Impact of ICARDA's Research

Introduction

Since the Fourth EPMR, ICARDA, in close collaboration with its partners, has produced a broad range of technologies, and institutional and policy options that have considerably enhanced the opportunities for agricultural productivity improvements in the dry areas as demonstrated by the following examples of impact studies. They confirm the important contributions that agricultural research can make to the improvement of the livelihoods of the resource poor farmers in the dry areas.

Impact of Crop Improvement Research

Wheat production in Egypt was stagnant in the period 1980-85 at about 2 million tones but, as a result of both area expansion and yield growth, it increased dramatically in 1986-93. There was more than twofold increase in average production from about 1.9 million tones in 1982-84 to 4.4 million tones in 1991-93. Overall, from 1980-93 wheat production grew at an estimated average rate of 8.2% annually, 60% of which was due to yield increases. This production growth is a result of both technological advances (i.e. the use of high-yielding varieties, fertilizers, pesticides and machinery) and policy changes. The estimated economic benefits from the adoption of an improved wheat variety (Giza 164) in Sohag and Qena for 1988-99 are estimated at a rate of return of 36%. Giza 164 was jointly developed by Egyptian NARS and ICARDA.

The net present value of the stream of expenditures and returns over the 1970-1999 from durum wheat research in Morocco was estimated at about USD 111 million. Durum improvement research in Morocco has generated an internal rate of return (IRR) of 31% during the same period. Sensitivity analysis clearly shows that substantial increases in returns to investments in durum research can be achieved through the reduction of the research lag. For example, reducing the research lag to 9 years, instead of 13 years as considered in this study, would lead to a 21% increase of IRR, while a reduction of the research lag to 5 years would lead to a 40% increase of IRR. Rapid and widespread adoption of new varieties cannot be achieved without efficient seed production and distribution systems that will ensure on-time seed availability and adequate seed quality. The study provides evidence that virtually all the durum varieties released in Morocco between 1982 and 1988 are derived from CIMMYT/ICARDA germplasm, either as introduced advanced material or as parent material used in INRA crosses. This close collaboration has been strengthened over the years and has enabled the Moroccan durum program to release a substantial number of durum modern varieties (MVs) that not only carry resistance/tolerance to prevalent abiotic and biotic stresses but also compare well with traditional durum varieties in terms of grain quality. For example, pio-

neering research conducted on Hessian fly resistance resulted in the development of durum germplasm combining drought/heat tolerance and Hessian fly resistance and has now entered a phase of intensive on-farm testing. Sawfly resistance has also been successfully incorporated into drought/cold tolerant durum wheat germplasm. These achievements provide a clear indication that, despite the complexity and difficulty associated with crop improvement research, especially in drought-prone environments, a solid foundation has been established for durum germplasm enhancement targeted to these environments.

Stress-tolerant durum wheat varieties, developed by CIMMYT/ICARDA durum wheat improvement program for WANA, have been adopted by the national program in Syria, where about more than two third of the total durum wheat area in Syria is grown by these varieties. An estimation of the impact of modern agricultural technology on wheat in Syria was an increase of 1.66 million tons of durum wheat. National income would increase by about 348 million US$. About 34% of this increase is due to the impact of the use of improved varieties. Interestingly, benefits of modern technologies in durum wheat have accrued to all farmers–small, medium and large–in contrast to the experience in many other countries where large farmers tended to benefit the most.

Results obtained from agricultural research on sustainable wheat production have had influence on improving and developing agricultural technologies appropriate to farmers in Syria. These technologies had a clear impact on substantial increase of total wheat production on national level during the last few years and sustain it. Since 1990, though, there has been a shift in agricultural policy in Syria with focus on enhancing productivity of both durum and bread wheat through use of high-yielding varieties, chemical fertilizers, and pest-control measures suited to local conditions. Irrigation infrastructure has improved, extension and credit institutions have become available, and farm mechanization is being encouraged. Consequently, wheat production in Syria has exceeded demand since 1993.

