Integrated research and technology transfer for sustainable development of semi-desert areas in Northwest Egypt

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Abstract

Matrouh Resource Management Project (MRMP) - a resource management and rural development project with a strong adaptive research and technology transfer base - operated in the Northwest Coast of Egypt. The project targeted the sustainability of the fragile and highly degraded natural resource base, and livelihoods security of poor Bedouin communities in dryland areas there. ICARDA provided technical assistance for research and development (R&D) programs. Community-based, multidisciplinary, and participatory approaches to R&D were used to integrate natural resource management (NRM) with production improvement and capacity building. Simple technological packages were tested, disseminated, and adopted through joint research/ extension/ community efforts; and substantial improvements were realized in the areas of soil/water/rangeland development and conservation, agricultural productivity, and farm income. Water harvesting increased water supply by 100%, satisfying domestic needs for over 8500 households with their flocks, and for about 3000 ha of crop area, in a region severely deficit in water. Yield of barley (the main crop in the area) increased by about 60%, and improved varieties were adopted by about 50% of producers. Similar gains were achieved in horticulture and livestock production. Introducing new germplasm and practices (soil/water/crop management, rotations and crop mixtures, and fodder shrub inter-planting) promoted more productive and intensified farming systems. The project effectively contributed to capacity building of the national agricultural research and extension system and local communities to apply new approaches to R&D. This paper explores how large-scale development projects, assisted by international agricultural research, can enhance adoption and impact of new technologies by facilitating effective integration of research with extension and farming communities.

Introduction

The pastoral Bedouin communities in the Northwest Coast (NWC) of Egypt have accumulated, over time, indigenous knowledge, skills, and resource management practices that have for ages maintained ecologically balanced systems in a harsh semi-desert environment. They have also developed drought-coping strategies, traditions, and a lifestyle that have sustained their livelihoods, and maintained equity and social peace between and within the Bedouin tribes. However, in the last few decades, Bedouin settlement programs have taken place based on agricultural development because of increasing water supply by water harvesting techniques, and improving water use efficiency by introducing improved agricultural technologies.

The settlement of Bedouins and the rural developments implemented on these marginal drylands have transformed the traditional pastoral system to sedentary farming. This transition, combined with population growth, urbanization and aggressive intrusion of the tourism industry, and the drive to modernize the Bedouin lifestyle, have exacerbated the human and livestock pressures on an inherently fragile resource base, creating a cyclic resource degradation and poverty. Vast areas of rich natural vegetation have been damaged, overgrazed, and/ or marginally cultivated. Biodiversity has been eroded, natural habitats and ecological systems deteriorated, and agricultural productivity has drastically declined. Recently, new developments in upstream areas of some watersheds have badly affected rainwater runoff to old 'well-developed' downstream areas, initiating conflicts that might threaten social peace between and within the tribes. Due to the importance of the issue, the Government of Egypt placed serious

effort to tackle resource management problems in Matrouh Governorate through initiating a developmental project that operated from 1995 to 2002.

The Matrouh Resource Management Project (MRMP) had the mission of controlling resource degradation, improving agricultural production, and alleviating poverty in vast dryland rainfed areas of the NWC. It was a resource management/ rural development project with a strong adaptive research and technology transfer base, co-financed with US$ 29.6 million by the World Bank, the Government of Egypt (GOE), and the project beneficiaries. The project realized its mission by utilizing and disseminating the outputs of adaptive research in its development activities, and by providing technical and financial support to local Bedouin communities to implement improved approaches to sustainable natural resource management and socioeconomic development.

The Egyptian Ministry of Agriculture and Land Reclamation (MALR), with endorsement of the World Bank, contracted the International Center for Agricultural Research in the Dry Areas (ICARDA) in 1996 to provide technical assistance (TA) to the project for achieving its objectives. The TA was provided for all project components: soil and water management, adaptive research for crop/range/livestock improvement, extension, human resources and social development, and for project management.

This paper summarizes the MRMP/ICARDA experience in using holistic, community-based approaches for promoting and adopting technologies that effectively contributed to natural resource sustainability, and poverty alleviation in NWC Egypt.

