trees.

This project was carried out by a small silvicultural research unit created within the Jordanian Department of Forest and Soil Conservation. The termination date of the project was 2 December 1979, or forty-five (45) months after the date of acceptance of the grant letter. Two extensions were authorized postponing the termination date until 2 December 1981. However, the proposal for a second phase submitted in 1982 was not accepted by IDRC .

### **Objectives:**

The objective of this project was to improve the effectiveness of the existing afforestation program and to try new techniques for planting trees in desert areas by harvesting runoff water. Specifically, the project objectives were:

- to undertake silvicultural studies to improve afforestation methods on severely eroded and biologically degraded land;

- to evaluate the tree-growing potential of selected sites in the arid zone utilizing rainfall-runoff collection plots; and
- to train local staff in experimental methods for forest research.

**Activities:**

- Testing of three gradoni terraces where forest trees were planted, representing four genus, Acacia, Atriplex, Tamarix and Simmondsia;
- Soil working plus gradoni type trial. This trial tested continuous gradoni terraces at 3 m, broken gradoni terraces spaced at 3 metres and "crescents" built to catch run off. Trees were planted in each component of this trial;
- Fertilizer trials in *Pinus halepensis*; and
- Control of weeding in nurseries.

**Research achievements:**

Few positive and negative conclusions can be drawn from the project's activities. On the negative side, progress throughout the period of 1976–1981 was slow primarily because of technical, administrative and financial problems. The project was not fully successful due to the lack of professional researchers and the poor motivation of the personnel. On the positive side, research workers were well trained, two professional foresters were trained at the M.Sc. level and two research officers took intensive training courses in the U.K. From a biological perspective, experiments showed that certain species like the *Eucalyptus camaldulensis* can survive and grow in desert wadis with a low level of protection.

## **PROSOPIS (Common Mesquite)**

**Research institution:** Agricultural Research Corporation, Sudan

**Project numbers:** 3P-77-0147 and 3P-82-0173

### **Background:**

Natural forests have been seriously depleted in the Sahel resulting in a precarious ecological situation and in a shortage of forestry products (fuel, fodder, building poles, etc.), which are of great value to the rural communities. Sudanese Authorities, realizing the urgency to counter these negative trends, are promoting effective programs of reforestation in order to improve the conditions of life and the harsh environment of the Sahel region.

The scanty and erratic rainfall, which occurs sporadically over the years, and the high cost of classical afforestation programs have made it essential for the Sudanese Authorities to consider cheaper methods of planting forest trees in rural communities. At the same time they are continuing to investigate the utility of the more conventional techniques and their costs. This movement towards reforestation by local communities, using indigenous multipurpose tree species generally well-known by pastoralists and farmers, were welcomed by these communities as they are aware of the value of trees.

The project was developed in two phases. Phase I was approved in 1978 and lasted until 1982. Phase II began in 1983. The file was closed in March 1988.

### **Phase I:**

The objective of this phase was to raise the pastoralist's standard of living. This was to be achieved by introducing ecologically well adapted species and varieties of *Prosopis*, a tree which provides fuel and fodder while combining hardiness with maximum productivity. The specific objectives were to:

- select ecologically well adapted and highly productive varieties of *Prosopis* for Sahelian conditions;
- study the potential of the *Prosopis* species as a source of animal nutrition; and
- investigate how large scale reforestation using suitable species and varieties can be achieved.

**Research achievements:**

During the first phase, several varieties and provenances of nine species of *Prosopis* were planted in screening trials at four sites in Northern Kordofan and Southern Khartoum provinces. The trial sites had mean annual rainfall levels of 150 mm to 400 mm, The sites were fenced and nursery-raised potted stock was used. Artificial irrigation was applied. After 5 years of growth, the results confirm the superior performance of two species; namely, *P. chilensis* and *P. juliflora*. The remainder of the species showed poor survival and growth.

Studies of the nutritive value of *Prosopis* pods were carried out and chemical analysis revealed that the pods have a high nutritive value (13% protein, 25% fibres and 55% N free extract).

The investigations of techniques of large scale afforestation with local *P. chilensis* were mainly directed towards the presowing treatment of seeds, identifying flowering and fruiting characteristics and measuring biomass production from coppicing and from natural regeneration.

In conclusion, the first phase reached interesting results with regard to the most suitable species that was adapted to the arid climate. Trials established in on different sites will continue to yield results of increasing value in the future.

The project also allowed three members of the research team to improve their technical knowledge and facilitate their obtaining Master's degree by using the experiments as part of their theses.

Despite the difficult climatic conditions, in which the project was developed, Phase 1 has yielded satisfactory results.

**Phase II:**

The objective remained unchanged. Specific objectives were:

- to study the growth rate and productivity of promising species and varieties of *Prosopis* in terms of fuelwood and pod production;
- to investigate methods appropriate for large scale plantations; and
- to continue studies on the potential of *Prosopis* pods as a source of animal nutrition.

**Research achievements:**

In comparing Phase I with Phase II, it can be concluded that the major problem of Phase I was the true identity of the local Common Mesquite (*Prosopis* spp). Two researchers devoted their time and effort into defining the local variety by conducting a survey of the different populations of *Prosopis* in Khartoum province. In 1986 they published a pamphlet suggesting that this species is *P. chilensis*. This point requires further investigations and botanical research to be undertaken by specialists.

Measurements of the Phase I plantations continued so as to assess annual and total growth, fuelwood and pod production, survival rate and the effect of different silvicultural treatments on these parameters. The experimental design employed in Phase II appears to have improved over earlier work.

Concerning large scale plantations, little research appears to have been carried out on this objective. One attempt at a large scale and inexpensive plantation seems to have resulted from the 1984 distribution of *Prosopis* pods to villagers for feeding their animals.

Animal nutrition studies have been carried out more smoothly than the species field trials. This was partly because of the good cooperation between local institutions, where the chemical analyses were done, and partly because of the accessibility of the research sites. The results suggest that *P. chilensis* seeds have a higher content of protein than either leaves or pods. Therefore, they might be a useful feed supplement although they should be crushed to ensure complete digestion. This research is considered very useful and has the potential for the improvement of the livestock survival.

**Comments and conclusion:**

Although research staff have proved to be entirely committed to the research activities, working hard to achieve the maximum of the project's objectives, their interest and commitment to the research appears to have declined since 1984. This is due to the growing and constant political and economic problems that affect Sudan.

The progress of work was also affected by the departure of the project's leader who left for another position with a regional organization. His replacement and the accountant also left, which placed all the burden on the Director of the Research Centre who took over and was responsible for completing the project's activities. Communication problems caused frequent delays in the project's activities. Consequently, very few results were obtained. In fact, Phase II turned out to be less successful than Phase I due to the total breakdown of the national infrastructure, staff changes and turnover.



## **SHELTERBELTS**

**Research institutions:** National Forestry Research Institute, Tunis, Tunisia  
National Agricultural Research Institute, Tunis, Tunisia  
Arid Regions Institute, Medenine, Tunisia

**Project numbers:** 77-0018 Phase I, 83-0295 Phase II, 88-0085 Phase III

### **Background:**

Wind is an important element of the climate of Tunisia, a country with an extensive Mediterranean coastline. Winds are a near-constant presence eight or nine days out of ten along the coast and in Gafsa Bay, while in the country's northwest they blow at least six days out of ten. Not only are the winds omnipresent, they are also fierce causing soil erosion, increased evaporation and transpiration, grain lodging, rapid flower desiccation and fruit fall.

As part of its policy to intensify agricultural production and counterbalance a growing grain shortfall, the Tunisian government has launched an ambitious, high-cost program to irrigate a 62 000 ha area in addition to the 175 000 ha already completed. It is believed that, with supplementary irrigation and higher inputs, grain production can be boosted to four or five times the current level.

Under the intensification program, farmland will be developed along the lines of an orchard that is surrounded by windbreak hedges or shelterbelts. The Tunisian Ministry of Agriculture has made it a priority to promote shelterbelt technology and quickly extend it to the peasant population.

Before the project was launched in 1977, the agricultural and forestry research institutes conducted a study, which revealed that most shelterbelts in the country had not been established scientifically and therefore provided crops with only moderate protection. Thus, project activities were initiated in three phases between 1976 and 1993. There were some short interruptions, and a new project manager joined the team at the start of Phase II. The research for Phases II and III was performed by the National Agricultural Research Institute (INRA), not the INRF.

**Phase I:**

The project's primary objective was to determine the physical and biological effects of forest shelterbelts on crops in an effort to increase crop yields while providing maximum, year-round protection from the wind.

The specific objectives were to:

- determine the types of shelterbelt best suited to provide physical protection for crops;
- determine the effects of a shelterbelt upon the microclimate within the sheltered area;
- determine the biological effects of shelterbelts on crop growth and yield in irrigated dry zones; and
- determine the effects of shelterbelt trees on water balance and nearby soils.

Phase I activities started in September 1976 and should have been completed in 1982, however, the completion date had to be extended until June 1982 due to late project start-up. A great deal was accomplished during Phase I, particularly in studying the aerodynamic and climatic impact of shelterbelts in Tunisia's semi-arid lands.

A study of the effectiveness of several types of shelterbelts revealed that mixed types work best in the region. The shelterbelt extends protection over a distance of 28 times the height of the trees, at a threshold of 20% effectiveness.

Impermeable shelterbelts result in higher air temperatures over the entire sheltered area. Protected wheat and bean crop yields were observed to increase, while potato yields doubled. These preliminary results were confirmed in Phases II and III.

On the completion of Phase I, experts from 14 countries gathered together at an international seminar on shelterbelts, held in Tunis in 1983. At the end of the seminar, the Ministry of Agriculture asked regional Agriculture and Forestry representatives to prepare an inventory of all irrigated agricultural areas in the country. The inventory would be used to establish a national program to set up shelterbelts in those areas in order to boost production.

**Phase II:**

Phase II was begun in September 1984 and completed in December 1987. The National Forestry Research Institute (INRF), which had been solely responsible for Phase I, the National Agricultural Research Institute (INRA) and the Arid Regions Institute (IRA) were all involved in the new programme.

The general objective was the same as that of Phase I. The specific objectives, broader in scope, were to:

- determine the effects of shelterbelts on the physiology, successive growth phases and production of market garden plants and citrus fruits in northern and central Tunisia;
- determine the nature and profile of shelterbelt design best suited to arid conditions and examine crop yields in the sheltered areas;
- enumerate the forest species used in shelterbelts and define appropriate arrangements;
- study the cost-effectiveness of shelterbelts; and
- prepare extension material to disseminate the results obtained.

**Main research achievements:**

It is estimated that the research objectives were met, through the parallel efforts of many specialists in a variety of disciplines working together as a well-coordinated team.

Market garden plants: overall tomato production in sheltered areas was 25% higher than in unsheltered areas. Higher air and soil temperatures in sheltered areas boosted early tomato yields by 30%. Fodder crop tests showed a 100% increase in the production of foliage in sheltered areas. Results for citrus fruits were less dramatic, and somewhat less clear. When the shelterbelt was too close to the crop (less than 50 m away) fruit production decreased.

Observation of climatic factors continued at the station to determine the impact of shelterbelts on temperatures within the soil in sheltered areas, as well as on humidity, total radiation, wind direction and strength and temperature fluctuations in the course of the day. By linking aerodynamic studies with climatic observations, researchers were able to test a range of

different shelterbelt types determining their impact on diurnal and nocturnal temperatures.

In view of the importance of saving water, researchers also studied how shelterbelt trees and crops compete for water. The experiment was conducted on an irrigated alfalfa plot protected by a shelterbelt made up of three lines of trees. Results revealed a fertility gradient where fertility rose as distance from the trees increased. There was also a high-competition zone near the trees, an intermediate-competition zone somewhat farther away and a low-competition zone beyond that.

In arid zones, nine shelterbelt types were tested for effectiveness in preventing sand shift. Researchers also studied the impact of natural vegetation belts on barley yields in areas of high wind erosion.

The inventory of forest species used in shelterbelts led to a study of 400 farmers throughout Tunisia and to a paper outlining the main points of the study. The species in question were subsequently established in demonstration plots regularly visited by groups of farmers and agricultural extension agents.

### **Phase III:**

By the end of Phases I and II, which had lasted eight years, shelterbelt research had confirmed the positive and highly significant impact of windbreak protection on the yields (on test plots) of various small-scale agricultural operations. But the dissemination of results obtained in Phases I and II had barely begun; first, had to work on the technical aspects and study the feasibility of shelterbelt technology on farms had to be completed.