Improved wheat varieties have substantially increased land and water productivity under rainfed conditions in Iraq compared to local varieties. Wheat yield increased by 37-50% under rainfed conditions and by 17-40% under supplemental irrigation due to the use of improved varieties. Similarly, water productivity increased by 14-28% under rainfed conditions and by 15-17% under supplemental irrigation. These results have important research and policy implications on optimization of the use of rain and scarce water resources.

Adoption of new barley varieties ranges between 20 and 40% in some WANA countries. In Iraq, the use of Rihane-03, an improved ICARDA-barley variety introduced to Iraq through the Mashreq and Maghreb (M&M) project, has led to a barley yield increase over the commonly grown local variety Aswad by up to 20% under low rainfall conditions and up to 40% under more favorable environments, under the same managements and levels of input use.

The impact of the ICARDA barley breeding program was analyzed, and it documented the production and release of new varieties, ICARDA's contribution to national varietal release and ICARDA's contribution to NARS pre-breeding research. A total of 111 barley varieties have been released in 23 developing countries during the 1980-99 period. ICARDA's contribution to varietal releases was determined using the origin of released varieties using pedigree analysis. This analysis concluded that about 78% of all barley varieties released by the 23 developing countries during the 1980-99 period were ICARDA-related material; either ICARDA crosses or selections or with at least one parent from ICARDA or direct releases received from ICARDA germplasm accessions. The overall average diffusion to 1999 of improved barley varieties, weighted by area, for nine countries (Algeria, Ecuador, Egypt, Ethiopia, Iraq, Jordan, Morocco, Syria and Tunisia) is 15%, of which 10% are planted with ICARDA crosses or varieties with ICARDA parents, and 5% are planted with NARS varieties. The gross annual research benefits from barley improvement research for these nine countries were estimated at about 105 million US dollars in 1997. The internal rate of return (IRR) to research investment ranged from 26% to 69%, largely depending on the size of cultivated area, adoption rate, the speed of adoption and research costs.

Box 1: Adoption and impact of improved barley varieties

Diffusion of new barley cultivars progressed well in WANA countries. This process continued with increased efforts by national scientists on adaptation trials, and consequently more new cultivars. Farm surveys and impact assessment studies clearly demonstrated the efficiency of research investments in barley production technologies. New barley cultivars increased total factor productivity in targeted zones/communities by as much as 35% compared to local varieties (see table below). The increase in barley production contributed greatly to household food and feed security. It further supports crop/livestock integration at the farm level.

Country	Adoption rate (%)	Adoption degree (%)* (%)	Impact on productivity
Iraq	60	54	17
Jordan	55	67	25
Lebanon	11-20	15-56	19-23
Libya	17	12	
Morocco	46	40	35(grain), -12(straw)
Syria	32	21	20

* Adoption degree is the percentage of land planted with improved varieties.

Source: Shideed, Kamil H. and Mohammed El Mourid (eds). 2005. Adoption and Impact Assessment of Improved Technologies in Crop and Livestock Production Systems in the WANA Region. The Development of Integrated Crop/Livestock Production in Low Rainfall Areas of Mashreq and Maghreb Regions (Mashreq/Maghreb Project). ICARDA, Aleppo, Syria, viii+160 pp.

In lentil, progress has been reported on disease resistance and in low-cost machine harvest systems. Use of double-knife cutter bar, self-propelled mower, and adjusted combine harvester has significantly enhanced adoption of new varieties and mechanical harvesting, which in turn led to a substantial increase in lentil area, especially in Syria, Turkey, and Sudan. For example, in the Urfa province of Turkey (a major lentil-producing province) 78% of the 150,000 hectares annually planted to lentils are mechanically harvested. In the Hassake province of Syria nearly two-thirds of the 25,000 hectares annually grown are mechanically harvested. In Morocco, however, although survey results show extremely high adoption of new lentil varieties (minimum of 22% in Safi province and 100% in Khouribga and El Brouj provinces), manual harvesting remains the predominant harvest method used by over 75% of farmers.

The profitability of adopting new technology depends on how the demands for inputs are changed and how large the productivity improvement is. Thus, an understanding of the effect of new technologies on productivity is crucial for better understanding of potential diffusion of the technology among farmers. In Iraq, improved lentil variety (Baraka) increased total factor productivity by 14%, implying a yield advantage of 14% over the local cultivar under the same levels of input use.