The Challenge

MRMP was challenged by a multitude of constraints - biophysical, socioeconomic, policy and institutional. The project area extends over 300 km alongside the Mediterranean Sea, with 70-km inland, on the central and western part of the NWC region of Egypt (Fig. 1). It is a semi-desert region, though its harsh environment is tempered by maritime influence. The principal occupation for the tribal Bedouin population (about 140,000 people) is agriculture. The cultivated area is about 7 % of the total, with very low productivity, cropping intensity and diversity. Fallow land is 9 %, rangelands 48 % (mostly degraded), and 36 % is barren land. Most landholdings are under tribal usufruct, but, except for communal rangelands, individual land boundaries are well defined and respected. Public services (credit, marketing, transportation, health, education, housing, etc) are lacking, employment and economic opportunities are scarce, and the population is among the poorest and most deprived in the country.

Figure 1. Matrouh Resource Management Project area in the northwest coastal zone of Egypt

Farming in the project area involves risks and uncertainty problems. Rainfall, the principal source of water, is low and highly erratic. The long-term (1944 to 1992) annual average for Marsa Matrouh station is around 145 mm (min and max 50 and 275 mm, SD 65 mm, and CV 46 %). However, this coastal rainfall average declines rapidly as one moves in-land. Farmers may face risks even in years of relatively high rainfall, because of uneven distribution in the growing season. Many farmers sow barley, the principal crop in NWC, on every piece of cropland in years of good early rains, saving some most productive parts for watermelon - a highly profitable summer cash crop. In some years however, most annual rains may fall early in the growing season then cease. No rains in spring would result in multiple losses for farmers; poor barley production, sometimes leaving no seeds for the next year resulting in a need to buy seed at additional cost, and no cultivation of watermelon.

Most soils are poor and eroded. Crop and livestock yields are low and highly variable. Very low input farming is practiced, using local varieties and breeds of low genetic potential, though well adapted to the area. Barley yield is about 600 kg/ha for grain and 700 kg/ha for straw. However,

in only two out of 10 years the yield may exceed 1200 kg/ha; and in four years out of 10 there might be very little or no grain yield at all, and the crop is grazed green. A declining yield trend was also observed due to the effect of barley monocropping and successive years of drought. Yields of different fruit species were also commonly low and varied considerably, spatially and temporally. Pests posed another risk that has recently increased with enhanced agricultural development. Rodents also could cause serious damages to earthen dikes and crops. Insects and diseases, coupled with improper management practices, have resulted in hundreds of unproductive orchards, needing substantial measures for rejuvenation.

Resource scarcity and poverty is another major source of risks and vulnerability. The majority of households in the project area are below the poverty line, and farm income for the ultra poor is not sufficient even for survival. They need to seek off-farm employment, mainly working for the better-off farmers. Farm income is not only low, but also uncertain; perhaps declining by over one-third in 2 years out of 5, and it could be negligible in 1 out of 5 years. Illiteracy rate is high, professional skills are lacking, and economic opportunities and employment are very scarce. In successive years of drought, a good proportion of the population has suffered dramatic hardships, barely managing to survive. Bedouin traditions and tribal solidarity, that had withstood threats and maintained community survival in the past, started to weaken with new development program and the thrust towards modernization and individualism.

Rainwater management, using participatory, community-based approaches to integrated watershed management (IWM), was the corner stone on which the strategy and plans of the project were built. However, the lack of data critically needed for IWM, and lack of experience of project staff and local communities in these new R&D methodologies were also other difficult challenges that the project encountered.

Project Objectives

The first objective of MRMP was to support the Bedouins to implement coping strategies and programs of conserving and effectively utilizing the available water, the soils, and the vegetative cover, ensuring resource sustainability and environmental improvement of the area. The second objective was to contribute to poverty alleviation and to improve living conditions of the local Bedouin population. Special attention was given to promote on-farm and off-farm income-generating activities, particularly among women and the rural poor. The underlying strategy was to develop an effective mechanism that encouraged active participation of local Bedouin communities in sustainable management of their natural resource base and in alleviating rural poverty.

Project Components

The project addressed the above-mentioned challenges through the following R&D programs whose implementation was done in an integrated manner with effective community participation:

- Adaptive research;
- Watershed management: water harvesting and soil conservation;
- Rangeland and grazing management;
- Extension and training;
- Provision of rural finance;
- Monitoring and evaluation; and
- Empowering rural women in development.