The objective of Phase III was to focus on the broad dissemination of results to farmers operating in irrigated areas and to Ministry of Agriculture extension agents.

The specific objectives were to:

- extend shelterbelt methods;
- establish demonstration plots;
- estimate the overall impact of shelterbelts on yields grown intensively with irrigation;
- assess the yields of sheltered crops and shelterbelts in three regions of Tunisia; and

- evaluate the cost-effectiveness of shelterbelts in irrigated areas.

**Main research achievements:**

Few new technical activities were initiated during Phase III. Researchers continued to monitor experimental equipment already in place at climatological stations, and set in motion measures to help farmers learn about the benefits of shelterbelts while providing the financial and technical assistance without which they cannot protect their crops.

Three technical memoranda were completed and presented at a National Shelterbelt Seminar, held in 1989, which gathered together most officials in charge of external (agricultural, forestry, veterinary and extension) Ministry of Agriculture services. Slides taken at experimental sites were combined into a film illustrating the problems of shelterbelts in rural areas which was shown to many agricultural extension agents. The Tunisian media (radio and TV) contributed actively to the extension of the researchers' technical message through another film shown in villages and rural centres.

Three promotional spots on shelterbelts are regularly shown on a special broadcast. Researchers have prepared concise fact sheets that were distributed among farmers and discussed. Some test plots were converted to regional demonstration sites that peasants can visit to gain practical knowledge about crop protection methods.

Priority was given to training national managers in a variety of disciplines at various levels (technicians and engineers). A substantial budget was set aside for professional development internships, university courses and educational trips. These efforts have helped raise the standard of Tunisian research institutions and made it possible to establish a local team of highly skilled, specialized researchers. Training programs have strengthened the bonds between Tunisian institutions, Canadian and European centres by contributing to the transfer of knowledge that will benefit farmers.

**Conclusion:**

Despite the slow pace of Phase I activities, the "Shelterbelt" project has had a real impact on Tunisian agricultural development due to a perfect synthesis of the objectives set by researchers and agricultural production planners. The research combined basic climatological work with studies of the practical problems encountered by farmers in their struggle against wind and sand. It resulted in the development of a comprehensive, sound "technological package" designed to boost agricultural production and protect soil resources more effectively against erosion and progressive desertification.

The project's success is largely due to the participation of scientists from different disciplines who worked together in a spirit of harmony and openness. Research conducted on experimental stations was consistently supported by on-farm demonstrations under real conditions.

These studies are the first of their kind to be undertaken in North Africa and the Sahel. Agricultural and climatological data for the area, particularly on winds and their impact on agricultural production, are scanty. This means that both the basic and the practical achievements in Tunisia will be very useful to farmers throughout the Maghreb.

As we saw in Egypt for the "Casuarina" project, it took a great deal of effort to help farmers understand and accept the technical message and bring them to the point where they could take over. This was not achieved until the end of Phase III, more than 15 years after the studies were initiated.

The only way to speed things up is to work hand-in-hand with farmers from the very start and through every stage of the project, constantly adjusting scientific procedures in response to the stated goals of project's beneficiaries. This approach implies a profound change in researcher's attitudes and working methods, and requires them to keep an open mind and listen carefully to non-researchers.

But time can only be compressed so far. All projects must be allotted enough time for researchers to obtain "usable" results and integrate them into the production process.

## **ROOT SYMBIOSIS**

**Research institutions:** Forestry Research and Experimentation  
Division, Morocco

**Project numbers:** 85-1007 Phase I, 90-0063 Phase II

### **Background:**

Some 40% of the energy used in Morocco is derived from wood and coal. Recent studies have shown that the amount of wood harvested by the government represents barely 20% of that taken by the local population for fuelwood and construction. Existing forest capital, which regenerates slowly, is thus severely compromised, with the result that some 20 000 to 30 000 ha of natural forest are lost each year.

To make matters worse, mountain regions where most large tracts of forest are found, are subject to intense water erosion, exacerbated by the clearing of slopes.

The Moroccan government has introduced two programs (the National Reforestation Plan and the Struggle Against Erosion) based primarily on intensive, large-scale reforestation (approximately 20 000 ha/year). Tree planting efforts have had limited success as seedling mortality rates topped 30% in the second year of planting. These high figures, which raise the cost of reforestation, are due to the poor quality of seedlings produced in state nurseries.

The mycorrhization of seedlings in the nursery is a low-cost, "soft" technique that strengthens them and raises their resistance to transplantation and water stress. It is considered that inoculated seedlings can be produced in the nursery for use in intensive reforestation programs.

### **Phase I:**

The general objective of Phase I was to learn about large-scale mycorrhizal production and inoculation methods in order to improve the yields of conifer species used in reforestation programs in Morocco.

The specific objectives were to:

- identify, isolate and reproduce local mycorrhizal strains able to form a relationship with the main conifer species;
- select the mycorrhizal strains that demonstrated the most effective symbiosis; and

- determine the impact of selected strains on seedling performance at reforestation sites.

### **Main research achievements:**

On-site studies revealed a latent mycorrhizal population, with very low numbers of propagules, in Moroccan forests. Several fungi were isolated in pure cultures from ectomycorrhizae originating in forest nurseries or natural forests.

In the nursery, Maritime pine and Canary pine seedlings were inoculated with a local fungal strain, after monitoring its development in the field. Seedlings inoculated with *Pisolithus tinctorius* were introduced into four different ecologic regions in order to determine their on-site survival rates and growth in comparison with non-inoculated seedlings.

### **Phase II:**

Phase II research activities began in August 1991 and are still under way.

The general objective was the same as in Phase I: to increase plantation yields by using ectomycorrhizae in nurseries.

The specific objectives were to:

- inoculate seedlings in experimental nurseries with improved strains of *P. tinctorius* and study their on-site performance;
- produce seedlings inoculated with the most effective strains of *P. tinctorius* in pilot nurseries; and
- promote the use of mycorrhizal inoculation among reforestation workers through extension activities.

As project activities are still under way, there are no conclusive results. Tests on controlled inoculation with *Rhizopogon* spp. spores are proceeding in three pilot nurseries. Both the percentage of inoculated seedlings and the percentage of ectomycorrhizae per seedling required for effective performance have been determined. Furthermore, researchers have produced liquid vegetative inoculates from a total of ten different pure cultures; each was used to inoculate 100 Maritime pine seedlings. When the seedlings are 6 months old (3 months after inoculation), the percentage of inoculated seedlings and the mean percentage of ectomycorrhizae per seedling will be assessed.



A three-day workshop was organized by researchers to train nursery technicians in the new technique and familiarize them with experiments conducted as part of the project.

## **ARAB DATABASE FOR ARID-ZONE PLANTS (ADAP)**

**Research institution:** Arab Centre for the Studies of Arid Zones and Dry Lands (ACSAD)

**Project number:** 86-0057

### **Background:**

Approximately 5000 plant species grow in the arid lands of Arab countries. These plants have direct and indirect usages for mankind. Indirect usages includes providing grazing for livestock and maintaining the environment. In the Arab countries, these xerophytic plants produce more than 50% of the forage consumed by livestock. An example of a direct usage is the usefulness of woody plants. Woody plants are used as source of fuel by people, they form the habitat for wildlife and protect the soil from erosion.

Some xerophytic plants can be used as genetic resources for breeding crops. Natural vegetation is also used as a criterion for soil classification and the recognition of areas suitable for agriculture.

Xerophytic plants exist in fragile ecosystems very susceptible to degradation. Thus, there was a need for an information unit that collected, indexed and disseminated information regarding xerophytic plants. This information unit could also be used to develop a database consisting of published and unpublished research reports, project reports and pertinent information received from local sources. A long term goal of such a database is that it would be made available and accessible a range of users.

IDRC provided funds for an Arab Database for Arid-zone Plants (ADAP). The project commenced in May 1987. It was granted a six month extension and concluded in April 1992. Information was collected and stored by the system and included all the important plant species that grew in the Arab region. The project covered the arid zones of the Arab countries. The information was comprised of: taxonomy with local names; ecology and life forms; geographic distribution in relation to vegetation communities; and biology and ways of reproduction.

### **Objectives:**

The objective of this project was to establish an information system for xerophytic plants in the Arab countries designed to meet the needs of researchers and those concerned with the use of xerophytic plants.

It was also to provide information services to a wide spectrum of development projects. The creation of an Arab Database for Arid-zone Plants

at ACSAD made all the information gathered on xerophytic plants available to the 20 member countries of ACSAD.

The specific objectives were:

- to establish a database on xerophytic plants in the Arab countries;
- to store and retrieve source documents dealing with xerophytic plants in the Arab countries; and
- to disseminate available data on xerophytic plants to the users in the Arab countries.

**Research achievements:**

An integral database system using Dbase IV was developed and linked with the two textual databases, a reference and a thesaurus. The database includes over 1300 important botanical species native to the Arab countries. The various processes for data input and modification, including those for handling specific inquiries and extracting printed outputs, were designed to be user friendly. The system was tested during a training seminar in 1990 to improve its efficiency.

The project produced manuals, lists of species, a dictionary and references to serve as a guide for the users of the system. The manuals and references will be modified as the need arises.

A comprehensive data collection sheet and a user guide were prepared providing practical examples. A detailed system operation manual was also prepared to train the personnel of the participating national institutions and to ensure eventual dissemination of the system to other institutions.

The project had a human resource and development component: a study tour by senior project staff, training of ADAP range management engineers, training of national personnel and a promotional seminar geared towards senior managers as potential users of ADAP services. In 1990, a training course was held for 21 individuals from the national participating institutions from six countries. The trainees were introduced to the ADAP database.

A special unit was established to disseminate information on the ADAP services. Inquiries can be submitted according to their environmental, botanical or economic value. Questions presented by a variety of users can be answered efficiently.

**Conclusion:**

The project was successful in accomplishing the stated objectives. At the conclusion of the project, ACSAD was provided with a functioning database at the service of Arab countries. Although the amount of data already recorded can not be considered exhaustive or absolute, the work can be considered an effective initiative aimed at improving and the safeguarding knowledge about plants in fragile ecosystems prone to degradation. The scientific material produced is of the utmost interest and importance as it provides assistance for scientists, managers and technicians in the Arab countries and could be widely used if ADAP is "marketed" correctly by ACSAD. It is recommended that efforts be focused on the "Dissemination/Utilization" strategy for ADAP in parallel to its expansion by adding new plant species or other components.

## **AGROECOLOGICAL CHARACTERIZATION**

**Research institution:** International Centre for Agricultural Research in Dry Areas (ICARDA), Syria

**Project number:** 88-0281

### **Background:**

The Middle East and North Africa region contains 978 million hectares of land, of which about 35 million hectares are under irrigation and 93 million hectares are rainfed. In addition to the variability of weather over time, there exists a wide range of diverse climatic conditions, soils and other land resources across space. The weather-induced uncertainty, in addition to the local diversity of land resource, complicates the planning, conduct and interpretation of agricultural research, the extension of research findings and the formulation of effective agricultural policies. Consequently, improved agricultural technologies must be tested in a range of possible environmental conditions, to ensure that adaptations are appropriate. This makes agricultural research in these regions time consuming and costly.

These problems can be alleviated with the help of simulation techniques. Using simulation, the results of experiments are supplemented with simulated data predicting performance over a large number of years and a variety of sites. Such methods are largely untested in semi-arid environments, despite the fact that their use elsewhere has been shown to be of considerable value in clarifying the understanding of plant-environment interactions. ICARDA has assembled a wheat growth simulation model, SWG, a spatial weather generator and MULTISIM, a multivariate crop yield generator. ICARDA has also developed a package for agro-ecological characterization (PAC). The project was designed to validate this tool in Morocco and Turkey. These countries were selected because of their contrasting climates and the availability of time-series data sets.

This project commenced in 1989 and has been extended twice. It will terminate in October 1994.

Several institutions are involved in the project. A coordinating institute has been selected by each of the national programs: INRA (Institut National de la Recherche Agronomique) in Morocco and APK (Council for Research Planning and Coordination) in Turkey. The national meteorological services of Turkey and Morocco have both undertaken studies to define agroecological zones of their countries.

To thoroughly test the package, wheat has been selected as the test crop since it is the major food crop of the region. This crop has been intensively studied, a widely tested computer simulation model is available and data are already available from national programs.