Reports also indicated that, in Bangladesh, where farmers mainly cultivate landraces, which are low yielding and susceptible to disease, new lentil varieties are making major headway. Through partnership with the Bangladesh Agricultural Research Institute (BARI) the lentil's genetic base has been broadened with the introduction of genes for disease resistance critical for development of useful lines. The partners developed improved, disease-resistant varieties that are now the centerpiece of complete production packages that have met with eager acceptance from Bangladesh's farmers. Farmer-to-farmer seed dissemination has further disseminated improved lentil. To date, about 60,000 ha out of a total area of lentil of 160,000 ha have been planted to improved varieties. Lentil farmers have also adopted related improved production practices, including relay cropping and mixed and intercropping, which have helped to further increase farmer income.

Likewise, lentil production and productivity in Nepal has significantly increased in the last 15 years, contributing to food security in the country as well as income generation for many small-scale farmers, agro-industries, traders, and exporters. Total lentil production in Nepal has risen from 63,000 tons in 1986 to 150,000 tones in 2003. Its productivity has increased from 593 kg/ha in 1986 to 818 kg/ ha in 2003. Some of the newly-released varieties, originating from ICARDA-supplied germplasm, have been adopted by the farmers in areas where there was no lentil earlier. Two recently released varieties, 'Shekar' and 'Sital', yield around 1.2-1.5 ton/ha and are preferred by farmers for their large seeds and resistance to the wilt/root-rot complex. Many elite lines selected from ICARDA international nurseries are awaiting release for different agro-ecological niches.

Similar to the barley study, the impact of ICARDA lentil breeding program was analyzed, and it documented the production and release of new varieties, ICARDA's contribution to national varietal release and ICARDA's contribution to NARS Pre-Breeding Research. A total of 52 varieties have been released by 22 developing countries during the 1980-1999 period. ICARDA lentil breeding program has contributed to 81% of the released varieties. The overall average adoption rate for six countries (Bangladesh, China, Egypt, Iraq, Jordan and Pakistan) was estimated at 17% in 1997. The total Gross Annual Research Benefit (GARB) for 1997 was estimated at about $ 7.7 million US for the seven countries (Bangladesh, China, Egypt, Iraq, Pakistan, Jordan and Syria). Large producing countries such as Bangladesh, Pakistan and Syria benefited most from this technology. Other small producing countries did not realize as much benefit, because of low adoption of improved varieties. Innovative ways of enhancing varietal diffusion at a much faster rate is a necessary condition for realizing greater returns from agricultural research.

Winter chickpea technology, which has been shown to increase chickpea productivity by nearly 60% over traditional spring sowing common in WANA, has made a headway, especially in Syria and Morocco. In Algeria and Tunisia, where farmers' and consumers' prefer large seed chickpea, the development of varieties with large seed size combined with Ascochyta blight resistance are expected to increase adoption of winter planting technology. On-going study involving a large sample of farmers in three provinces in Syria has been implemented to further assess the impact of improved technological package of winter chickpea on farm income and household livelihoods.

In Lebanon, it is reported that collaborating farmers are adding value to their farming systems by intercropping vetch with fruit trees. This maximizes land use and is particularly beneficial in dry areas where farm sizes are generally small. Other farmers are also improving their livestock systems and generating income by growing barley/vetch mixtures as a highly nutritious fodder, both for their own animals and as a cash crop. As a result of the success of common vetch in El Bab district in Syria, the Ministry of Agriculture and Agrarian Reform decided to increase the area planted to vetch in 2000/2001, with very encouraging results. In Hama province, sheep grazing on vetch gained 200-240 g/head/day, a figure that compares well with that for sheep fed on concentrates. Farmers were enthusiastic about vetch as it provides useful green fodder during dry spring periods, when other feed is scarce. Vetch can also eliminate the need to move sheep to distant places to feed. A widespread increase in demand for vetch seed is another clear indicator of success. In Syria, Jordan, Lebanon, and Iraq, the area devoted to vetch for seed is increasing following the promotion of mechanical harvesting.
Using farm data, the profitability of crop rotations (barley-barley, barley-fallow and barley-forage legumes) was calculated considering risk of production, and recommended barley and a mixture of common vetch and barley for mixed crop-livestock systems in Nineveh province, north Iraq, which has low rainfall (200-300 mm annually), as these options had higher returns and lower risks.