Methodological Approaches to R&D

One of the major factors that effectively contributed to impressive achievements of the project was the decentralized management and adoption of innovative methodological approaches to R&D. The project implemented community-based R&D programs to achieve its objectives, integrating holistic, multidisciplinary, and multi-institiutional approaches: (a) integrated watershed management approach (IWM); (b) farming system (FS) approach to R&D; and (c) community action planning (CAP).

The IWM approach (Fig. 2) recognizes the whole of a watershed as a consolidated biophysical and socioeconomic unit of development. A systematic framework for IWM was established. It incorporates hydrological assessment, actual and potential land use and socioeconomic issues. It combines qualitative and quantitative analysis of resources (land, climate, plants and animals, and human) to assess the development potentials. Implementing the approach was based on modules, which were designed and used as a basis for hands-on training of the Soil & Water staff on the

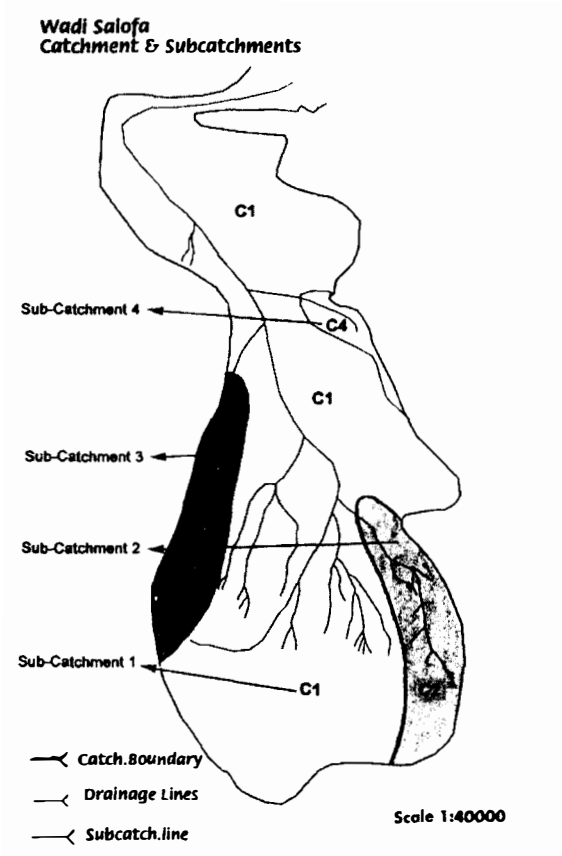

Fig 2.1. Catchment boundry, subcatchment and drainage

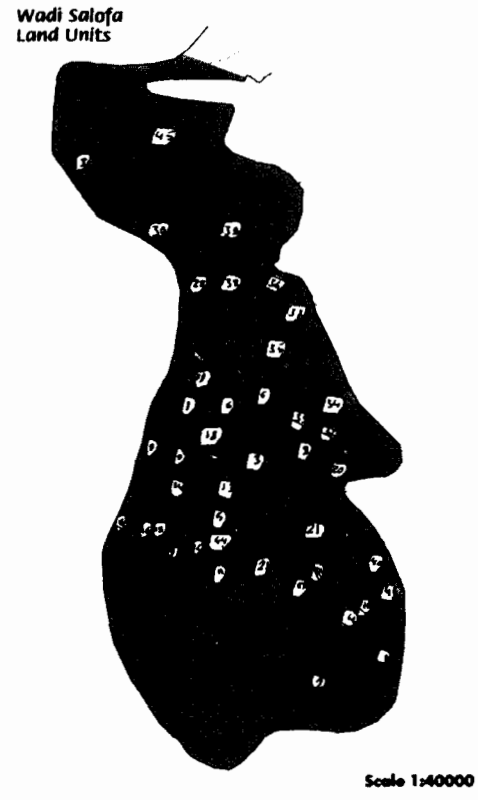

Fig 2.2. Land use and wadi Salfa

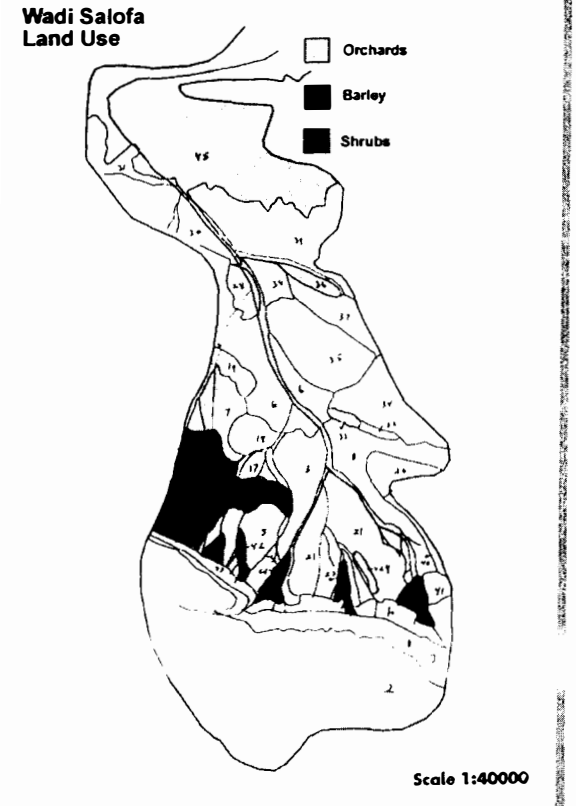

Fig 2.3. Potential and actual land use

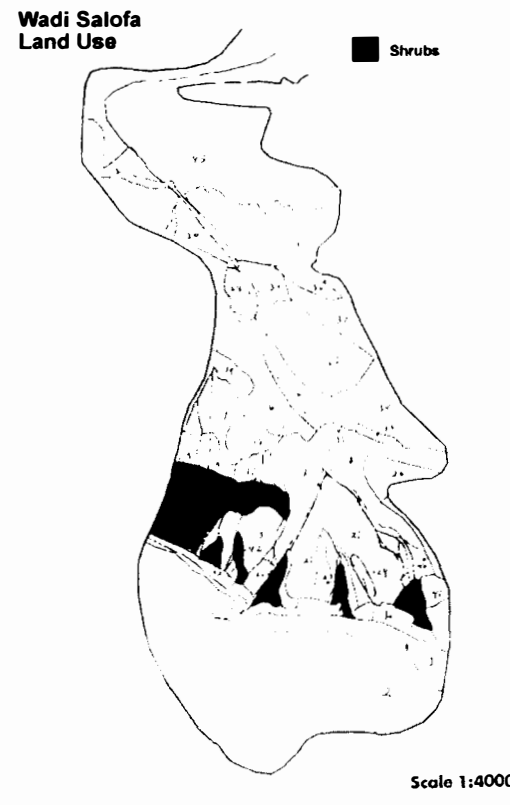

Fig 2.4. Potential improvement

Figure 2. Integrated Watershed Management (IWM) approach for the project area