The project supports scientists from ICARDA and agricultural research institutes and meteorological services in Morocco and Turkey to jointly undertake the testing and calibration of PAC and demonstrate its value to agricultural research.

**Objectives:**

The objective of this project is to make available simulation modules for the characterization of variable agroecological conditions, including their impact on agricultural systems, to national institutions.

Specific objectives are:

- to calibrate and thoroughly test a set of models for characterization of physical agricultural environments;
- to adapt and demonstrate the usefulness of PAC for solving problems of national relevance, in the area of agroecological characterization, identified by national institutions;
- to train national staff in the theoretical background and practical application of PAC, database maintenance and management;
- to document and disseminate PAC and the experience gained during their validation and application for future users.

**Research achievements:**

From the Moroccan side, although data including information on rainfall and maximum/minimum temperatures for over a 30 years period for 187 stations were made available, the data was not fully validated because many series were fragmented, containing major gaps.

Contour maps at 1:500,000 scale have been digitized for project areas. Significant progress has been achieved in processing soils data from project area. A unified soil map covering nearly 70% of the area has been constructed using several different soil classification schemes. A large portion of this map has been digitized. Parallel to drawing and digitizing the maps, representative soil profiles are being prepared for each mapping unit. So far, over 50 profiles have been defined. Also, data sets for the validation

of the wheat model (SIMTAG) were acquired from stations in the northern and southern parts of the project area for which the model had not been previously validated.

With reference to crop yield data, some useable data for a small number of villages was obtained. The collection of more data from the northern portion of the project area is anticipated. However, there is some delay in the validation of SIMTAG even though the data sets for this purpose were assembled. Estimation of global radiation and sunshine was undertaken by the Meteorological Service using programs that made it possible to obtain monthly coefficients for a small number of stations for which both radiation and sunshine data are available. The Moroccan team is presently undertaking a number of case studies using PAC such as: a climatic atlas, a soil map, an assessment of drought risk during the different development stages of wheat, optimal planting time for wheat, optimally adapted wheat varieties, optimal strategy for supplemental irrigation of wheat and land suitability for various crops. These case studies will be presented to a workshop in March 1994 the proceedings of which will be published.

**Training and dissemination activities:**

- three in-country training workshops held in Morocco;
- participation of staff from different Moroccan agencies in the case studies discussed above;
- publication of package user manual; and
- publication of workshop proceedings.

In Turkey, precipitation and temperature data for all 69 synoptic and climatic stations and data for nearly 100 precipitation stations has been fully validated through a long series of more than 50 years duration. Except in the collaboration with the meteorological services, the project made very little progress in more than three years and collaboration with the agricultural research institutes and required crop/soil data sets are still not available.

The idea of using the 1:800 000 scale soil map of the country was rejected due to its oversimplification and difficulties in defining reference soil profiles for the mapping units. It is planned to digitize a 1:1 500 000 scale map and complement it later with greater detail from the large scale map. Researchers have put together a very detailed soil map at 1:200 000 scale, covering the project area, with the exception of one province in the southeast.

The assembly of data sets in the format required for the validation of CERES-wheat began in one site representative of the eastern part of the

project area. As the Turkish climatic data sets were not available until recently, the Spatial Weather Generator (SWG) could not be validated at the time of the assembly of the data sets. The good quality of the data sets now available guarantees that a proper validation will be possible in the near future.

### **Conclusion:**

This project had to be extended for two years for a number of reasons. An analysis of these reasons is essential for an understanding of some of the difficulties involved with similar projects. The most serious of the problems encountered relate to difficulties caused by the slowness with which data become available. This was largely caused by the size of the task of digitizing the data and the need assess its quality because it came from numerous meteorological and agricultural research stations. In Morocco it took four years instead of two to assemble all the climatic data required from the project area. This problem raises the very important requirement that minimal data set need to be determined.

A second issue relates to the need of developing "user friendly" computer packages. The amount of training required in this project for the institution of proper data quality control and in the use of programs and computer models was quite extensive. Efforts need to be put simplify these requirements.

Finally, this project highlighted a number of problems related to collaboration between institutions that traditionally are not used to working together. In this case between the meteorological services and agricultural institutions.

In spite of these problems and the delays, it can be said that usage of the advanced techniques for agro-ecological characterization introduced by the project and their utility is now firmly established in Morocco, and that the usage of the methods and tools provided will continue after the completion of the project.



## **PASTORAL SYSTEMS OF THE MAGHREB**

**Research institution:** Arid Regions Institute, Tunisia

**Project number:** 89-026

### **Background:**

This project is the Tunisian component of a series of three studies on pastoral systems in North African countries. Phases I and II were implemented in tandem with similar projects in Algeria and Morocco. Phase I consisted of a survey and inventory of the research zone.

The research zone, Neffatia, is located in the southern part of Tunisia. It receives an average annual rainfall of 170 mm. Soils are subject to extremely high wind erosion and 45% of the land is vulnerable to sand encroachment. Vegetation in the area is currently overexploited some consequences of which are a reduction of the vegetative cover and in the number of fodder plant species, as well as an acceleration of the desertification process.

Socioeconomic changes on the southern Tunisian rangelands in the past three decades have caused many patterns to alter: former nomads and semi-nomads are more permanently settled; communal land is being privatized more quickly; and grain farming and tree plantations are becoming more extensive. The results of three decades of development in the region are not satisfactory because the ecosystem is deteriorating constantly while disparities in land ownership, livestock herds and farm equipment are appearing.

### **Main research achievements of Phase I:**

Extensive stockraising is the main agricultural activity, though productivity in numerical terms is low. The fragmentation of formerly communal land used primarily for stockraising has led to their privatization and to greater diversification in economic activities.

Large farms with substantial land resources, where stockraising still dominates, have succeeded in maintaining a satisfactory quality of life, while traditional pastoral farming is facing numerous obstacles and finding its very existence threatened. Pastoralists, who engage in stockraising in conjunction with agricultural and other lucrative activities, enjoy a satisfactory standard of living, while peasants who are landless or work plots of inadequate size are marginalized and must work off the rangeland to live.

The physical survey completed during Phase I showed the region to be characterized by a very wide variety of ecological microzones made more

complex by the diversity of its residents' land base. The situation-specific development plans to be tested during Phase II focus on a range of objectives: rangeland regeneration; immobilization of shifting dunes; enhancement of various soil types; olive plantations; and improvements in sheep and goat husbandry.

Experiments on test plots have just begun, and no results are yet available. However, it should be noted that the experiments will be founded on "shelterbelt" project results and use the vast body of ecological data for the region collected under that project. This will clearly save time and make it possible to integrate on-site activities more quickly. The first annual report in Phase II makes no mention of measures to allow for pastoralists' input into technical proposals, nor of their involvement in the success of project activities. But if pastoralists play no active role in project activities, those activities will remain, as they have always been in the past, the exclusive province of local technicians and will have no significant impact on the future of the area.

## **PASTORAL SYSTEMS OF THE MAGHREB**

**Research institution:** Rural Development Branch National  
Agricultural and Veterinary Institute ,  
Morocco

**Project number:** 3P-89-026 Phase II

### **Background:**

This project is the Moroccan component of a series of three studies on pastoral systems in North African countries (Algeria, Morocco and Tunisia). The two-phase project was implemented by an INAV multidisciplinary team, in close cooperation with local representatives of technical ministries in charge of rural development. During Phase I, which lasted 15 months, researchers defined the zone under study and identified natural resources, rangeland exploitation methods and constraints to zone development. Work was delayed somewhat in the first year due to coordination problems and personal conflicts within the team, but the delays had no impact on the quality of research or its results.

Morocco's pastoral resources have declined significantly in recent years, due to a variety of climatic and socioeconomic factors. By virtue of their material conditions and social marginalization, pastoralists have become one of the most disadvantaged social classes. Population growth and low rangeland productivity have led to profound socioeconomic changes in the Moroccan rangelands since the 1960s. These changes in turn have led to even more profound transformations in rangeland exploitation methods and the living conditions of the rangeland population.

The project zone is located 400 km south-east of Rabat, in a region that has been significantly short of rainfall for ten years. Most nomadic pastoralists in the zone are extremely impoverished. They have small herds, engage in subsistence-level stockraising and have little access to services and credit. No development projects are planned for the zone, which seems to have been abandoned by the authorities of the government.

The survey completed in Phase I revealed that rangeland dwellers exhibited less social instability than those in other pastoral regions. Environmental deterioration seems to be more closely associated with low herd mobility and a series of drought years than with an increase in herd size.

### **Objectives:**

The project objectives are almost identical to those of the Algerian component: to produce an analysis of the zone, study the institutional

organization, action strategies and economic dynamics in the region and establish methods to improve pastoral output. Researchers encouraged beneficiaries to participate in the studies. The project fostered a more general approach to institutional range management in Morocco.

**Main research achievements:**

A study of government activities in the zone revealed that most development projects have not been very successful. Development has frequently been limited to technical considerations with no regard for complex human factors and sociological data and with no effort made to inform the people concerned. Officials focused on improving grazing. The real needs of the people, however, are both more diverse and more immediate. They include adequate water supplies, herd health monitoring and credit availability. Furthermore, communications between the zone and the outside world must be improved.

As part of the project, researchers conducted a comprehensive study of 148 pastoralists in the four sections that comprise the rural commune of Missouri.

Production systems featured communal ranges with subsistence-level family stockraising. Fodder production has fallen sharply after a decade of drought; as a result, the local population is more dependent on the outside world. Herds are being supplemented with market-bought barley, more ewes are being sold and more people are migrating to the cities. Drought has caused herd size to drop considerably. The herds are owner-operated and are owned by the pastoralists studied.

Transhumance over great distances outside the region has become very rare; most movement occurs within a radius of 20 km. Inadequate grass production is forcing pastoralists to supplement grazing for 6 to 10 months a year. All the pastoralists studied engaged in some rain-fed farming, growing barley and wheat on small tracts on the range cleared by themselves or their ancestors. The results of previous research can be used to improve the pastoralists' ecological environment and living conditions. One priority is to encourage pastoralists to find ways to conserve runoff water and use it to revegetate microplots. Current herd productivity, which is very low and would probably be boosted by healthier conditions and improvements in herd genetics and nutrition.

Studies on the dynamics of fodder resources in Missouri have shown that rangeland is not degraded over the entire zone. Camps where pastoralists pause during their wanderings are the areas most vulnerable to overgrazing. The density of such camps and their mobility in a given zone may be

determining factors in the deterioration of the vegetation cover. That deterioration in turn forces pastoralists to sell animals regularly to pay for supplementary fodder, cover credit costs and pay herdsmen.

Herd size thus tends to be governed by climate and rangeland conditions. This means that the changing way of life of Missouri pastoralists will not automatically lead to an increase in the number of animals on low-productivity rangelands and indeed may lead to reasonable stability in an uncertain environment.

Pastoralists living in a difficult, low-potential environment like Missouri have evolved specific strategies to deal with their precarious situation and ensure their own survival while stabilizing the fragile ecosystem that surrounds them.

Their methods include:

- limiting herd size;
- exploiting fodder resources with caution; and
- relatively extensive emigration.

Taken together, these practices and attitudes illustrate pastoralists' awareness of their uncertain living conditions, as well as the extent to which they consider themselves an integral part of their environment. They seem to have far less interest in intensifying stockraising than in safeguarding their extensive production system and protecting their way of life from vanishing altogether.

Their survival strategy is founded on management by consensus. Since rangelands are owned collectively, all pastoralists without exception are guaranteed access to environmental resources with specific range areas allocated to individual families and groups.

The project team developed a new approach to gain a clearer picture of the pastoral system practised in the zone while learning about the pastoralists' living conditions and achieve a better understanding of their motivations and strategies.

After numerous visits to the zone, one research team member stayed permanently with the group of pastoralists under study. Sojourns with pastoralists' family units were interrupted by dialogue with other researchers so that study methods could be adjusted as required.

A new phase, instituted in 1991-92, was to culminate in a system where pastoralists and local technicians would jointly monitor experiments and the improvements proposed for the zone. Herdsmen were to be responsible for monitoring such factors as vegetation conditions, animal behaviour and weather conditions. These activities would help researchers understand how pastoralists perceive the rangelands ecosystem in relation to their herd management methods. The study, discussed by researchers, development agents and pastoralists, led to the development of concrete measures to improve pastoral potential. It is an attempt to share pastoralists' knowledge about their rangelands and involve them directly in the selection of technical options aimed at boosting production and improving fodder resources management.

