Annex IV. Examples of Technology Transfer Activities and Impact of the Outreach Programme

The headquarters and field research activities constitute one overall programme and, consequently, it may seem difficult to appraise the technology transfer and impact of the outreach activities separately. However, there are many useful examples which would not have occurred without the additional research activities funded through special projects and implemented under the outreach programme. For different sub-regions a number of these are presented in the following. The information has been summarized from reports mostly provided by the Regional Coordinators. Detailed impact studies have not always been carried out but, in cases where this has been done; the excellent results obtained have been clearly demonstrated. There is no doubt that similar results would be achieved if economic on-farm surveys could be carried out to determine the impact of the work undertaken under all the regional programmes.

Activities in Central Asia and the Caucasus

One of the great benefits of the ICARDA coordinated programme for Central Asia and the Caucasus (CAC) is that it has for the first time since 1991 provided a neutral forum for an active interface among NARS leaders and scientists from the eight countries of the CAC region. ICARDA was the first Centre of the CGIAR to establish a regional programme in the region and has posted staff in the Tashkent office since 1998.

Under this regional programme NARS are being strengthened to become more efficient and responsive to the new emerging challenges in the region. So far, over 2500 scientists have either been trained or given an opportunity for participation in various meetings, workshops and conferences. To improve communication opportunities special efforts have also been made to impart English language training to around 300 young scientists. Infrastructure has been upgraded and ICT networking through e-mail and Internet access has been established. Notwithstanding the fact that this regional program is rather young significant progress has been made in a number of research areas. This was mainly possible because of the availability of a large pool a well qualified staff which, however, was working mostly in isolation and lacked the means to carry out the necessary research since 1991.

Plant Genetic Resources and Germplasn Development

In cooperation with IPGRI, plant genetic resources units have been established in each of the eight CAC countries. Collection missions have been undertaken and in total over 1800 accessions of different crops have been collected and added to the genebanks.

Based on material sent from the joint CIMMYT/ICARDA/Turkey Programme on Winter Wheat Improvement new varieties have been developed and currently ten of them or in the final approval stage by the State Variety Testing Commissions (STVC) in the various countries. Two winter wheat varieties emanating from the introduced materials have already been released, one under the name of Dostlik (which means friendship) in Uzbekistan and Mtskhetis in Georgia. In field experiments Dostlik,

which in 2003 is multiplied on 300 ha, shows significant yield advantages over the varieties currently grown; it has good resistance to yellow rust and some tolerance to salinity.

Three winter barley varieties and one spring barley variety have been submitted to the STVCs in Kyrgyzstan, Azerbaijan, Uzbekistan and Kazakhstan. One improved chickpea variety will soon be ready for release in Azerbaijan, and one is already grown by farmers in Georgia. An improved lentil variety has been released in Georgia, and one has been submitted for testing to the STVC in Uzbekistan.

Natural Resource Management

Very encouraging progress has already been made with the introduction and adoption of improved soil and water management technologies. This has been achieved under the project on Soil and Water Management initiated in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan, and financed by the Asian Development Bank from 2000 onwards. While considering the following examples it should be noted that under the USSR regime these countries applied standardized production practices, including mono-copping, high dosages of fertilizers, and deep ploughing; all aimed at producing maximum quantities of cotton and wheat.

- Improved irrigation technologies, developed and tested on-farm, increased average yield of winter wheat by more than 40%, reduced soil erosion by almost 60%, and increased water use efficiency by 50 – 100%. These technologies are now ready for adoption on approximately 1.4 million ha of sloping land in Uzbekistan.
- In southern Kazakhstan, the introduction of improved irrigation technologies, led to about 30% of water saving compared to traditional furrow irrigation. It also reduced the pressure on the drainage system by 40%.
- Experiments using treated wastewater for irrigation of fodder and industrial crops and tree plantations in Kazakhstan and Tajikistan led to promising results with respect to the potential reduction in use of scarce water resources.
- Under rain-fed semi-arid conditions of northern Kazakhstan, minimum and zero tillage resulted in 15% higher grain yields compared to the general practice of deep ploughing. Currently, zero tillage has already been adopted by farmers on approximately 10,000 ha.
- Reduced tillage has also led to promising results in Turkmenistan; water productivity increased by 25% compared to the traditional deep ploughing practices.
- In Uzbekistan and Tajikistan, cotton planted as a double crop after winter wheat gave similar yield under no-tillage compared to traditional deep ploughing and mono-cropping. The no-tillage practice has now been introduced on about 4,000 ha in these two countries.
- Crop diversification has been promoted through the introduction of chickpea, safflower, soybean, common bean, mungbean and groundnut. Chickpea, earlier an unknown crop, is now grown on about 3,000 ha in northern Kazakhstan, while in southern Kazakhstan, safflower is produced under rain-fed conditions on some 70,000 ha and soybean on 2,000 ha. In Kyrgyzstan, common bean (*Phaseolus vulgaris*) now occupies some 2,500 ha, and rain-fed chickpea some 3,000 ha.