IWM techniques. These modules were for watershed appraisal, planning, design, and monitoring and evaluation of development and conservation measures, and their outcomes. Based on land characterization and use and rainfall-runoff analysis, the water balance in the watershed was calculated. Alternative options of new development measures were set and evaluated with the concerned beneficiaries for decision-making and implementation of the best option technically, economically, and socially.

The FS approach to R&D deals with the whole of the farm as a consolidated production unit to be developed. It also recognizes the important role of its supporting institutions. The approach was employed to define and characterize major FSs and recommendation domains and their spatial distribution at the regional, sub-regional, and local community levels; to identify and prioritize problems; and, to guide the design of integrated resource management/ research/ and technology transfer programs according to farmers' definition and prioritization of their problems.

The CAP approach recognizes each of the 38 local communities as a consolidated social unit of the rural development. It was operated as a planning and implementation vehicle of the R&D plans (Fig. 3).

Technologies Tested and Transferred

The demand-driven R&D programs implemented by the project tested, adapted, and disseminated technologies for conserving the fragile natural resource base of the target area, improved and sustained agricultural productivity, and enhanced farmers' incomes. Areas of particular concern and first priority of the programs were water harvesting and soil conservation technologies; planting fodder plants for range rehabilitation; animal husbandry and grazing management; and crop production and cropping systems improvement, including fruit trees and protected agriculture, efficient crop-water use, and integrated pest management (IPM).