## **PASTORAL SYSTEMS OF THE MAGHREB**

**Research institutions:** Centre for Research on Development Economics, Algeria

**Project number:** 89-0265 Phase II

### **Background:**

This project is the Algerian component of a two-phase activity also being conducted in Morocco and Tunisia. Phase I consisted of establishing an approach and methodology, defining study zones in each of the three countries, identifying their resources and determining the information available on physical and socioeconomic aspects of the various environments. Most Phase I objectives have been satisfactorily achieved. An impressive mass of data has been collected and analyzed, making it easier for researchers to define objectives and complementary studies for Phase II.

The Algerian rangelands covers some 20 million hectares between the 100 mm to 400 mm isohyets. The space is put to direct use by a pastoral and agro-pastoral population estimated in 1977 to number about 400,000. Growing herd size and an increasingly sedentary way of life have resulted in overgrazing of the rangelands and its consequent deterioration. This disruption of the former ecological balance has been accompanied by growing internal contradictions within pastoral society. In contrast to the past, herds are increasingly concentrated in the hands of a rich minority.

Among the three Maghreb countries, Algeria has made the most systematic effort to improve living conditions for small and medium-sized agro-pastoralists on the rangelands. It has adopted a series of administrative laws and regulations and in 1977 it eliminated certain taxes levied on farmers and pastoralists in the region. It has also introduced a range of incentives for the local population.

However, Phase I results revealed that most government initiatives had failed, for three principal reasons:

- some of the measures taken were not properly suited to the region;
- the population had no input into government decisions; and
- sociological data for the region were not taken into account.

Initial results of studies conducted in one of the two zones have confirmed that living conditions for the local people are fairly marginal and that the physical environment of the rangelands is being intensively degraded.

#### **Main research achievement of Phase I:**

A study of production system dynamics showed that permanent settlement has increased greatly (75%) and that agro-pastoralists engage in a range of activities. Household income is derived from stockraising, farming and other income-generating activities such as trade and construction site work.

Although there are no major land or herd owners in the zone, herds do tend to be concentrated in the hands of a few individuals. Over one third of the pastoralists are absentee owners, contracting the care of their flocks out to herdsmen. Grass fattening of animals for the market, a practice unknown in 1977, is becoming current today.

Families with medium-sized herds (10 to 100 head) constitute 35% of the total. Generally, their herds exhibit low productivity and poor performance. Veterinary products are difficult to obtain, and thus few health protection measures are taken.

Since fodder productivity on rangelands is low, pastoralists need to provide supplements more frequently either by purchasing concentrated feed or by growing grain on the range. These yields are extremely low.

Water supply is becoming an acute problem for both people and animals. As a result, most of the pastoralists' demands of the government are for adequate water. Water shortages lead to the underutilization of rangeland located far from wells and the overexploitation of areas near water supply points.

In conclusion, researchers found that the zone exhibited advanced deterioration of the rangeland with intense erosion (particularly in cultivated areas) and a severe climate with only 200-300 mm of highly erratic rainfall. Soils were thin, very fragile and low in organic matter.

#### **Phase II:**

Phase II started in 1990 and was to last 36 months. Its general objective was the same as that of Phase I: to achieve a sustainable increase in production and improve the living conditions of small and medium-sized pastoralists and agro-pastoralists on the Algerian rangelands while halting the rangelands's deterioration and fostering its regeneration.



Research activities were conducted in two zones subject to different rangeland use and deterioration conditions. A body of qualitative, quantitative and technical data was collected from 20 agro-pastoralists in each of the two zones. The population was encouraged to participate in the situation analysis and in establishing development plans and herd management methods.

The specific objectives were to:

- examine the land ownership system in the zones under study and determine its impact on pastoral resource management;
- study pastoral production systems to establish methods of raising pastoralists' incomes;
- submit practical proposals for integrating the participatory approach into development planning to institutions in charge of rangelands development;
- in cooperation with the local population, formulate technical proposals for pastoral unit development;
- test a number of agro-pastoral improvement methods in the field and assess their technical and socioeconomic impact; and
- provide team researchers with complementary training on methodology.

**Main research achievements:**

The land ownership system was studied by means of monthly exchanges with 20 agro-pastoralists in two communities. It appears that the most intense conflicts arise between pastoralists on the rangelands and members of the same tribe living in villages. The village dwellers grass-fatten their animals and also want to enjoy the benefits of "communal" rangelands.

The research showed incomes to be higher than generally stated and well integrated into the market economy. Those who can be called "poor" do not live on the rangelands but work in the towns. Any increase in agropastoralists' income is closely tied in with herd productivity. In particular, animal mortality must be reduced through veterinary monitoring, reproduction performance must be improved and the cost of purchased feed minimized. Pastoralists must have sufficient fodder available on-site to keep their herds healthy and keep productivity up. Some ways of achieving this include planting fodder shrubs, improving barley yields and sowing fodder species.

Researchers have not yet studied the problems associated with the participatory approach to formulating development plans for the zone. That activity is scheduled for 1993.

### **Conclusions:**

Initial studies conducted in the two zones on the Algerian rangelands revealed the diversity of social, economic and environmental conditions that prevail. Despite the presence of substantial fodder resources and a favourable climate, land ownership patterns are shifting away from the traditional "communal" approach towards rangeland appropriation by individuals. There is also a trend towards production systems that combine agriculture and stockraising.

Pastoralists in these zones are generally comfortably off and have sufficient means to make fairly substantial investments. Their general investment strategy is to appropriate rangeland and extend grain growing activities. Barley, grown on land ill-suited for it, is used primarily as fodder. Its production serves to confirm the grower's right of ownership to the plot on which it was grown, a plot no longer used by the commune as pastureland. The "race for land" and the rapid transformation of the rangelands from "communal" territory to a patchwork of ever-larger plots, privatized *de facto*, attests to the fact that traditional, communal farming methods no longer work. Social structures, which once served to apportion rangeland use among those entitled to it, are no longer able to arbitrate cases of conflict nor to determine the way the land will be used.

The effect of cultivation upon rangelands is twofold. Firstly, cultivation cuts into the total range area and reinforces the dominant position of the more prosperous social classes who can afford to clear, fence in and work new lands. Secondly, grain growing destroys soil structure making the land vulnerable to all types of erosion. The soil ends up completely sterile, loses all production potential and yields to encroaching sand dunes.

Future studies must focus on ways to replace confrontational rangeland exploitation methods gradually with an approach that preserves the historic rights of local communities and guarantees the sustained productivity of the pastoral sector, in an open economy, with the aim of meeting Algeria's requirements for pastoral products.

Pastoralists will accept technical innovations only if they have greater input into decisions affecting their environment and only insofar as technical improvements do not overextend the finances of individual households.

The Algerian government has established a variety of organizations to develop the rangelands. These are supported by an impressive array of legal and regulatory instruments. However, the High Commission for the Development of the Rangelands (HCDS) seems to have recognized the fact that the local population needs to be consulted and involved in the planning, implementation and assessment of projected development plans.

Development agents are still not taking a sufficiently flexible approach in reformulating projects and implementing them locally; the projects frequently fail to have any impact on the local population.

## **GENERAL CONCLUSIONS ON THE THREE PASTORAL SYSTEMS IN THE MAGHREB PROJECTS**

The parallel studies of problems associated with pastoral systems in the three Maghreb countries was an excellent IDRC initiative. The IDRC has tackled one of the most difficult and complex issues related to rural development in the Maghreb.

The national research teams involved have done superb analytical work. In each country, they played an important part in drawing the attention of government authorities to the increasing marginalization and poverty of pastoralists and agro-pastoralists living on the North African rangelands. All three countries are undergoing rapid change in land ownership and herd management patterns, and all are seeing a shift in the pastoral sector's place in the general economy.

Pastoralists and agro-pastoralists are becoming poorer because of a significant degradation in pastoral ecosystems under the combined effects of drought and human activities.

The project's main objective was research with a participatory, interdisciplinary approach. Project activities served to highlight the obstacles and problems inherent in that approach, which seemed to mean something different to the researchers in each of the three countries.

The researchers' varying perspectives reflected their diverging views of what they considered an appropriate level and degree of participation by the groups involved (researchers, development agents and agro-pastoralists). The projects illustrate three broad trends, with agro-pastoralists involved to varying degrees in the implementation of development proposals for the regions studied.

The projects have made it possible to develop a new approach to pastoral systems in North Africa. Socioeconomic, cultural and historical factors in the three Maghreb countries were studied closely. In all three countries, a dialogue emerged between researchers and pastoralists; the pastoralists were not considered subjects for investigation but seen rather as partners, who through their experience and knowledge made a positive contribution to proposed development plans for the zone under study.

The achievements of the studies were twofold: they served to highlight similarities between the three countries and to reveal significant differences between current conditions in the rangelands.

In Tunisia, stockraising has for many years been one component of an integrated production system that combines it with annual tillage crops and fruit farming. Formerly communal rangeland has now been privatized, with the government opting to focus on irrigating the region to boost agricultural production and raise the living standards of the agro-pastoralists.

In Algeria, stockraising has remained a pastoral activity. The country has significant fodder resources. Rangeland is starting to be worked by individuals with a trend towards agro-pastoral production systems.

In Morocco, the zone under study was both dryer and poorer. Extensive stockraising remains the main source of income, and operations are communal. Researchers in Morocco opted for in-depth studies of human and physical environments in the zone, as well as of resident pastoralist expertise.

Pastoralists were closely associated with the study and consulted prior to the implementation of specific technical projects.

This approach required a major commitment by researchers, who had to remain discreet and set aside adequate time for cooperation with pastoralists who are the ultimate beneficiaries of the project's activities.

## NEW LAND WATER SURVEY

**Research institution:** Desert Development Centre, American University Centre, Cairo, Egypt

**Project number:** 89-0094

### **Background:**

The five year Land Reclamation Plan for Egypt (1987-1992) stipulated that approximately 61,000 ha. must be reclaimed annually. Most of this area is desert, which planned to be irrigated by either Nile or groundwater. A major concern regarding this ambitious land reclamation plan was the uncertainty of the availability of water in sufficient amounts to meet both irrigation and domestic needs. In addition, there was scepticism as to whether the quantities of water allocated to the reclaimed lands in the Water Master Plan and Land Master Plan were based upon the actual water requirements of specific crops and cropping systems.

In the past, there has been a limited number of studies on crop water requirements, the crops best adapted to irrigation in desert conditions and the management of the irrigation of desert soils under Egyptian conditions. There was also limited knowledge concerning the social organisation of water distribution in the new lands and the farmers' attitudes vis-a-vis an eventual implementation of a water pricing policy by government. The collection of this information was necessary for the identification of sound and sustainable long-term development of the Egyptian deserts.

To accomplish this goal, the DDC planned to undertake a survey of existing information pertaining to the different aspects of water management. The results of this survey formed the basis of water management studies for the South Tahrir region.

### **Objectives:**

The objective is to document and critically evaluate the information available on the technical, economic and social aspects of water utilisation in the reclaimed lands, with special emphasis on South Tahrir.

#### Specific objectives:

- to collect and evaluate existing information on national requirements, availability, allocation and delivery of irrigation water for desert agriculture;

- to examine the government's direct and indirect water pricing policies and to study farmers' attitudes toward these policies;
- to critically review the literature on water requirements and the efficiency of water use for the major crops planned to be grown under irrigated desert conditions; and
- to review the literature pertaining to the efficiency of different irrigation techniques used in desert agriculture in Egypt.

**Research achievements and conclusions:**

The project's activities lasted only for three months in 1989 and resulted in a state-of-the-art report on the conditions of water use in the land reclamation area with a number of recommendations.

In relation to planning for the development and use of water resources by the year 2000 and beyond, the report indicated the main factors to be taken into consideration. A plan was proposed for improving the efficiency of water use by achieving maximum restraint in water use and maximum control in water conveyance and distribution. Sixteen proposals were submitted relating to agriculture. Drinking water and industrial use were also mentioned.

According to these suggestions it is stated that the availability of water would not be a limiting factor to Egypt's economic growth if this resource were properly utilized and the necessary control and maintenance projects implemented. A scenario for water use by the year 2000 was suggested as a transitional stage between the current, low efficiency system of 45% to 55% and an ideal system where the field irrigation efficiency reaches 75% under surface irrigation and the drinking water use efficiency exceeds 90%.