- Double cropping of cotton after winter wheat has been introduced in Uzbekistan on 5,000 ha. In Tajikistan, double cropping has been practiced using different crops after winter wheat such as cotton on 5,000 ha, buckwheat on 3,000 ha, tobacco on 1,000 ha and rice on 1,000 ha.
- Wheat-cotton rotation is now getting popular due to the introduction of conservation tillage, varietal adjustments and alternate furrow irrigation technologies. It is expected that the area under cotton-wheat rotation in the CAC Region will increase to about 200,000 ha in the next two to three years.

Crop/Livestock Integration

The project on Integrated Feed and Livestock Production in Steppes of Central Asia undertaken in Kazakhstan, Kyrgyzstan, Turkmenistan and Uzbekistan with support of IFAD since 1999, has led to the following outputs.

- Research on socio-economic and public policy matters identified the main livestock production constraints; described the different types of farming units and marketing channels, and determined the access to rangelands, and community property rights.
- For range rehabilitation promising results were obtained in the steppes of Kazakhstan, Turkmenistan, and Uzbekistan, by using various native shrubs.
- Intensive forage production technologies using a rotation of triticale, oats and fodder pea, followed by maize gave dry matter yields of about 14 t/ha under irrigated conditions in Uzbekistan and Turkmenistan.
- Feed block technology for sheep feeding is increasingly adopted in Uzbekistan and is being tested by a number of farmers in other countries.
- Improved livestock management technologies, such as early weaning, early lambing and market oriented lamb fattening, allowed farmers to generate more income in all the Central Asian countries.
- Farmers in the region, who never practiced milking of sheep before, are now getting interested to adopt this practice, to increase their income.

Iran/ICARDA Collaborative Agricultural Research Programme

The Iran/ICARDA Project on Strengthening Agricultural Research for Dryland Farming in the Highlands of Iran started in 1990 and has continued to consitute the base for research collaboration on

- germplasm enhancement of various food and feed crop species for dry-land conditions,
- the development of rain-fed crop production technologies,
- research on the integration of crop and livestock systems, and
- study of socio-economic factors limiting agricultural production in rain-fed highland areas.

The project has led to the establishment in 1993 of the Dryland Agricultural Research Institute (DARI) at Maragheh, with three major research stations at Maragheh, representing the cold-winter areas, at Kermanshah representing the cool-winter areas, and at Gachsaran, representing the mild-warm winter areas.

ICARDA provides annually about 1000 kg of germplasm seed representing more than 6000 entries/genotypes of different crops to researchers from DARI and the Seed and Plant Improvement Institute (SPII). Special emphasis is placed on germplasm with specific attributes suitable for growing in Iran, in particular, adaptation to drought, heat, cold, salinity, and tolerance to diseases and insect pests. Iranian researchers have evaluated and used this germplasm in their breeding programmes, which has led to the release of a number of cultivars. This included seven wheat cultivars, five barley cultivars, two chickpea cultivars and one lentil cultivar. A number of advanced breeding lines of wheat, barley, chickpea and lentil with superior performance are being retested during 2003 in multi-location on-farm sites, before a final decision is taken on their possible release.