The global benefits of ICARDA germplasm research for barley, durum wheat, chickpeas, lentils and faba beans were estimated at US$196.9 million per year for the period 2001 to 2022. The breakdown is given below:

- Barley: US$60.3 million per year for the period 2001 to 2022; about 63 percent of this would benefit consumers while 37 percent would benefit barley producers.
- Durum wheat (ICARDA/CIMMYT germplasm improvement): US$ 84.5 per year; of 60% of this would benefit consumers and 40% would benefit producers.
- Chickpeas: US$28.5 per year, with these benefits being `captured predominantly by producers (57%), while consumers obtained less (43%).
- Faba beans: US$ 14.3 million per year, with consumers capturing 59% and producer 41%.
- Lentil: US$ 9.4 per year, with consumers capturing 64% and producer 36%.

ICARDA's spillover impacts on developed countries were also documented. Such analysis is important in the sense that it provides decision-makers in developed countries with information that would be helpful in supporting international agricultural research. The spillover benefits of ICARDA commodity improvement research on Australia was estimated for barley, durum wheat, chickpeas (kabuli), faba beans and lentils. The annual spillover benefits of ICARDA research of these five crops to Australia were estimated at US$7.4 for 2001-2022.

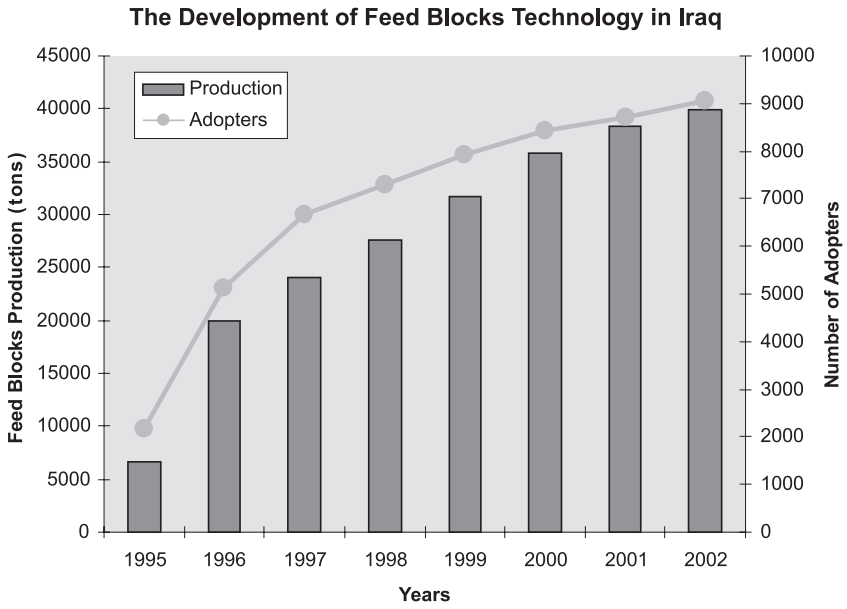
Adoption and Impact of Crop-Livestock Technologies

The feed block technology (see Box 2), promoted in implementing the Mashreq & Maghreb (M&M) project, is subject to continuous economic evaluation in order to monitor its adoption among sheep owners. To this end information on 81 sheep owners in Iraq was collected, including flock size, amount of feed block bought and number of times a sheep owner is buying the feed blocks during the season. The collected information reveals that sheep owners of all flock sizes are using feed blocks to supplement the feeding of their sheep.

To assess the use of feed blocks on sustainable basis, the frequency of buying feed blocks by sheep owners was recorded, and results showed that 53% of sheep owners bought feed blocks only one time during the season, and 31% of the farmers bought feed blocks for two times. More interesting is that some 16% of the sheep owners bought feed blocks for three times or more, up to seven times in one season, implying that those farmers depended mainly of feed blocks to feed their animals. The overall average is that sheep owners bought feed blocks for two times during 1999/2000 season, implying the use of the technology on continuous basis.