A significant amount of water could be obtained from the development of groundwater as well as from rain and runoff in the Egyptian desert and Sinai. Continuous monitoring of water inputs and outputs at the various water establishments, and for the Nile as a whole, is essential to improve the efficiency of water use and to accurately determine losses and gains.

Finally, the project team made some recommendations regarding the pricing policy.

## ACACIA ROOT SYMBIOSIS

**Research institutions:** National Forestry Research Institute,  
Tunisia  
Laval University, Quebec City, Canada

**Project number:** 89-1016 Phase II

### **Background:**

Some 35% of Tunisia's total area is taken up by extensive rangelands, which are being improved and enhanced by the planting of such fodder shrubs as *Acacia cyanophylla*. Fodder production resulting from reforestation activities is estimated at seven hundredweight per hectare, more than double the soils' usual potential. To that figure can be added the wood of trunks and branches used as fuel. The increased productivity of marginal lands was achieved by planting high-performance vegetation well suited to the various soil types found in the zone and particularly tolerant of saline soils.

The project's aim was to test a number of microbiological and micropropagation techniques in an effort to obtain genetically superior acacia clones with higher nitrogen fixation capability. Analysis of the microbiological complex associated with the species is one rapid and fairly economical way of boosting the productivity of reforestation activities.

Project activities were initiated in 1986 and lasted for only 18 months. The purpose of the introductory research was to establish methods for researching the mycorrhization of *A. cyanophylla* after evaluating local microbial flora.

The general objective was to increase rangeland productivity by planting a genetically improved form of *A. cyanophylla* inoculated with mycorrhizae.

### **Research achievements of Phase I:**

Forty-eight strains of rhizobium were isolated on three different ecological sites, one of which was the saline soil of a coastal dune. Though all strains tested proved infectious, their effectiveness could not be demonstrated. Acacia trees found on the three sites exhibited significant dependence on endomycorrhizal fungi. This indicated that acacia growth might be stimulated by inoculation with the fungi.

Preliminary inspection of 5 plantation sites revealed low levels of natural mycorrhizal fungi in the soils. Only spores of the genera *Glomus* and *Gigaspora* were found. Inadequate technical equipment, lack of expertise on the part of researchers and the scarcity of fungi samples in the field made it impossible to produce the endomycorrhizal inoculum.

### **Phase II:**

The specific objectives were to

- select and propagate effective and competitive rhizobium strains well adapted to local conditions;
- select and propagate endomycorrhizal fungi strains; and
- improve the nodulating power of ***Acacia cyanophylla***.

### **Main research achievements:**

Some 40 *Rhizobium* strains were harvested, identified using microbiological tests, and selected on the basis of infectivity, resistance to drought and resistance to soil salinity.

Some of the strains isolated tolerated high salt concentrations. All strains were infective and formed nodules with *A. cyanophylla*. Inoculation with rhizobium increased the amount of plant matter produced, improved nitrogen fixation and boosted resistance to water stress. When acacia seedlings were watered with salt solutions of varying concentrations, we observed that salinity had a greater impact on the growth of uninoculated seedlings than on that of inoculated seedlings. Seedling root growth decreased as salt concentration increased. Biological nitrogen fixation correlated closely with salt concentration in the watering solution and the degree of water stress to which the plants were subjected. The rhizobium strains isolated have low nodulating power in high-salinity soils.

By selecting local rhizobium strains with a degree of resistance to some water stress and salinity, nursery-grown seedlings can be inoculated increasing their resistance to transplantation stress and negative responses to climate fluctuations, particularly to the long annual droughts.

For the genetic improvement of *A. cyanophylla*, five local source sites were selected from which seeds were collected. Seedlings grown from the collected seeds were introduced into a number of test stations so that researchers could compare the performance of seedlings from each source site under the ecological conditions of each test station.



For micropropagation tests we used axillary buds from six-year-old trees. Experiments were conducted to develop balanced culture media that would make it possible to grow well-rooted, ready-to-plant seedlings. The rooting rates obtained did not exceed 26%, which was a fairly poor result.

In the near future, *in vitro* micropropagation of node explants will make it possible to improve the rooting rates of shoots from axillary buds and acclimatize the shoots in the field. With this method, seedlings selected for high productivity and adaptation to both water stress and soils of varying salinity can be grown on a scale in nurseries.

**Conclusion:**

Research initiated on the symbiotic complexes of *A cyanophylla*, combined with the production of high-performance acacia clones through *in vivo* and *in vitro* micropropagation, will soon lead to genetically superior seedlings that can be used in the reforestation of marginal dry or saline soils. Reforested rangelands will be protected from further degradation and revert to sustained production of the wood and fodder resources needed by its disadvantaged dwellers. A contribution will have been made to saving vast areas of Tunisia's arid lands from desertification and to improving the living conditions of pastoralists by ensuring that their herds survive.

## DEVELOPMENT OF THE MOUNTAIN ZONES

**Research institutions:** National Forestry Research Institute,  
Algeria

**Project number:** 90-0179

### **Background:**

Algeria has an area of some 2.4 million km<sup>2</sup> and a population of almost 23 million. Only one-tenth of its land area is suitable for agriculture, an activity accounting for 8% of GNP and employing 26% of the labour force. High-altitude zones (steep slopes with gradients exceeding 12%) cover some 8.4 million hectares. Agriculture, though long neglected, is now making a comeback. Since 1987, the Algerian government has shown sustained interest in the sector and offered greater incentives to promote food production and a return to the land.

The government's efforts are aimed at reducing food imports, which in 1987 stood at almost 25% of total imports. That year, Algeria produced less than 35% of its own requirements in cereals, sugar, oil and dairy products.

The project covered two rural communes in the Blida Atlas mountain region, which has a mean altitude of 1000 m and an annual rainfall of 430-776 mm. The zone has excellent production potential from an ecological perspective. It contains numerous waterways and its rainfall is adequate. However, it presents a number of constraints to development including steep slopes, difficult access, scattered microplots, poor soils and land that is predominantly communal. Living conditions are becoming increasingly precarious; the environment is deteriorating steadily and young people are migrating to the cities. Excessive logging and repeated fires have exhausted forests and exacerbated erosion with soils becoming less fertile as a result.

To counter this catastrophe, the Algerian government has implemented a series of regional development projects based on the integrated development of watershed areas. The plans are designed to revitalize agrosylvopastoral production and establish the basic infrastructure needed to lure former villagers back to the land. The implementation of such projects requires knowledge of local ecosystems, their production potential, physical and human constraints to development and knowledge of the ways in which the living conditions of the local population could be improved. The purpose of this project is to acquire that knowledge and to answer questions asked by planners and development agents before enhancement projects are finally put in place.

Researchers will conduct small-scale tests of certain initiatives and methods, on experimental stations and with some peasants, to see whether they are applicable to mountainous conditions before extending them to other parts of the Tell massif. The project is also aimed at revitalizing economic sectors in the mountain zone by helping villagers boost agricultural, pastoral, fruit and forest production on their own plots or on communal pastoral land.

**Objectives:**

The general objective is to increase agricultural production by revitalizing the economy in mountain regions through integrated development plans and projects focusing on watersheds.

Specific objectives are to:

- enumerate the physical and human resources in the zone under study;
- develop enhancement methods; and
- conduct an economic study of development initiatives.

**Research achievements:**

Since project activities have only just begun, no research results are yet available.

## **YELLOW DWARF VIRUS**

**Research institutions:** International Centre for Agricultural Research in the Dry Areas (ICARDA), Syria.  
Laval University, Canada.  
Instituto de Investigaciones Agropecuarias, Chile.

**Project number:** 90-1033

### **Background:**

Barley yellow dwarf virus (BYDV) is an aphid-transmitted disease of cereals. Though some 100 species of graminee are potential hosts, crops such as wheat, barley, oats and triticale, are particularly susceptible. BYDV is widely spread

in temperate and tropical regions and is the cause of substantial crop losses. A large number of environmental and agronomic factors influence the extent of loss, which varies widely over time and according to location.

Cereal crop yield losses due to BYDV in developing countries have not been sufficiently documented. However, there are indications that the amount is sizeable, particularly in South America. Although BYDV is considered to be one of the principal constraints in the production of wheat and other grains, recognition of its importance has been hindered by the fact that its symptoms are often variable in expression and are easily confused with those of nutrient deficiency as well as other diseases.

While control of the vector of BYDV by insecticides is often economical in developed countries, lower crop yields and value in the Third World make this approach impractical, especially for the subsistence farmers. Measures such as resistant varieties and cultural control methods are cost-effective alternatives. Therefore, they offer the best solutions for safe and feasible disease control management.

Wheat and barley are the principal cereals grown in the Middle East and North Africa. In Tunisia and Morocco, yields of both cereals are well below the regional average. Research on BYDV in these two countries has been far less active compared to that undertaken in Chile. However, the information available indicates that the BYDV may be causing the most critical problem in the region.

Since 1981, Laval University, in collaboration with Agriculture Canada and supported by IDRC, has been testing breeding material and lines from CIMMYT, ICARDA and national programs for their reaction to BYDV. An

average of 30 000 experimental plots were inoculated in 1982–1984. Laval University developed a reliable system for screening large amount of genetic material under uniform aphid infestation and well defined disease challenge. Laval University is widely recognized as a world leader in this field. This project was developed in four phases:

Phase I: 1981 to 1985. Research focused on sources of resistance to BYDV in wheat, barley, oats and triticale, and upon the incorporation of this resistance, by backcrossing, into lines of agronomic interest.

Phase II: 1985 to 1986. Investigations were conducted to find new and better sources of BYDV resistance and to transfer BYDV resistance into agronomically useful lines of wheat.

Phase III: 1986 to 1990. The summary of results in this phase are as follows:

Bread wheat: "Maringa" cultivar was the best tolerant spring wheat giving near top results for seven out of eight years. About ten other lines with heritable tolerance were identified.

Barley: The cultivar "Freja" was strongly recommended as a source of resistance to BYDV as well as having some drought resistance.

Triticale: was considered to be a good source of BYDV resistant and aphid resistant genes that could be transferred to wheat. Several lines were found to be stable over several years of testing and were recommended to breeders.

A semi-dwarf line of an interspecific hybrid of bread wheat provided apparent immunity to BYDV and good agronomic characteristics. This is considered to be a promising finding since no semi-dwarf bread wheat has ever been found with resistance to BYDV.

Facilities for artificial inoculation and screening were extended to five sites in Chile and 10 million aphid per year can now be produced.

Over the three years of the project a total of 7000 cereal genotypes were evaluated at Chilean stations and several lines of bread wheat, durum wheat, triticale and barley were found to have higher tolerance levels than tolerant checks.

In Morocco, surveys conducted three times a year at four sites during 1986–1987, revealed that 20–30% of the fields contained large patches infected with BYDV.

Screening of bread and durum wheats, barley and oats was done at two sites in Morocco and controlled yield loss studies were conducted on cereal cultivars. Yield losses of about 25% were recorded for the bread wheat cultivars tested in 1986–1987.

The most important results of research carried out in Phase III was that BYDV causes severe damage to the roots of a plant thereby reducing its uptake of water and nutrients. This, in turn, reduces resistance to other abiotic stresses, particularly drought or cold. Based on the aforementioned results, simultaneous selection for drought and BYDV tolerance seems very promising.

#### **Phase IV:**

Project activities started in late 1991.

The objective was to ensure that developing countries participate in and benefit from research that develops new cereal lines that are BYDV, drought and disease tolerant/resistant.

Specific objectives:

- to develop and evaluate BYDV-resistant wheat and barley lines adapted to drought-prone conditions;
- to contribute to the basic knowledge related to the interactions of BYDV with biotic and abiotic stress and to develop strategies for multiple stress resistance;
- to evaluate and quantify physiological and economic crop losses due to BYDV in various agroclimatic zones of Morocco and Chile;
- to describe dynamics of aphid populations in Morocco and in Chile; and
- to train Moroccan researchers.

This last phase of the project will provide support to Laval University for the purpose of testing the interaction between drought tolerance and BYDV resistance. Emphasis will be put on supporting national programs in Morocco and Chile, to train their staff, build on their technical capability in order to determine the distribution of the disease in their respective countries and to improve the selection of resistant and tolerant cereal lines adapted to local conditions.