In addition to these breeding successes, production technology packages have been developed by DARI researchers working jointly with ICARDA scientists for the major agro-ecologies of Iran. This included adoption of appropriate varieties, time of planting, seed rate, fertilizer rate and placement, drill sowing, and weed control. Farmers using the improved technologies in rain-fed areas have seen their yields increased by 10-50 % for wheat crops, and 100-300 % for chickpea, despite the severe drought that prevailed during the past four years. These successes have been demonstrated in field days to farmers who expressed a keen desire to adopt the new technologies, and these were applied in 2002 on some 4,000 ha of demonstration-cum-adoption fields in four provinces within Iran during 2002. During 2003 the improved production package is used on 55,000 ha.

ICARDA contributed to a major effort on the introduction, development and production of oilseed crops, particularly rapeseed. Three oilseed consultants were seconded to SPII and DARI in 1999. As a result of this, promising varieties and proper production technologies have been identified and are adopted by farmers, mostly in irrigated areas. However, there is also a real potential for oilseed crops, both rapeseed and safflower, in rain-fed areas of Iran. Grain yield of rapeseed is 4-5 t/ha on properly irrigated farms, and about 1 t/ha on rain-fed farms. The area grown to rapeseed has increased from 11,000 ha in 1999 to 48,000 ha in 2002.

During the period 1990-2001, a total of 737 scientists and technicians have been trained through ICARDA-organized courses either in-country, or outside Iran. In addition, 60 scientists have been sponsored by the project for PhD degree training at foreign universities. While 10 of these researchers are still pursuing their studies, most of the others have returned to Iran and are contributing effectively to the enhancement of the research capacity of their respective institutes.

In conformity with its strategy of encouraging or establishing collaboration in agricultural research among countries of CWANA, ICARDA, through its Teheran Office, has conducted a number of regional activities, with a strong backing from the Agricultural Research and Education Organization (AREO) and with the participation of a large number of Iranian scientists.

Activities undertaken under the West Asia Regional Programme

Results obtained in the Marhreq region under the Masheq and Maghreb Project offer a useful example of new technologies developed and adopted as part of the outreach programme. The Mashreq-Maghreb Project has developed and introduced several improved crop and livestock technologies into the farming systems of Iraq, Jordan, Lebanon, and Syria. The adoption of these technologies has been determined through on-farm surveys. In depth economic analyses have been carried out to determine the benefits of the use of improved barley varieties, the adoption of feed blocks, the introduction of vetch in barley rotations, planting of cactus, and early weaning of lambs. It has been clearly proven that the Mashreq and Maghreb project has contributed significantly to the welfare of farmers in the dry areas of West Asia.

Results demonstrate that improved barley varieties fitted well into the prevailing production systems; the rate of adoption, i.e. the percentage of farmers adopting the new technology, was over 50% in Iraq, Lebanon and Jordan, and 32% in Syria. Planted areas to newly developed barley varieties constituted 54% of the total barley growing area in Iraq, 67% in Jordan and 21% in Syria. The high adoption rate is attributed to better productivity, improved disease and lodging resistance and in some areas to distinctively higher returns.

The feed block technology has been expanding rapidly among sheep owners in countries in West Asia. In Iraq, the collected information revealed that sheep owners are routinely supplementing the feeding of their sheep with feed blocks. In other countries, the feed block technology is also gaining grounds, for example its adoption rate was 21% in Jordan.

Cactus planting and subsequent use in animal feeding is expanding in the West Asia region. However, expansion to new environments is mostly by government decisions. Several other technologies contributed to increased welfare of the rural poor in selected zones of the region. *Vetch* introduction in barley rotations and early weaning of lambs showed adoption rates of respectively 28.5 and 28.8% in Syria, and influenced in a positive manner sheep production and related economic returns.

Farm size, land tenure and type of farming systems influenced in many situations the level of adoption of a given technology. In Jordan, for example, mixed crop and livestock production systems had the highest adoption rate for all technologies. Similarly in Syria, adoption was highest for farmers practicing livestock, or mixed crop/livestock production systems. Land tenure had a noticeable positive impact on the adoption of improved barley varieties and vetch introduction and growing in Jordan.

Examples of economic impact

Performance indicators and relevant methodologies have been used to assess technology impact on farm income and its distribution, and on household food/feed security and productivity. Benefits and costs associated with each technology have been assessed to calculate the internal rate of return (IRR) and the benefit-cost ratio.