Box 2: Diffusion of Feed Block Technology

Multi-nutrient feed blocks are made from locally available agro-industrial by-products and other ingredients. Ingredients vary from country to country, but can include rice bran, sugar beet pulp (after processing for sugar), date pulp, olive cake (the residue from oil processing), residue from the production of tomato paste, by-product from the processing of dairy products, such as the whey of milk, and waste from intensive poultry production units. National resources of such potential feedstuffs are considerable. The ingredients are mixed, baked and pressed in block forms using simple equipment. The blocks can also be enriched with added vitamins and/or minerals. Diffusion of this technology is progressing very well in most of participating countries with particular mention to Iraq, where feed blocks has been transferred widely to farmers through private investors. The MM project had a large role in the movement of the feed blocks into other MM countries, especially Jordan, Morocco, Tunisia and Algeria. An important contribution of the project is to accelerate spillover or the movement of technologies between countries. The MM project accelerated introduction of drought-resistant plants, cactus and atriplex, facilitating their introduction into Mashreq countries (Iraq, Jordan and Syria).



Source: Shideed, Kamil H. and Mohammed El Mourid (eds). 2005. Adoption and Impact Assessment of Improved Technologies in Crop and Livestock Production Systems in the WANA Region. The Development of Integrated Crop/Livestock Production in Low Rainfall Areas of Mashreq and Maghreb Regions (Mashreq/Maghreb Project). ICARDA, Aleppo, Syria, viii+160 pp.

Farm survey data of 156 farmers were collected in Jordan to assess the adoption and impact of feed blocks. Results show that the adoption rate of the technology is 21%. Benefits of feed block supplementation are tremendous in all countries. Among the benefits observed in Jordan are:

- A daily weight gain of 30 kg/head/day was obtained for sheep fed on feed blocks, which is equivalent to feeding 200 gm of barley a day.
- Improved ewes' fertility by more than 18 % and daily weight gain by 36-52% during grazing cereal stubble.
- Improved daily weight gain of lambs by 12-50% over the lambs fed only on barley grain.
- Use of feed blocks could replace 20-50% of concentrate feed consumed by animals.

Previous on-farm demonstrations and on-station trials have shown the importance of feed blocks in improving the efficiency of sheep production. The use of feed blocks resulted in increasing sheep production efficiency by 32% in Iraq as a result of increasing reproductive efficiency and thus, increasing the number of lambs born. Results show that an additional meat production of 4.09 kg/ewe/year is attributed to the use of feed blocks. Similarly, an additional milk production of 8.28 kg/ewe/year is attributed to feed blocks. These additional meat and milk production requires a total intake of feed blocks of 116 kg/ewe/year in addition to the use of conventional feed resources (barley grain, straw and green fodder). To assess the economic feasibility of using feed blocks in sheep feeding, benefit-cost ratio (B/C ratio) and internal rates of return (IRR) are calculated using the corresponding adoption rates and performance indicators for each country. Based on these analyses the present value of benefits associated with additional meat and milk production can be compared with the present value of the costs of feed blocks used in animal diet. For Iraq, the B/C ratio is 1.56 and the IRR is 67%. These results indicate that high economic returns are associated with the use of feed blocks in sheep feeding. The above B/C ratio value implies an additional return of 0.56 Iraqi Dinar is associated with each one Dinar invested in feed blocks. Comparing the IRR of 67% with the effective rate of interest of 10% indicates that investment in feed blocks for sheep feeding is paying high dividends.

Feed blocks contributed substantially to the feed resources during drought seasons. An average amount of 11.4 kg of feed blocks per head was used during the drought season of 1999/2000; a maximum of 85 kg per head was used by some sheep owners during this season. Because of drought, no alternative feed resources of high nutritive value were available and the feed blocks had really bridged the feed gap for many sheep owners.