## **MARGINAL AREAS**

**Research institution:** International Centre for Agricultural Research in the Dry Areas (ICARDA), Syria

**Project number:** 91-0239

### **Background:**

The rangelands and drylands of the Middle East and North Africa have for a long time been considered have little or no contribution to national economies. However, rapid population growth, the increase in urban consumer's demand for livestock products and limited opportunities for intensification in more favoured areas has resulted in intensified agricultural production on marginal lands. Consequently marginal areas now play an important role in national economies. The frontiers of cultivation have moved into more drier areas and the grazing of stock on the remaining rangelands has intensified. One of the most important consequences of these changes appears to be the degradation of the natural resource base in dry areas. It has been estimated that about 70–85% of rainfed crop land and 85% of rangelands are affected by desertification to varying degrees. The deterioration of quality and the depletion of ground water resources is also a serious concern in some areas.

Before any decision on comprehensive research in marginal areas can be made, several questions need to be answered and an evaluation of the impact of research on development within marginal and higher potential areas is required.

This study sought to provide answers to these questions and to create a basis for the formulation of a comprehensive research program at ICARDA in marginal areas of the Middle East and North Africa. The study provided ICARDA with the basic information needed for an in-depth assessment and evaluation of the problems, needs and potential impact of research on the use of marginal areas. This information should assist ICARDA in determining proper allocation of its resources to the study of the various agroecological zones.

In the long term, the identification of physical, socioeconomic and policy constraints and research priorities will permit the formulation of carefully selected research and intervention projects, which may have important impacts on the economy, environment and populations concerned.



**Objectives:**

The objective of the project was to identify and assess the current role, the situation and the sustainability issues with reference to marginal areas in the Middle East and the North African region and to provide the basis for evaluation the needs for research and development in those areas.

**Specific objectives:**

- to assess the present and potential contribution of the marginal areas to national and regional economy and development;
- to assess the sustainability issue of marginal areas in light of the natural resource base degradation, the living standards of the people and the farming systems;
- to evaluate past and present research and development activities in the region and their impact in solving the problems in the marginal areas;
- to assess the potential impact of technology generation and transfer options for the marginal areas; and
- to discuss and present future research needs.

As originally conceived, the project was divided into two major components. The larger was a series of five modules: focused review; studies on various aspects of the marginal areas production systems, i.e. concepts and problems; systems complexity at the micro-level; technical issues; inventory of research and development; and impact analysis. The smaller component was a series of country studies undertake by local consultants from five countries (Syria, Jordan, Egypt, Tunisia and Algeria). The purpose of the country studies was to encourage and utilize national expertise in the collection and assessment of baseline data at the national level for use in the final synthesis at the regional level.

**Research achievements:**

This project commenced in January 1992 and was completed in March 1993. The five country studies were completed. The following is an overview of the findings:

- Rangelands or savannah, are characterized as areas with winter rainfall of 50-250 mm and a ground cover of grass and/or shrubs.

- The bulk of crop and rangeland production contributes to animal production. It is difficult to estimate the contribution of the savannah areas to the national economies. Tourism has recently become an important dimension, especially in Tunisia and Egypt where desert and rangelands are adjacent to the Mediterranean and Red seas.
- Two basic trends seem common to all countries: increasing numbers of sheep on shrinking ranges and decreasing contribution of open rangeland grazing to their nutritional requirements.
- The following points were common to all five countries:
  1. decreased area of range due to encroaching cultivation;
  2. Increased intensity of grazing due to various factors among them greater mobility of flocks, lack of control over access to rangeland, provision of water on the rangeland and higher stocking rates;
  3. subsidy programs for livestock feed that encourage larger flocks but not higher quality animals (often linked with support prices for barley production);
  4. flow of merchant and speculative capital to finance livestock and/or barley production on the grassland and savannah; and
  5. the resulting degradation of plant and soil resources. (Desertification with formation and encroachment of sand dunes.)
- The causes of land degradation can be grouped under three basic headings: climate change, collapse of user control and economic forces. The question of land tenure is addressed in all studies.
- Solutions can be grouped under at least four headings: importance of developing non-livestock economic alternatives for grassland/savannah inhabitants; importance of social institutions to regulate the use of resources with a bias toward cooperative organizations based on local membership and control; the need to revisit present pricing policies and feed supply programs; and the introduction of improved technologies based on local knowledge and research.



## **SPACE REFERENCE INFORMATION SYSTEM (SRIS)**

**Research institutions:** National School of Engineers, Tunis, Tunisia  
Geomatics Centre, Laval University, Canada

**Project number:** 91-1019

### **Background:**

In Tunisia, agriculture forms the basis of the national economy employing more than two-thirds of the rural labour force. However, inadequate and erratic annual rainfall severely limits the choice and yield of agricultural activity. Moreover, erosion in its various forms leads to:

- an annual loss of 10 000 hectares of agricultural land;
- a drop in soil fertility, which in turn leads to low crop yields;
- premature silting and infilling of control dams as each year, some 25 million cubic metres of sediments are deposited in the dams;
- substantial water loss; some 500 million cubic metres of water escape the dams and are lost to the sea; and
- flooding, which causes tremendous damage to infrastructure and human settlements.

Erosion control is the cornerstone of agricultural development in Tunisia. It is based on a multidisciplinary approach and implemented through projects that take into account all relevant technical and socioeconomic factors, recommending solutions that strike a balance between cost-effectiveness and maximum technical efficiency.

The formulation, implementation and follow-up of a water and soil conservation policy requires extensive knowledge of physical conditions (such as geomorphology, geology, ecology and pedology) and human conditions (such as living standards and socioeconomic activity) in the area. There is no other way of designing integrated development projects that are technically feasible, socially acceptable and cost-effective.

The Merguellil Wadi watershed (154 000 ha) was the site selected to study problems associated with the deterioration of natural resources and establish methods for using ecological and technical data preserve those resources.

The use of remote sensing and the Space Reference Information System (SRIS) to map natural resource utilization patterns is a new way for planners and engineers to study the resources. Water and soil protection is a complex activity, requiring a multidisciplinary information system.

**Objectives:**

The general objective was to establish methods for the joint development and use of SRIS and remote sensing techniques to conduct engineering studies relating to water and soil protection in Tunisia.

The specific objectives were to:

- identify needs and constraints associated with SRIS use;
- analyze the human, institutional and information-related environment;
- prepare a book of specifications for the localised data management system (LDMS), adjusted for the appropriate type of development;
- enumerate and examine mechanisms and methods to collect, process and analyze pertinent data; and
- conduct a detailed study of activities relating to the establishment of watershed development projects, information needs, and methods and software that are being or could be used.

A major part of the research focused on remote sensing, the SRIS and ways of integrating the two systems. Engineers and planners from the Water and Forests Directorate, the agency in charge of fighting erosion, will have access to:

- a geographic information system that can be applied in watershed development efforts;
- theme maps created on the basis of remote sensing data;
- ways of comparing conventional methods of studying watershed regions with the methods proposed under the project.

The project will also include training on remote sensing and SRIS for Tunisian engineers and researchers.

**Conclusion:**

Tunisian and Canadian researchers intend to test, on an experimental watershed zone, new, faster and more thorough methods of identifying and characterizing physical and human resources. The methods will be applied in all phases of development in other watershed areas. Development agents will have access to as much information as possible; the information will be used in analysis, variant simulation and decision-making before engineering projects or other activities are implemented.

The research will represent a remarkable technical advance for Tunisian researchers and technical personnel, an advance that will allow them to wage a more effective battle against erosion. Erosion is still dealt with in traditional ways, with environmental studies and resource identification proceeding very slowly, and yielding only fragmentary information that results in sectoral, rather than integrated, development projects.

Remote sensing and the Space Reference Information System are high-performance tools that will enable the Tunisian authorities to determine faster and better ways of developing their watershed areas.

Since the project is in its initial stages, no results are yet available.

## **AROMATIC PLANTS**

**Research institutions:** National Agronomic and Veterinary Institute, Morocco  
St Jean sur Richelieu Research Station,  
Quebec, Canada

**Project number:** 92-1011

### **Background:**

Seventy-five percent of Morocco's territory consists of degraded and eroded mountains, arid plains in the south and southeast and plateaus in the east. The ecologically poor rangelands, which can support only extensive stockraising and subsistence crops, present severely limited opportunities for development. Aromatic plants, or herbs, constitute the natural vegetation cover and certain species are already significantly overgrazed. In other regions, some communities distil herbs to produce aromatic extracts but disorganized and immoderate harvesting have led to the medium-term disappearance of many aromatic plant species and the progressive desertification of an already fragile environment.

In one of the zones under study, a pastoral region of Eastern Morocco, ongoing changes in agro-pastoral systems, and a series of drought years, have resulted in overgrazing and in the gradual transformation of pastoral space into cleared farmland. Since the rangeland ecology is not suitable for mechanized grain growing, agricultural production is falling steeply leaving highly impoverished, eroded soils that can no longer support new activities.

Efforts to safeguard the rangelands ecosystem and its productive potential are taking the following forms:

- reforesting areas now being cleared;
- increasing the production potential of rangelands;
- providing the local population with means to add value to the natural resources available; and
- working towards better management of natural resources.

It is in this spirit that researchers from INAV and the St Jean de Richelieu Research Station jointly initiated a study of aromatic plants covering the Moroccan rangelands.

**Research achievements - Phase I:**

Phase I ran from 1990 to 1992 lasting 24 months. It yielded a substantial body of results, which will be confirmed in Phase II. Phase II started in 1992 and is scheduled to last 36 months.

Two pilot distillation devices were built during Phase I. One is a completely new design that reduces distillation time by at least 60%. After some technical adjustments, to be completed in Phase II, the device will be patented for subsequent distribution.

Wild sage is one of the most sought-after species in the essential oil industry. Researchers have succeeded in identifying the individual species' ecotypes that contained the chemical compounds used in producing standard essential oil. A second herb has also been at the forefront of researchers' efforts: for the first time, a chemical profile of verbena essential oil has been derived. As part of this project, the oil was produced and marketed in Morocco, also for the first time. Growing verbena is now four times more profitable than it was before.

The conditions required to grow verbena and wild sage were determined in detail. A number of varieties were selected and propagated in the nursery for large-scale introduction into their final habitat in the form of plantations.

**Phase II:**

The general objective was the same as that of Phase I: to implement efficient, rational and sustainable methods for exploiting the natural resources of the Moroccan rangelands, and in particular, to establish methods for exploiting so-called "aromatic" plants in order to fight encroaching desertification and boost the income of the rangelands population.

The specific objectives were to:

- study the impact on ecosystems of exploiting aromatic plants in an unplanned fashion;
- identify, select, introduce and improve aromatic plant species;
- improve distillation methods;
- use essential oils to create higher value-added finished products;



- disseminate results to users and provide support for the production sector; and
- market essential oils and other finished products.

**Research achievements:**

Since Phase II research activities started only in January 1993, no new results are available yet.

## **WATER/LAND MANAGEMENT**

**Research institutions:** University of Alexandria, Egypt  
University of British Columbia, Canada  
University of Guelph, Canada

**Project number:** 92-1501

### **Background:**

The northwest coastal region of Egypt (NWC) covers an area of approximately 2.4 million ha and stretches some 480 km along the Mediterranean Sea from Alexandria to the border with Libya. The annual rainfall is low and sporadic (100–180 mm) along the coast. It tends to decrease slightly from East to West and drastically from North to South. The region has an indigenous Bedouin population which traditionally has been pastoral.

A very impressive program has been underway for the past 20 years to improve the efficiency of water collection, storage and redistribution as well as biomass production and increasing the diversity of crop production. The population is gradually shifting from a system entirely dependent on natural grazing to a system of partial cultivation with fruit gardens and barley production in selected areas. The transformation from pastoralists to semi-sedentary cultivators has been very successful. However, the land use intensification, settlements of the indigenous people and external factors have created new problems that need to be examined carefully to determine the sustainability of the resources in the area.