The impact of improved varieties on barley productivity is evident in Iraq; the net benefit was 19%. Similarly in Syria it has been shown that planting of both improved and local varieties at the same input levels will result in a yield gain of 20% from the improved variety. These varieties increased the household food security, measured in kg of barley grain/household/year, by 14% compared to local varieties.

The use of feed blocks increased sheep production efficiency by 32% in Iraq as a result of the increased number of lambs born. Results also show that increased meat production of 4.09 kg/ewe/year may be attributed to the use of feed blocks. Similarly, increased milk production of 8.28 kg/ewe/year is obtained following the use of feed blocks. The calculated benefit/cost ratio was 1.56 and the IRR 87%. Comparing the IRR of 87% with the effective rate of interest of 10% indicates that investment in feed blocks for sheep feeding is paying high dividends.

Economical analysis of the introduction of forage legumes in Iraq showed that the rotations of barley/vicia, barley/vicia-barley mixture and barley/fallow are more profitable than other alternatives. For farmers with mixed crop-livestock enterprises, the rotation of barley/vicia and barley/vicia-barley mixture have been recommended as they serve better the goal of crop/livestock integration. These case studies showed that the introduced technologies were economically attractive, regardless of government subsidies. However, government incentives are important at the early stages of technology adoption to secure widespread dissemination.

In recent years ICARDA is coordinating a regional project on the conservation and sustainable use of dry-land agro-biodiversity, which is implemented in Jordan, Lebanon, Palestinian Authority and Syria. The preliminary impact of the project is the increased awareness of local communities and major decision makers of the importance of the local agro-biodiversity. The relevant Agricultural Research Institutions and Forestry Departments have now developed biodiversity units to promote in situ and ex-situ conservation. The governments and local communities are increasingly using local wild fruit trees in reforestation efforts. In Syria, the number of wild fruit tree seedlings planted has increased from 30,000 to more than 600,000 in three years. So far twelve in situ conservation sites have been created in the participating countries.

Activities in the Arabian Peninsula

The Arabian Peninsula is characterised by low and erratic rainfall, high evaporation rates and very high temperatures. The countries in this sub-region, Bahrain, Emirates, Kuwait, Oman, Qatar, Saudi Arabia and Yemen, face the challenges of developing sustainable agricultural production systems, in particular, making more efficient use of their scarce water resources and preserving the environment and biological heritage. Three main research themes are pursued by the Arabian Peninsula Regional Program (APRP) with, at the same time, strong emphasis on strengthening the national institutional and human resource capacities. These themes are:

- on-farm water use and irrigation;
- rangeland, shrubs, irrigated forages and livestock; and
- protected agriculture.

Examples of activities undertaken in recent years and achievements include the following.

On-farm Water Use and Irrigation Management

- Specialized equipment has been introduced in the UAE to obtain more accurate measurements of water use efficiency.
- The establishment of a weather stations network for the Arabian Peninsula has been initiated with the distribution of eleven automatic weather stations. The objective is to link the weather stations to the ICARDA-APRP Internet website to make data available to the end-users to estimate near real time crop water requirement as an input to more efficient irrigation water management.

Rangeland, Shrubs, Irrigated Forages and Livestock

- A potential solution to water shortage and rangeland problems is the development of production systems based on indigenous species with relatively low water requirements. Plant and seed collection missions have been carried out in all countries of the Arabian Peninsula. From the species collected, a total of 27, including 10 grasses and 15 shrubs/trees, were identified as high priority according to various criteria. Feed quality of some of these has been determined with initial results showing their nutritional value to be as high as that of introduced material.
- Rehabilitation of heavily degraded rangeland in Saudi Arabia and Yemen through the seeding and transplanting of drought tolerant indigenous shrubs and trees and proper grazing management has been very successful.
- A preliminary study on water use efficiency was initiated in UAE comparing two native grasses (*Cenchrus ciliaris* and *Lasiurus scindicus*) and one exotic species (*Chloris gayana*). A more comprehensive study is now undertaken in UAE comparing the above species with *Panicum turgidum, Choelachyrum piercei* and *Medicago sativa* for their water use under drip irrigation.
- Bulk seed production of priority species is pursued in all countries and samples of *Cenchrus ciliaris*, *Coelachyrum piercei* and *Lasiurus scindicus* were collected from a natural reserve in UAE. The material has provided an opportunity to test seed scarification and cleaning equipment.
- A seed technology unit has been established in UAE to enhance quality seed production of indigenous forage species. A similar unit is being established in the Sultanate of Oman.
- In UAE four grasses have been multiplied at two locations of 5 ha each. Similar activities are ongoing in the Sultanate of Oman, Qatar, Saudi Arabia and Yemen.
- Suitable fodder shrub species have been identified in the northern part of Saudi Arabia. These include: *Atriplex leaucoglada, Salsola velosa, Salsola tetrandra, Atriplex halimus* and *Tragnum nudatum*.