NRM: water and soil

To improve and sustain agricultural production within the existing agro-ecosystems, the project introduced environmentally sound water harvesting methods to make efficient use of the rainfall. These methods, that were the outcome of both research work and improved indigenous techniques, included:

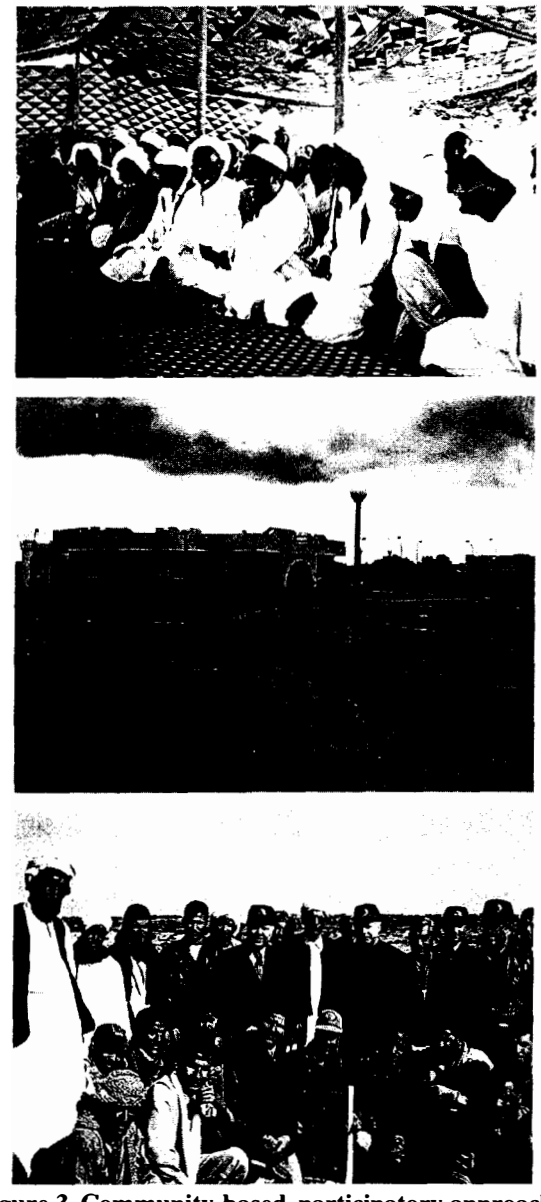

Figure 3. Community-based, participatory approaches

- Construction of underground indigenous cisterns and reservoirs, to be used mainly for domestic needs and watering livestock; and, for supplementary irrigation of orchards in case of water surplus availability;
- Construction of small dikes (dry stone, cemented-stone, and earth) laid along the contours and across wadis to retard flood flows and more fully utilize surface runoff for improved yields on existing farms, fodder tree plantations, shelterbelt trees, soil erosion control, and for creating, through sedimentation, new potentially fertile soils for orchard establishment (Fig. 4); and
- Several micro-catchment techniques were also utilized to enhance water availability to agricultural areas, particularly for fruit trees and forage shrubs (Fig. 5).

Figure 4. Dikes for water harvesting and soil conservation

Figure 5. Micro water-harvesting R&D

Rangeland rehabilitation

The project focused on rangeland improvement in the more densely populated areas, where land tenure and use are well defined. Technologies tested and transferred for rangeland rehabilitation (Figure 6) were based on:

- [illegible] introduced new adapted range species;
- Planting fodder shrub seedlings (with and without fencing) such as *Acacia* spp., *Atriplex* spp., and spineless cactus;
- Direct reseeding of deteriorated pasturelands by annual and perennial species, such as those mentioned above, medics (*Medicago* spp.) and other species of forage legumes and grasses; and
- Provisions were made for encouraging interested farmers to establish small nurseries.

Crop production improvement

Technologies promoted for crop production and cropping system improvement were focused on germplasm improvement and cultural practices. A particular emphasis was given to the improvement of barley, the principal crop in the target area. Technologies tested and disseminated (Fig. 7) were the following:

- **Improved varieties:** New barley varieties developed by ARC-Egypt and ICARDA for rainfed production were tested and dissemi-

Figure 6. Intensive range development

Figure 7. Barley improvement technology

nated to barley producers. The variety 'Giza 126' proved to be the best, and the project provided considerable amount of seed to farmers to enhance its adoption.