Some of the main issues that need to be addressed are:

- water efficiency and aridity. Water is the critical resource in the coastal area where annual precipitation ranges between 75 and 250 mm. Ground water resources are severely limited and salinity is a major problem. The efficiency of established water collection systems needs to be evaluated to determine how best to extend such systems and to determine the impact of importing water from external sources;
- changes in land utilization and production systems. Water distribution improvements have led to a major change in land use. It has reduced the area under natural pasture while expanding fruit trees and barley cultivation. The consequences of this shift need to be evaluated in view of competition

between the existing animal-based production system, greater crop sensitivity to drought, loss of soil fertility and soil erosion;

- increases in animal population. In recent years, Bedouins have increased the size of their animal herds to meet a very important market export for animal products. Such an increase has potentially serious consequences in terms of carrying capacity and feed demands;
- population growth in relation to resource availability. The potential problems associated with rapid population growth are the higher demand for water and more pressure on pasture land;
- land degradation. The current push by the government to increase wheat production has serious implications for soil fertility and water and nutrients consumption;
- external pressure. The expansion of tourism with its demand for land and water and the recent use of new technologies and mechanization will have a significant impact on resources in the region, and
- impacts of the shift towards a market economy. At present, the impact of more cash income on the family and community is not known

To assess the sustainability of the production system, it is necessary to determine the marginal opportunity costs of increased exploitation and the most effective directions for future investment.

The main focus of the project is to examine key processes that need to be understood for sustainable land management in the coastal region. This will be accomplished by studying a representative test area, monitoring critical processes and developing appropriate resource management models for future extrapolation to the region as a whole.

**Objectives:**

The objective is to develop an integrated spatial model of Bedouin resource management systems, to assess its sustainability under international, regional and local change scenarios.

Specific objectives:

- evaluate the efficiency of the elaborate water collection systems in relation to soil and land utilization and identify impact of water availability on crop varieties and productivity;
- document long-term changes in the grazing land vegetation cover;
- describe the barley production system to assess the consequences and trade-offs of intensification and introduction of wheat production;
- evaluate horticultural production in relation to water constraints, nutrient availability and land allocations;
- evaluate the consequences of internal and external forces on human and animal population dynamics, production systems and socioeconomic structures within and between Bedouin tribal units;
- develop models of the new Bedouin resource management systems with Geographic Information Systems (GIS) as the integrating tool;
- evaluate extension needs and programs for the management of dry land tribal communities with special focus on agriculture and household needs; and
- provide training in the use of GIS technology for resource modelling and the use of Rapid Rural Appraisal (RRA) techniques for evaluating the socioeconomic conditions and processes in the Bedouin communities.

**Achievements:**

A technical training session was held in June 1993 involving five members of the University of Alexandria staff. Presentations on the theory, concepts and practical applications of GIS in integrated resource management, were made by the University of British Columbia's (UBC) representatives. This session lasted for 12 days, including three days that were devoted to selecting five sites for monitoring water balances and collection efficiency in underground cisterns. UBC visitors and Alexandria University team took this opportunity to discuss project integration and provide general guidelines for collecting a

minimum data set for the GIS. A timetable was developed to schedule tasks to be accomplished during the first year of the project.

Following the visit of UBC's representatives, a field visit was undertaken by Guelph socioeconomists. During this visit, the project team received training in farming systems, socioeconomic data collection and the integration of the data from the various study sectors prior to the initiation of field work. Reports indicated that the two visits were successful in training the Egyptian staff on the basic techniques of using GIS techniques and RRA approach.

Moreover, some good steps have been taken to strengthen the links between Canadian and Egyptian institutions and to facilitate the beginning of the research activities. This project follows an interdisciplinary approach, which allows the interaction of socioeconomists with environmental and agricultural scientists. The technical equipment was tested and is functioning well.

Although the project's objectives are ambitious and somewhat complex, it is expected that it will enhance and strengthen the scientific background of the national researchers and will make a significant contribution to the integrated development of the region.

## **WATER HARVESTING**

**Research institutions:** Faculty of Agriculture, Jordan Department of Civil Engineering  
Concordia University, Canada  
International Centre for Agricultural Research in the Dry Areas (ICARDA), Syria

**Project number:** 92-1502

### **Background:**

Over 85% of Jordan has an average annual rainfall of less than 200 mm. Irrigated land constitutes less than 1% of the total land area. Local agriculture is severely deficient in food production with less than 17% of the wheat consumed produced locally and an average of only 20% of the meat consumed. With a population growth rate of 3.6%, forced immigration to the country and a shrinkage in per-capita income, Jordan has no choice but to utilize all its land and water resources.

The only potential areas left for development are those of the arid and semi-arid lands receiving an annual rainfall of less than 200 mm. In response to this critical situation, the Faculty of Agriculture at the University of Jordan (FAUJ) initiated a major research project in 1985 for these areas with the assistance of the European Economic Community (EEC). The project was aimed at combating desertification in Jordan, through the evaluation of low-input agricultural alternatives and water harvesting. The project was located 30 km southeast of Amman at a site with a rainfall of 100–200 mm. Three small earthen dams were constructed to collect water from a watershed covering approximately 70 km<sup>2</sup> for use in the supplemental irrigation of fruit trees and range forage species. Possible data and field experiment results have been gathered on the site. These range from meteorological information and runoff data to the evaluation of various techniques for water spreading and supplemental irrigation for various crops.

The FAUJ-EEC project has demonstrated over the past few years that the implementation of small-sized water retention schemes may be very efficient in terms of water harvesting. Before such a concept can be widely used it was necessary to evaluate different water storage and utilization methods in order to arrive at the optimal, sustainable water harvesting and management strategies for entire watersheds. To make this possible, an integrated model is required. Such a model needs to integrate the following components:

- 1) the accurate prediction of water runoff over both micro and macro watersheds;
- 2) the formulation of a process for an optimal selection and design of water storage modes; and
- 3) the determination of optimal and sustainable utilization management techniques of the stored water.

Such an integrated model does not exist. Its development is the overall objective of this project.

**Objectives:**

The objective is to develop an integrated model adapted to arid and semi-arid regions capable of devising optimal and sustainable strategies to increase crop production and reduce soil erosion.

The specific objectives are:

- to collect, assemble, organize and analyze soil, water and socioeconomic data from the watershed for input into the different model components;
- to organize the collected information into a Geographic Information System (GIS) and to interface the model with the GIS;
- to develop the three components in a micro-computer based software and integrate them into one model;
- to disseminate project results as related to model capability, limitations, application and utilization; and
- to strengthen Jordanian institutional capability in hydrological modelling and Geographic Information Systems.

**Conclusions:**

Although the research methodology seems complex it is very innovative and useful with an enormous potential impact. The project will help develop an efficient tool that could facilitate agricultural planning and development in arid and semi-arid zones. Its application will facilitate the optimal use of runoff water and adequate water harvesting techniques resulting in improving agricultural production and water resources management. This model will also contribute to research capacity building, in land and water management, by using the GIS approach and computer modelling. Once the model is available and tested in a single local site, it is expected that it will

be extrapolated to other watersheds of the region with the same ecological characteristics. Consequently, the project's impact could be expanded over the region helping farmers develop areas presently exposed to degradation by using more efficient water harvesting methods.

As the project's activities have only recently started (June 1993) with a duration of 36 months, no results are available at this time.



## **DRYLAND RESOURCE MANAGEMENT**

**Research institution:** International Centre for Agricultural Research in Dry Areas (ICARDA), Syria

**Project number:** 92-5016

### **Background:**

This project is part of a larger project entitled "The Dryland Resource Management Project" (DRMP) coordinated by ICARDA and involving five other countries: Jordan, Lebanon, Libya, Pakistan and Yemen. The DRMP project was developed in response to the growing concern about the degradation of natural resources upon which agricultural production depends: namely the soil, water and natural vegetation. In the drier areas the Middle East and North Africa these resources are limited and easily degraded. The increasing pressures on soil, water and natural vegetation seriously threatens their potential for future productive utilization, resulting in disastrous consequences effecting the indigenous populations and the entire ecosystem.

The overall aim of the project was to assist the national programs to collaborate in addressing the agricultural and environmental problems of the drier lands of the Middle East and North African region. Teams of national scientists were to conduct localized studies each offering a critical assessment of existing systems of agricultural production and resource management in dry areas and assessing their impact on the natural resource base. In addition, recommendations for future improvements were to be made.

The first step was to assess the dimension of the problem of resource degradation in each selected area. This would not only provide a valuable regional overview of the problem but would also assist in the selection of study locations for detailed diagnostic work.

The objectives of the study conformed to those of DRMP. They can be outlined as follows:

- to describe and analyze current resource management practices and indigenous perceptions for the purpose of developing sustainable improvements; and
- to initiate multidisciplinary activities, within the national programs, addressing the problems of resource management in the drier areas.

The Yemeni project was conducted by a team of scientists from the Agricultural Research and Extension Authority (AREA), the Faculty of Agriculture (FOA) and the University of Sana'a. The investigations focused on "water management systems" including watersheds, mountain slopes, water harvesting (terracing), run-off down wadi beds and giving high priority to the degradation of upper terraced slopes. The latter appears to be the primary problem in many areas.

The proposal was approved by IDRC in May 1992. The study area was selected in the south eastern part of Hajjah Province, Yemen, for the following reasons: 1) it is broadly representative of both agroecology and resource problems of Yemen's western escarpment, which is the major rainfed agricultural region in the country; 2) within a small area, it contains all the major elements of the mountain slope-wadi bed system of water and soil management; and 3) it is accessible from the operational bases of the research institutions.

The area consists of mountain tops and rangelands with terraced slopes descending to the wadi course. Agriculture is supported by traditional methods of water harvesting mainly using terracing. The area was divided into a number of agroecological zones. The study covered a transect of all the zones in order to examine the water resource management system. As the terraces on the slope are more or less abandoned, runoff is increased, which not only eroded the slopes, but led to destructive floods in the wadi bed and washed away valuable productive land. Although identification of the main underlying causes of the degradation of the resource management systems in the area was one of the objectives of the study, many other contributing factors were observed.

The objectives of the study conform to those of DRMP. The specific goals of this case study were:

- to develop and test a multidisciplinary and systems-oriented methodology for assessing problems of resource management;
- to analyze existing systems of resources use, identifying the underlying causes of resource degradation;
- to evaluate existing and alternative resource management strategies within the study and in cooperation with the local communities; and
- to make recommendations for appropriate future research and development activities.

**Research achievements and conclusions:**

The total surveyed area for which the land resources were studied was 3450 ha. The study resulted in the preparation of a geological map, physiographic map, soils map and four main physiographic zones were identified. The rate of farmland terrace deterioration was determined. Approximately 50% of the terraces were shown to be moderately to severely eroded and uncultivated.

The studies undertaken by specialists covered several topics: land and water resources, natural vegetation and rangelands, crop and livestock productions and socioeconomics. Terraces are used for expanding cultivated land for cereals and horticultural crop production, as well as reducing degradation of the slopes by water erosion.

In general, surface water resources are very limited in the area being restricted to runoff water from steep mountain slopes immediately after heavy rain storms. Almost 85% of the cultivated lands are farmed by the rainfed agricultural farming system. Furthermore, most of the runoff water is harvested and diverted into the agricultural lands during rain storms.

However, water shortages, which leave about 50% of the agricultural land unused, is believed to be the major limiting factor for increasing agricultural production. The majority of the vegetation area is degraded due to the constant and increasing pressures of grazing, forage collection and the need for fuelwood for household consumption.

The rangelands vegetation reflects the use being made of it. The vegetation consists mainly of low grasses and small shrubs. Palatable and nutritious grasses, herbs and perennial have largely disappeared. Reduction of the soil's protective vegetative cover has resulted in accelerated erosion and desertification.

Analysis of the dynamics of farmland use indicates that there is a net loss of land in most farms due to deterioration from erosion and drought. Crop yields are low because of the low levels of inputs used and the lack of knowledge. The efficiency of the extension agents is low and could be improved through the use of mass media such as radio and TV, which are available to farmers and are considered the major information source by many of them. Agricultural research services on field crops, vegetables and fruits to increase yield and farm income are scarce.

After extensive analysis of the area, the researchers suggested several potential recommendations for various environmental and socioeconomical development programs taking into consideration the underlying constraints and obstacles that hindered the rural development of this zone. These

programs are being prioritized and restructured into three categories in which several operational programs are being outlined. These principal categories are:

- Basic Rural Development;
- Resource Conservation; and
- Agricultural Production.

The continuation of this project over a second phase will contribute to the very impressive amount of scientific data and results the Yemeni team were able to collect during the first study.

The successful achievements of this case study were made possible by good coordination between the two Yemeni institutions involved and the strong commitment of the researchers who worked hard in the DMRP regional project. Therefore, the aforementioned results would not be utilized to the maximum if IDRC's assistance to this initiative is not complimented by future activities on testing and dissemination of appropriate technology.