- To increase farmer's income in the mountain terraces of Yemen, cultivation of cash crops in greenhouses has been introduced. The use of drip irrigation in plastic houses proved of interest to farmers because of more efficient water use. Cost/benefit analysis revealed that total costs can be recovered in three seasons.
- Integrated Production and Protection Management (IPPM) practices have been developed to provide greenhouse growers with simple applicable techniques for crop protection instead of relying mainly on pesticides. IPPM has been used successfully by both research stations and private growers in all the Arabian Peninsula Countries.
- Solarization techniques for the control of soil-borne diseases have been introduced on research stations and private farms with excellent results. It eliminated the use of hazardous pesticides. Training has been provided and a guide book has been made available to growers and extension agents in the region. The technique has been successfully adopted by many growers in the countries of the Arabian Peninsula.
- To increase quality and quantity of yield per unit of water, area and manpower, soil-less growing techniques have been introduced for vegetable and strawberry production. Economic analysis showed significant returns on the investment with major savings in water, fertilizers and labour, in addition to reduced salt accumulation and infestations by soil-born pathogens. Soil-less production has been adopted by many growers in different countries.
- Positive results have been obtained in experiments testing new designs of greenhouses and cooling systems. These provided extra crop protection and improved cooling, with possibilities to recover fresh water from the enclosed area.

An Information Technology System for Agriculture and Natural Resources Development in the Arabian Peninsula has been introduced in collaboration with research institutes in Egypt. An Internet based expert system for cucumber production under protected agriculture has been developed and placed on the Internet. This allows growers, extension personnel and researchers to take the right decisions for cucumber production. (www.icarda.cgiar.org/aprp/it.htm). Over the last four years more than 120 researchers and scientists from the sub-region have been trained by ICARDA. A Seed Technology Unit has been established at the Dhaid Research Station in UAE.

Activities in North Africa

The North Africa Regional Program (NARP) has evolved from a commodity focus, emphasizing technology testing/demonstration at the farm level, to a community and participatory based approach, addressing technical, socio-economic, institutional, and policy dimensions. Strengthening of NARS' capacities has been an integral part of most of the project activities undertaken. Activities aimed at assessing women's role in food production and household food security, such as durum wheat and wool processing, have been initiated throughout the region. Regional networks and

meetings have significantly fostered cross-fertilization of experiences among NARS' scientists. Special efforts have been undertaken to forge linkages with development projects to enhance the dissemination of new technologies and speed up their adoption by farmers. Various on-farm surveys have been undertaken to determine the adoption of improved technologies.

Crop improvement

Since 1980 the national programmes of Algeria, Morocco, and Tunisia, in collaboration with ICARDA and CIMMYT, have succeeded in generating several new varieties. For cereals some 100 improved varieties have been released between 1980 and 1999. The main feature of later generation varieties is their ability to perform well, even under the prevailing abiotic and biotic stresses. A large proportion of farmers' fields are now planted with new cereal varieties, and in particular the adoption of improved wheat varieties is widespread across the region. Improved barley varieties are now grown on 40% of the cultivated area in Morocco resulting in a 35% increase of productivity. The development of lentil varieties with good standing ability, well adapted to mechanical harvesting, has significantly enhanced adoption of new materials and mechanical harvesting. Moreover, the winter chickpea technology is making headway, especially in Morocco. Surveys show that the average yield advantage of improved varieties of cereals and food legumes ranges from 20 and 50%.

Natural Resource Management

Research and development efforts on sustainable crop and livestock systems have been initiated through projects such as the Mashreq-Maghreb project. As part of this a bio-economic model has been developed and validated, in particular in Morocco and Tunisia. This model provides valuable insights into the effect of macro-economic reforms on farmers' production strategies at the community level. It is a major tool for policymakers and researchers alike to better assess the implications of policy and institutional reforms on technology uptake.