- **Seed rate:** Most farmers use low seed rates of barley (less than 25 kg/feddan, 1 ha equals to 2.5 feddans). A range of seed rates was tested and 25-30 kg/fed was recommended.
- **Plowing:** Most farmers plow the soil only after sowing for seed covering. A practice of two cross-cultivations was recommended, one before and one after sowing.
- **Crop rotation:** Monocropping of barley was common in the area. The project introduced food and feed legumes in rotation with barley. The rotation of barley/ local vetch was most accepted by farmers.
- **Barley - vetch mixture:** Several combinations of barley-vetch mixtures were tested, and the recommended mixture was 75 % barley and 25% vetch.
- **Fodder shrub intercropping in barley fields:** *Atriplex* was tested at a variable intercropping spacing, and the recommended was 10-15 m between rows and 3 m between shrubs.
- **Improved production package:** A new, simple package of barley production (variety, modified plowing and sowing rate as above, with a small dose of phosphate) was introduced that increased barley yield substantially.

Horticulture

Improved horticulture technologies tested, adapted, and disseminated were related to:

- Introduction of new species and varieties of fruit trees and vegetables;
- Cultural practices, especially pruning, fertilization, supplemental irrigation, harvest, and post-harvest handling; and
- Introduction of plastic greenhouse technology, at a small scale.

Livestock

Livestock R&D emphasized the following:

- Improved fattening regimes;
- Veterinary and health improvement; and
- Improved flock management, including nutritional aspects using local feed materials.

Women in development (WID)

The R&D interventions of the project were gender-mainstreamed to highlight the role of women in INRM, and in the socio-economic activities of the Bedouin household. The WID program dealt with on-farm and off-farm activities such as:

- Small income-generating projects for livestock production (sheep and goats, rabbits, poultry, etc.); home-gardening, olive pickling, fig drying, handicrafts making, and other income-generating projects; and
- Awareness and skill improvement, focusing on literacy, improved nutrition and health and other aspects of housekeeping and household management.

Achievements, Adoption, and Impact

Secondary data from project documents, and primary data collected through rapid rural appraisals, farm surveys, and case studies were used to assess project achievements, and measure adoption of new technologies and their impact on farm productivity and income of the target population.

Technical assistance delivery

More than 3735 person days of on-the-site technical assistance was provided by 51 ICARDA scientists and outsourced consultants from 18 nationalities to the various R&D programs of the project. Particular emphasis was laid on training and human resource development. In addition to the extensive on-the-job training provided by all TA scientists, over 1450 person days of overseas training was provided for project staff and local farmers and herders in 12 countries.

Institutional developments

To respond to the urgent need for developing a local capacity for testing and transferring agricultural technologies suited to arid conditions, the project established the Matrouh Adaptive Research Center, and the Training Center for Rainfed Agricultural. The project also established an active agricultural extension unit/service, including the women in development (WID) program. The unit was jointly operating with the adaptive research and resource management programs. Research, particularly at the sub-regional level, was intimately linked with extension activities through on-farm trials and demonstrations, and through training of extension staff and community members. The two centers were additionally involved in research, training, and technology transfer for dryland areas at the national level, and have developed and maintained links with national, regional, and international research and training institutions.

To facilitate decentralized management and community participation in planning and implementing project activities, the project area was administratively subdivided into five sub-regions, with a sub-regional support center (SRSC) established for each. The target population was also sub-grouped by geographic, hydrological, and tribal considerations into 38 local communities (LC). Each LC had a Community Committee (CC) selected by its members to manage their affairs, facilitating a link between the community with SRSC and project management. Due to Bedouin traditions restricting direct contact of men and women, the CC comprised of two sub-committees (one each for men and women). Small social centers were also established, as well as small school buildings (15 newly established and 35 old rehabilitated).

The SRSCs were staffed and equipped to assist the CCs to formulate and implement community action plans (CAPs), based on R&D needs as identified by LC members. Membership in LC was discretionary, but the project gave no/ or low priority to non-members' requests for R&D. The LC mechanism facilitated effective implementation through beneficiary participation. The adoption survey revealed that over 85 % of the total households (HH) were familiar with project activities, either through LC delegates (75 %), direct contact with project authorities (65 %), or through the mass media (17 %). It was also found that about 65 % of HH had attended LC meetings, and participated directly in planning and implementation in CAPs.