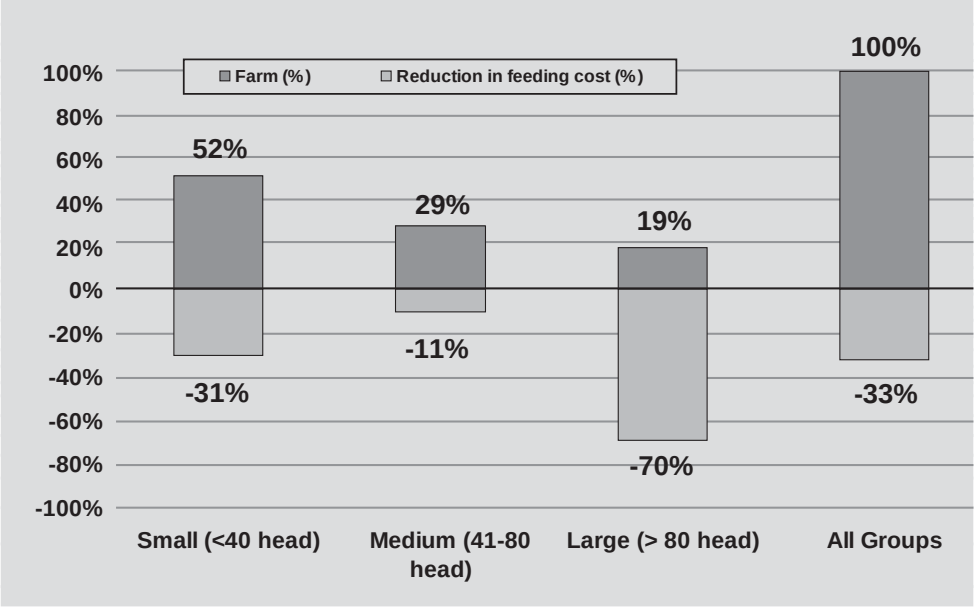
In Morocco feed block technology was adopted by 32% of sheep owners in a targeted community. Likewise, the adoption and impact of feed blocks technology was evident in Tunisia. The overall adoption rate among all sheep owners in Zoghmar community was 13%, whereas, the adoption rate was 54% among farmers participating in the activities of M&M Project. This high adoption rate among participating farmers clearly supports the effectiveness of the technology transfer mechanism of the MM Project. Adoption rate at the national level was 9.4% during 2001/2002 season. The adoption of this technology will help to save about 90 million Tunisian Dinar per year as a result of substi-

tuting high-priced feed. Feed block technology has greatly reduced feeding cost in Tunisia. The technology is being widely used to substitute expensive feed resources, such as barley grain and wheat bran, while maintaining the same weight gains for small ruminants. The estimated IRR at 57% clearly demonstrates the economic feasibility of feed block technology in sheep feeding.

Impact of Natural Resources Management Research

Conservation and sustainable use of the natural resource base for agricultural and livestock production in CWANA is an important goal of ICARDA. This can not be achieved without appropriate analysis of the social, institutional and economic factors that influence resource management from which greater understanding of resource users' perceptions, goals and limitations can be developed. However, methodologies for assessing the impact of natural resource management (NRM) research are not readily available and further complicated by the issues of attribution, time lag between research output and the realization of its impact, and valuation of natural research benefits and environmental attributes. Therefore, considerable research at ICARDA has focused on the development of appropriate methodologies to measure NRM impact in collaboration with the CGIAR Standing Panel for Impact Assessment (SPIA) and advance research institutes. As a result, appropriate impact assessment frameworks and related estimation approaches were developed and used in assessing the impact of natural research management research.