For rangeland development encouraging results have been obtained through the introduction of new plant species, in particular *Lathyrus*, *Medicago*, and vetch, as well as fodder shrubs, for example, *Acacia* and *Atriplex*, and spineless cactus varieties. Due to the increasing feed demand the area devoted to forage crops is gradually increasing. The sustainability of pasture development, however, strongly depends on appropriate grazing management with stocking rates tailored to the nature and state of the vegetation and the availability of other feed resources. NARP activities have therefore emphasized the implementation of a multifaceted approach including rangeland development, crop rotations with a larger share of forage crops, especially legumes, and the development of low-cost feed alternatives such as feed blocks and straw treatment.

Studies on the effect of land ownership on smallholders' investment behaviour showed that regardless of the land ownership rights, complete or partial, most farmers do invest in soil improvement operations such as de-stoning, tree planting, and well digging. However, land fragmentation, small plot size and remoteness negatively affect investment in land improvement. With regard to common pastures, the

mechanisms currently in place, governing access and use, do not provide a satisfactory balance between individual and social interests enabling optimal use and sustainable management.

Small ruminant production

Throughout the region, livestock represents a major component of the farming systems. Quantity and quality of feed is by far the most limiting factor to livestock production in the region. Due to its extensive nature, livestock production relies mainly upon grazing on communal lands that provide barely the minimum nutrient requirements because of degradation. NARP has been developing viable options to improve livestock production, especially through improved feed production. For example, barley-*Atriplex* intercropping has been promoted as a viable alternative to barley mono-cropping. The success of this approach is demonstrated by the fact that *Atriplex* is now also intercropped with other forage crops such as oats, while other forage mixtures, for example, barley/fodder pea and/or oats/vetch mixtures are increasingly used by the farmers.

The feed block technology has been identified as a breakthrough in overcoming the increasing shortage of feed in the region. The technology is simple, cost-effective, and its adoption by livestock owners was virtually instantaneous and has spread throughout most countries of the region. It has led to the development of a private feed industry, which has the additional advantage of providing important employment opportunities to rural labourers. The feed block technology greatly reduced feeding cost in Tunisia. The estimated IRR of 57% clearly explains why the technology is being widely used to substitute expensive feed resources, such as barley grain and wheat bran, while maintaining the same weights for small ruminants.

Another technology developed/revived to overcome feed shortages has been cactus, *Opuntia* spp., production. It is particularly well adapted to the harsh conditions of the dry areas, and is an important alternative source of feed as well as a means to control erosion and desert encroachment. In parallel to the development of new feed alternatives, ewes' fertility and reproductive capacity has been improved through the introduction of rams and the utilization of hormone treatment. Improved rams with a genetic potential to improve milk production and lamb growth have been identified and distributed to sheep owners for the genetic improvement of their flocks.

The IRR for cactus in marginal cereal production areas in Tunisia ranged from 61-66 %; while for cactus growing in the form of alley cropping with barley the IRR was between 81-89%. This increase in the IRR under alley cropping is solely attributable to the barley planted with cactus. Likewise the estimated IRR of combining *Atriplex* with barley through alley cropping in Morocco is 79%, indicating the efficiency of research investment in this technology. The IRR for barley cropping alone is 59%.

Nile Valley and Red Sea Regional Programme

The Nile Valley and Red Sea Regional Programme has had a strong impact on agricultural development in Egypt, Ethiopia and Sudan. Until1995 the total number of improved cultivars released was 17 for faba bean, 6 for chickpea, 7 for lentil, 5 for field pea, 8 for wheat and 3 for barley. In addition improved production practices have

been developed and transferred to farmers. These varieties and improved practices have been widely adopted and have resulted in significant production increases. In the following the results of the Matrouh Resource Management Project in Egypt are taken as an example, because an in depth impact analysis has been carried out at the end of the project in 2001.

The Matrouh Resource Management Project has been designed and implemented to break the cycle of natural resource degradation and alleviating poverty in the rain-fed areas of the north western coast of Egypt. The region has a semi-desert environment with an annual average rainfall of 150 mm, and water is the main constraint for agricultural development. The project has used holistic inter-disciplinary approaches to research and development in full participation with the local Bedouin community and technical support from ICARDA. It was designed to undertake the following activities to support the local communities.