Monitoring and evaluation (M&E)

M&E of project performance, and the impact of its outputs was a built-in component of the methodological approach. An M&E unit was established at project initiation, and was upgraded (staff and facilities) throughout the duration of the project. M&E activities were part of the main areas of project activities.

Adoption and impact

Water harvesting: Structures constructed almost doubled water availability for domestic use and crop production. Over 10,000 HHs (58 % of total HHs) benefited from cisterns establishment, and 8200 HHs (47 % of total HHs) from constructing dikes, mainly on more than 3000 ha of orchard and crop area.

Range and livestock: More than 7.5 million fodder shrubs and trees were planted, and/ or interplanted, improving fodder production on about 10,000 ha of rangelands and 2000 ha of barley area. These, with the improvement of barley production, increased fodder supply by about 10.5 million Feed Units (1 feed unit is equivalent to 1 kg barley), reducing the total feed gap in the project area by 20 %. More than 7000 HHs (67 % of rangeland holders) benefited, and 45 % increased their income by over 25 %.

Crop improvement: The improved package of barley increased yield by 65 %. The adoption survey showed that more than 53 % of barley producers adopted the package, increasing their yields (on about 30,000 ha) by 20 - 100 %. Some case studies' yield increased from 300 kg to 580 kg/feddan (93 %), and from 210 to 430 EP/feddan.

Fruit production: About 62 % of producers increased yields on about 15,000 ha of orchards by 25 - 100 %. The case study showed that the yield of figs and olives increased by 60 % (50 - 80 kg/tree for figs, and 30 - 50 kg/tree for olives), and average net benefit was increased by 52 % (from 57,000 to 86,000 EP/farm).

Total farm income: Income of over 58 % of the total HH (> 17,500 HH) increased because of the project interventions; the increase in most HH was by 25 % or more.

Women in development: The Bedouin women realized very impressive achievements. Over 5000 illiterate girls and women were educated, and more than 3100 women benefited from the skill-enhancing training activities. Several women-managed small income-generating projects were established (1500 home gardens, and over 610 small poultry projects). They have also contributed to environmental improvement by partially replacing fuel wood by gas ovens, establishing latrines, and using manual water pumps.

Conclusion and Lessons Learned

Integrating the adaptive research work with extension through the community-based, multidisciplinary, and participatory approach to R&D was one of the major factors for the success of the project. Combining the various implementing agencies (research, resource development, and extension) in one organizational and operational structure enhanced the implementation of project activities, as well as the adoption and impact of its outputs. Bringing these agencies to jointly operate under the project umbrella helped avoiding the time-consuming, inefficient, and bureaucratic mode of action deeply rooted in the official agencies in the developing countries.

However, it was a new approach that required new ways of thinking and operations. It took a year to complete the identification and application of proper methods and criteria for organizing the population into the 38 LCs, and to gain acceptance of the beneficiaries to make collective decisions and actions. Another two years were needed to complete the Community Action Plans for the 38 LC. Intensive training (formal and on-the-job) of project personnel and LC members was conducted on participatory approaches for setting the action plans.

The availability of sufficient resources, especially the budgets, and providing some incentives to project staff, mostly coming from other provinces to the remote areas of Matrouh, were also other important factors in the success.

On-the-job training was very effective for enhancing project implementation, and up-grading the skills and capacity of project staff and local communities to implement new R&D approaches to INRM and production improvement. Therefore, it was emphasized in the TOR of every technical assistance mission. The overseas training and study tours enhanced adoption of new technologies such as the micro-water harvesting systems, semi-circular and contour ridges, the *Atriplex* shrub and spineless cactus planting, barley-legume rotations and mixtures, and fodder shrub interplanting on marginal crop areas. When these techniques were first tested and demonstrated, the farmers showed hesitation in adopting them. However, after observing large-scale adoption of the technology, and discussing its impact with colleague farmers from other countries, farmers readily adopted the technology.

The experience gained from MRMP showed that injecting research and technology transfer programs in large-scale resource management and rural development projects is one way to achieve impressive adoption and impact of new agricultural technologies in the developing countries.

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