The impact of NRM research in crop/livestock production systems in arid and semi-arid areas of Morocco and Tunisia was assessed. Results indicate that *Atriplex* alley cropping (with barley) technology is adopted by 33% of farmers in the targeted community in Morocco, with nearly 24% of the land is planted in alley cropping. On average, adopters assign nearly 27% of their farmland to *Atriplex* alley cropping but this varies considerably across farms. Overall, the area planted to *Atriplex* has increased by 6% annually since 1999. Farm size, compensation provided by a development project, and flock size of small ruminants are the main factors explaining the expansion in the *Atriplex* plantation. Area in alley cropping increases with the increases in farm size, flock size, and the availability of the subsidy. The ex-post impact of the alley cropping on barley production is to increase barley grain yield by 17% compared to barley/fallow system. The technology has contributed to the increase in flock size of small ruminants between 2001 and 2004 by 25% among technology adopters compared to non-adopters due to the increase in feed supply. Likewise, the adoption of this technology has resulted in changes in the consumption and mix of alternative feed resources, and consequently of feeding cost. On average, the feeding cost of small ruminants has decreased by 33% due to the adoption of the *Atriplex* technology. This cost reduction is due to the substitution of costly and purchased feed resources, such as wheat bran and sugar-beet pulp, by *Atriplex* biomass and barley straw.



Impact of *Atriplex* on Feeding Cost

Source: ICARDA Caravan, No. 22, June 2005, pp 34-36.

To estimate the impact of alley cropping, the IRR was estimated for the 1992-2015 period, taking into account research and extension costs, as well as the subsidy provided by the development project, and all other costs. The estimated IRR is 29%. Results support the economic feasibility of research investment in *Atriplex* technology. To randomize the calculated IRR, stochastic simulation was conducted using the @risk program. This simulation gave mode of 25% under risk conditions, further supporting the profitability of *Atriplex* alley cropping.

For cactus pear (*Opuntia*) alley cropping the adoption rate is 31%, with 29% of the land planted in spineless cactus in 2002. A generally observed pattern was that the adoption of cactus alley cropping increased with farm and herd size. It was also observed that farmers without animals adopted the technology due to incentives provided by a development project. Government subsidy was found as a key factor affecting farmers' decisions in adopting cactus plantation in marginal cereal land. Increased barley grain yield and total biomass as well as plant cover on eroded marginal lands resulted in reducing feed cost by 13% among adopters. Simulation studies showed that the technology would reduce stocking pressure during dry years and increase farm income by 7%. The expansion in cactus plantation would result in reducing cereal cropping in marginal lands by 5%, and thus conserve the resource. The rate of return (IRR) of investing in cactus alley cropping (i.e., the rate of return for a farmer who receives the subsidy) was calculated at 53%, while for a farmer who has to pay for the full cost of cactus establishment the IRR would go down to 17%. If all R&D costs are included, the economic rate of return is 16%. Taking into account the uncertainty in the parameters that determine the rate of return, the application of the @risk program showed that the results are firm. The chance to get an IRR of more than 4% was found to be 95%.

Box 3: The Diffusion of Cactus Pear Technology from Maghreb to Mashreq Countries

Cactus, which is well adapted to the harsh environments of the dry areas, especially when combined with water harvesting techniques, represents a productive feed option for farmers in the dry areas, as well as providing means of protecting the natural resource base by controlling soil erosion, particularly on sloping land.

As a result of Mashreq and Maghreb project, the experience of the Maghreb countries in cactus production and utilization as a feed was transferred to the Mashreq countries in addition to Libya in the Maghreb. Exchange of experience, knowledge and expertise achieved within the Mashreq and Maghreb project had a strong multiplier effect. The benefits of cactus plantation are:

- Cactus is used as fodder bank for livestock. It can survive harsh conditions of only 150 mm of annual average rainfall.
- Cactus pads are commonly chopped in slices and easily fed to the animals.
- Spineless cactus can also be used to control desertification caused by wind erosion and sand-dune movements.
- Use of cactus in animal feeding can substantially reduce water consumption.

Source: Shideed, Kamil H. and Mohammed El Mourid (eds). 2005. Adoption and Impact Assessment of Improved Technologies in Crop and Livestock Production Systems in the WANA Region. The Development of Integrated Crop/Livestock Production in Low Rainfall Areas of Mashreq and Maghreb Regions (Mashreq/Maghreb Project). ICARDA, Aleppo, Syria, viii+160 pp.