- Natural resource development and conservation, including soil, water and vegetative cover;
- Adaptive research to improve agricultural production in relation to crops, rangeland and livestock;
- Extension, training and social development, including rural women development;
- Credit and rural finance for small income-generating projects; and
- Management, including monitoring and evaluation of performance and impact.

The holistic and participatory approaches addressed:

- The whole of the watershed as the physical development unit, ensuring resource sustainability and social equity;
- The whole farm as the agricultural development unit, ensuring optimum resource use efficiency and farmers' adoption of recommended technologies; and
- The local communities as a consolidated social development unit, in bottom up planning.

Resource development and conservation achievements

- Design improvements were introduced for cistern and concrete reservoir constructions, improving water storage capacity and reducing costs by about 40%, and for dikes to improve their stability and more efficient functioning;
- New techniques such as micro-water harvesting systems, contour and semi-circular ridges, and gabions have been introduced;
- An integrated watershed planning approach has been implemented to sustain natural resource improvement, and avoid disputes on property rights between resource users; and
- Awareness and skills of local communities were upgraded on improved cistern and reservoir construction, water purification techniques, and maintenance of structures.

Major areas of technology transfer

- Crops: improving barley productivity through new varieties and cultural practices; cropping systems by introducing new crops, crop rotation, barley-vetch mixtures, and inter-planting of fodder shrubs.
- Horticulture: improving the productivity of figs, olives and vegetables mainly through cultural practices; introducing new species and varieties; rejuvenation of old and deteriorated orchards; and introducing greenhouse technology and drip irrigation.
- Range: improving the management of natural rangeland, identifying palatable local species, annuals and perennials, for multiplication and distribution to farmers; improved practices for seedling production of fodder shrubs, transplanting and management.
- Livestock: early-weaned lamb fattening; improved and more economical nutrition by using urea-treated straw; barley-vetch mixtures, fodder shrubs and olive cakes; rotating rams and cross-breeding with Damascus goats for germplasm improvement.
- Farming systems: characterization of farming systems for problem identification and orientation of research programmes; and evaluation of research findings and adoption of impact.

Impact

- Water harvesting constructions increased water supply by 45%, and water stored in cisterns and concrete reservoirs, and behind specially constructed dikes, was 280% and 110% of what was envisaged originally under the project outputs. Water harvesting had increased the net benefits of the overall farming systems by 88% on average for about half of the beneficiaries.
- More than 5.1 million fodder trees have been planted on more than 15,000 feddan (1 feddan = 0.42 ha), and perennials and annuals have been reseeded on more than 2,500 feddan. Productivity of barley has been increased by about 70% on 45% of the total barley growing area, increasing total production by 8,830 Mt and net returns by LE 7.8 million (1 US$ = 5.9 LE), or LE 1,185 per adopter farm or household. In addition to this substantial increase in barley production, this represented also an increased feed supply recovering 20% of the total feed gap in the project area. Fodder shrub plantation has reduced concentrate use and feed expenses by 37% on average, varying from 29 – 75% for about 40% of the beneficiaries.
- Shelter belts have been planted on a total length of 64 km of sandy soils suffering from erosion and sand dune movements; 33% of farmers increased their orchard area, 19% adopted crop rotation, and 16% inter-planted fodder shrubs with barley, all contributing to soil conservation. Fig and olive productivity increased by 60% and vegetables by 27%.
- Activities implemented by women such as home gardening and tree planting around the house, as well as women small-scale income-generating projects generated various benefits. In the case of poultry LE 367 per production cycle of 20 chickens.
- The beneficiary social pool was enlarged from 6,000 households at the time of the original project appraisal, to more than 18,600.

- Over 3,620 illiterate girls have been educated, and many thousands of women benefited from extension workshops and other activities to increase environmental, nutritional, and health awareness. New income sources and employment opportunities have been opened for women and men.

The Matrouh Resource Management Project provides an outstanding practical example on how to apply a holistic, community-based, approach for the development and introduction of sustainable agricultural production practices. The project results clearly demonstrate that this can be done successfully even under very harsh production conditions.