## **GLOBESTAR RADAR TECHNOLOGY IN DEVELOPING COUNTRIES (RADARSAT)**

**Research institutions:** Canada Centre for Remote Sensing, Canada Institutions from Africa, the Middle East, and Asia

**Project number:** 93-1151

### **Background:**

Poor knowledge of their national and environmental resources is a basic restraint in the ability of developing countries to implement Agenda 21 programs for sustainable and equitable development (SED). Policy and decision-making for SED require unrestricted access to low-cost, reliable, accurate, homogeneous and timely geographical data at various scales in various formats.

Satellite remote sensing (RS) is a powerful technology, which can fulfil these information needs. However, RS technology still remains the monopoly of developed countries. Earth resource satellites are designed to fit the information needs of their owners and do not take into account specific needs of developing countries.

This project will bring together suppliers and users of radar remote sensing technology, particularly those associated with the forthcoming RADARSAT, to work collectively in order to explore the potentials and limitations in the use of this technology in conditions specific to developing countries. The advantages to recipients (developing countries) lie in upgrading their applications, capabilities in new remote sensing systems in the fields of resource management and environmental protection; establishing linkages at national, regional and international levels for sharing research methodologies, applications, results and specific findings; and in developing partnerships with Canadian institutions.

As a major improvement to optical systems, imaging radar can provide data on a specific region at a specific time or date regardless of prevailing weather and sun illumination conditions. Combined with data from other sources, radar is a powerful tool for use in natural resource management and environmental monitoring. The Canadian Satellite RADARSAT is scheduled for launch in 1995. With its on-board tape recorder and its large incidence angle (35 degrees), RADARSAT will observe and record data in areas all over the world even when they are outside the region covered by a ground receiving station.

IDRC is currently supporting a collaborative project (91-1039) aiming at building research capacity in the use of radar technology in Costa Rica and at testing radar data in applications of interest there and in other tropical countries. The present project will build on the successful model developed in Costa Rica to enable other developing countries to benefit from radar remote sensing technology.

**Objectives:**

The main objective is to increase the user application capabilities to enable developing countries to take advantage of the data, which will be made available by RADARSAT after its launch.

Based on the experience gained from the model developed in the Costa Rican project, this proposal is designed as a long-term, multi-phase global project with short-term measurable outputs in specific participating countries covered by each of the phases. As there will be several participating countries there are common objectives related to the activities of the project. These are as follows:

- to build on the success of the initial project in Costa Rica and support the development of research capability in several developing countries in Africa, the Middle East and Asia;
- to generate and disseminate training materials for the application and use of imaging radar in various environments;
- to develop applications of radar remote sensing for environmental and natural resources assessment, monitoring and management;
- to facilitate developing-country involvement in the RADARSAT agenda;
- to contribute to the success of the Canadian RADARSAT; and
- to strengthen partnerships between Canadian and developing-country institutions and to stimulate collaboration among developing-country researchers and institutions.

Specific objectives and applications will vary according to the needs and characteristics of the recipient countries. Applications will be mainly focused on the assessment, monitoring and management of natural resources in fragile environments and can include mountainous environments, coastal zones, inland water, soil erosion and the dynamics of desertification in arid

or semi-arid ecosystems. Several research applications were identified by recipients in the early stages of project planning. However, they are not exclusive and they may be revised according to the pre-project or pre-flight workshops to be held in eight countries (Pakistan, Vietnam, China, Thailand, Tunisia, Morocco, Jordan and Kenya) in mid 1993. Three of these workshops have already been held in June 1993 in Jordan, Morocco and Tunisia.

The aforementioned workshops involved Canadian participants and national representatives. The results of the workshops can be summarized as follows:

- the selection of the study sites was made in each of the participating countries where airborne data acquisition will be made, taking into consideration the national interest in natural resource applications, the access to sites and the basic data available in each site;
- each country suggested a number of applications for each site such as topographic mapping, land degradation and desertification process, surface and ground water studies; and
- expected national and Canadian contributions were agreed upon on a country-by-country basis.

In general, national institutions will provide human, technical and financial resources for their own program activities while Canadian partners will provide airborne data acquisition, reprocessing, training materials and the expertise of Canadian scientists and experts at no-cost for the host country. Furthermore, each program will be guided and led by a coordinating institution capable of organizing such an important multidisciplinary national program.

In conclusion, recipient countries for this project will take an active role as partners not as beneficiaries. In addition to developing a high-technology package and in order to obtain the maximum benefit of this program, Canadian counterparts will interact directly with national scientists to share the technical knowledge. National scientists, in turn, will pass on their knowledge to their colleagues thus creating an in-country capability for training and technology transfer in the field of radar applications and interpretation. This is the most important result expected from this project.

## **INTEGRATED WATERSHED DEVELOPMENT**

**Research institutions:** Department of Irrigation and Water Use,  
Syria  
International Centre for Agricultural  
Research in the Dry Areas (ICARDA), Syria

**Project number:** 93-8602

### **Background:**

Approximately 55% of Syria is arid to semi-arid, receiving an average rainfall of less than 200 mm. This area is considered unfit for arable agriculture. However, it is widely used by semi-nomadic pastoralists for animal grazing. The present contribution of the rangelands to the national economy is quite important not only because rangelands support a resident population, but they also supply urban markets with a good part of their requirements in animal products without much input from the state.

Unfortunately, the resources upon which production has been based, soils and water, are very pressed. Over-pumping of groundwater to irrigate fodder for livestock is having irreversible consequences on the groundwater resources. The extension of barley cultivation into the rangelands has proved to be extremely detrimental to soils and native vegetation. Moreover, the increase in the number of sheep using the rangelands has created progressive degradation of the ecosystem, due to overgrazing and trampling by herds.

An extensive study conducted over 50 000 km<sup>2</sup> of the rangelands has concluded that pastures are degraded in general. They are characterized by very low productivity due to the grazing and uncontrolled movement of livestock.

Since 1952, government agencies responsible for rangeland management have attempted to reduce the pressure on the scarce grazing resources in the poorest, most arid zones of the country. In another attempt to reduce the degradation of the rangeland resource, the government of Syria has recently given top priority to the initiation of applied research programs aimed at the conservation and integrated development of soils, water and vegetation of the rangelands. The selected strategy is to design sustainable land use programs in watersheds with the objective of providing stable and sufficient forage reserves for pastoral communities.

Two pilot watersheds have been selected by the Ministry of Agriculture and Agrarian Reform (MOAAR) for the implementation of the program and to



evaluate its efficiency, productivity and sustainability. The program will also attempt to formulate a general model for the development of rangelands in Syria. Large sums of public money will be invested in such activities as the construction of small-watershed water harvesting dams, the digging of contours and shrub planting.

This project will be the first research-oriented project to address the integrated development of the natural resources of the Syrian dry grasslands. It will evaluate a combination of vegetation, soil, water improvement and conservation technologies with the intention of identifying the most appropriate strategies for range management.

**Objectives:**

The objective is to develop a general model for the sustainable development of arid land watersheds through the integrated management of their components including water, soil and vegetation resources. The main goal is to improve range productivity while reducing soil erosion and increasing the efficiency of water use. The specific objectives of the project are:

- to collect, assemble and analyze the physical baseline data on two selected sites;
- to document and integrate the knowledge, perspectives and aspirations of the Bedouin and any other relevant users of the site into the formulation of future rangelands management activities;
- to increase the surface water availability and evaluate its optimal usage in fodder production;
- to evaluate the feasibility and advantages of conjunctive uses of ground and surface water resources for supplementary irrigation;
- to evaluate, in the upper part of the watershed, various runoff improvement techniques and compare their efficiency at soil conservation, in terms of erosion control and revegetation potential;
- to assess the impact on soil erosion and water conservation, of the alternatives under study; and
- to strengthen the research capability of participating institutions through local and external training.

## GENERAL CONCLUSIONS

The regional office for the Middle East and North Africa has been actively involved for a number of years in exploring and identifying sustainable management systems of natural resources in the region with emphasis on water and land resources with focus of fragile ecosystems. The focus on fragile ecosystems (arid and semi arid areas and highlands) has essentially been due to the fact that these ecosystems are the most threatened by degradation, and because little has been done in terms of research and development in these regions.

The importance of water in the region is well known: most of the region is characterized by severe water scarcity which is exacerbated by several other factors such as rapid population growth, urbanization, industrialisation and increased irrigation requirements to satisfy the additional demand for food, leading to the deteriorating quality of both surface and groundwater supplies. Projects developed in this area addresses a number of key factors such as the water-harvesting, water management and water conservation.

Soils and land management is also an integral - and integrated - part of the program. In those areas problems of degradation are immense and are related both to environmental factors (fragile soils, rainfall distribution) and to human factor such as mismanagement, policies, economic factors, etc. The program developed in the area addresses a number of key factors, such as the monitoring and evaluation of degradation in rangeland areas, the planning for integrated management of land and water resources and the identification of sustainable alternative systems to combat degradation.

An important common factor in several of the projects being implemented is the development and use of modern information technologies which can assist in the analysis of the complex issues under studies. A majority of projects in the program make use of remote sensing and geometric tools.

Finally, and as relates to the development of sustainable alternative livelihood systems in fragile eco-systems, IDRC is also developing projects aiming at providing extra value to the resources, while contributing to their protection and to the welfare of the populations depending on them.

The diversity of the objectives of the research projects presented in this report reflects the high priorities given by IDRC to assist developing countries in the Middle East and North Africa to develop their own long-term solutions to pressing problems related to desertification. Based on these twenty-five projects, one can conclude that the research undertaken by IDRC has provided the recipient countries and the international scientific

community with scientific data in the field of desertification. It is noteworthy in this context that innovative approaches and methodologies have been developed in areas such as pastoralism and desert management systems.

Some research projects have had a significant impact on the development of the areas concerned. Specifically, these projects are: "Casuarina," "Desert Farming Systems," "Brise-Vents," "Plantes Aromatiques" and "Yellow-Dwarf Virus." In addition to the single disciplinary projects covering the period from 1975 to 1980, the new multidisciplinary projects have contributed to a better understanding of the various aspects of rural development.

The development studies of desert lands (Egypt), grasslands and svannah (North Africa), dry areas (Jordan and Syria) have led to the development of specific techniques for crops, irrigation, soil protection and water harvesting, which can easily be extrapolated to ecologically similar areas.

It should be pointed out, however, that the application and practical use of the findings of these studies is not an easy task for researchers and development specialists. In agronomy, and more specifically in forestry or pastoral areas, a minimum of 10 to 15 years of maintained efforts is required for the results from experiments to be reliable and applicable. Furthermore, the beneficiaries of the results may not adopt nor integrate these results in to their production systems unless they are convinced of the benefits that the technological innovation will bring to them. The beneficiaries will not view the technological innovations exclusively in terms of increased production, but will include their assessment of reduced inputs and increased risks. Thus, "marketing" the potential benefits of certain technological innovations is vital and has been incorporated successfully in some of the projects.

Another valuable contribution of these research projects is the sizable amount of relevant knowledge that has been obtained about human communities: their relationships with their environment; the socioeconomic and institutional constraints to development; and conflicting interests between several social groups vis a vis the natural resources exploitation and the appropriation of land.

This improved understanding of the human environment has led to more realistic research objectives and to programs that are more appropriate to the needs of the target populations. For example, in the case of the regional project "Pastoral Systems," a better understanding of the way of life of the pastoralists and agropastoralists has greatly contributed to the development of consensual and less destructive methods of production and management of natural resources.



The main objective of the projects analyzed here is to develop sustainable management systems for the fragile ecosystems of the drylands and highlands of the Middle East and North Africa. The studies show that this objective can be achieved through a thorough knowledge of the local ecology, indigenous management systems, degradation processes and socioeconomic and policy issues. Experiments show that there are many ecologically sound ways that can be employed to improve local conditions of living if the financial resources are available. These include soil and water conservation measures, the planting of windbreaks, terracing the slope and the use of agriculture techniques suitable for dry areas. Most of the research has dealt with these innovations and several technical recommendations were concluded for each ecosystem.

The projects reflect an increasing interest of the national political authorities and the scientific communities of the North African and Middle Eastern countries in improved management of natural resources and in the improvement of living conditions of pastoralists and mountain dwellers. This awareness supported by research on the most threatened environments, will facilitate the mobilization of human and financial resources to reverse the current tendency toward the degradation of fragile ecosystems.