Results of 15-year simulations reflect the important reduction in soil loss and the considerable improvement in organic carbon under alley cropping systems compared to farmer's land uses in fragile soils in Morocco. On-site cost of land degradation was higher than the subsidy provided to farmers by the development project to disseminate the technology, providing further support to the value of increased investment in NRM research. Using an opportunity cost approach, the monetary value of the environmental benefits (reduced soil erosion and improved soil organic carbon) of *Atriplex* alley cropping was estimated at US$425/ha., which is well above the incentives of US$250-300/ha provided to farmers by the development project to disseminate the technology. These would be foregone opportunities had the investments in *Atriplex* R&D not been made.

The Institutional Impact of ICARDA's Cooperation with NARS

ICARDA has a strong outreach program. It has 6 regional programs (Arabian Peninsula; Central Asia and Caucasus; Nile Valley and Red Sea; North Africa; Latin America and West Asia) with resident coordinators and scientific staff. These programs have active research projects. In addition, most of ICARDA's research projects are implemented in collaboration with national programs. This intense collaboration builds the capacity of NARS research staff and transfers research methods to NARS which in turn affect

research organization and performance in a significant way. Over the years ICARDA has promoted and transferred a number of innovative research methods and approaches to NARS partners. These include methods for adoption studies, use of community approach and participatory research methods, application of INRM approach for natural resource management research, use of rural livelihoods framework, poverty analysis, long-term agronomic trials, long term monitoring of farmer practices, impact assessment, rapid impact on-farm research, Farmer Field Schools on IPM work, Farmer Interest Groups, Integrated Research Sites, and a variety of commodity specific breeding techniques and NRM field research methods. The purpose of these research approaches is to increase research relevance by taking into account input from users and, hence, increase the chances of research success and impact. Furthermore, these approaches through direct interactions are expected to increase the social and human capital of farmers.

Strengthening NARS capacities is an international public good of the CGIAR which fosters internal development processes, i.e., the capacity of research for development, which ultimately impacts on poverty alleviation, on natural resources management and on the conservation of the environment. Hence, the assessment of ICARDA's impacts on NARS research programs is critical.

Policy Implications and Impacts of ICARDA Research

ICARDA research has important policy implications which has enhanced the uptake of research outputs by policy makers in many countries in dry areas. Below is a list of some of the studies which reflect the impacts of ICARDA policy-oriented research.

1. The impacts of IFPRI/ICARDA policy and property rights research in the Mashreq and Maghreb countries
2. Policy change as a result of social science research: The case of barley fertilizer allocation in Syria
3. The policy impact of interdisciplinary research on adaptation of IPM for Sunn pest in wheat production in Iran, Syria and Turkey
4. Policy changes as result of ICARDA seed systems development in Afghanistan
5. Examples of policy and legislation changes induced by the West Asia Dryland Agrobiodiversity Conservation Project

Impacts of IFPRI/ICARDA policy and property rights research in the Mashreq and Maghreb Countries

ICARDA and IFPRI have cooperated in policy and property rights research on crop-livestock integrations in the Mashreq and Maghreb countries (the Mashreq/ Maghreb Project). The main contribution of this research was increased understanding by agricultural scientists and national policy-makers of the role of agricultural policy and property rights in the technology development and introduction process. The project also had played an important role in shifting to the extension mode of community organization

and the strengthening of the regional network of economists. These contributed to accelerated diffusion of new technologies and increased spillover between countries according to project participants and national government officials. The work also created awareness on the importance to shift from the welfare emphasis of drought relief with feed subsidies to new emphasis on productive investment. This created increased demand from agricultural scientists for better linking of the technology, policy and institutional issues in the community models developed in this project. The activity contributed to a series of new projects for rangelands which donors are now funding.

Policy change as a result of social science research: The case of barley fertilizer allocation in Syria

In areas that receive 200–350 mm annual rainfall, the Syrian agricultural policy has encouraged farmers to shift from wheat to barley, which is better adapted to such dry areas. The shift of wheat production to wetter areas and the promotion of the use of improved technologies, including fertilizer application, have maintained the long-term yield growth of wheat, and, consequently, Syria became self-sufficient in wheat in 1991. Barley is currently the principal crop in the dry areas of Syria; it is grown primarily for livestock feed.

In 1984, ICARDA and the Soils Directorate (SD) of the Syrian Ministry of Agriculture and Agrarian Reform (SMAAR) initiated a collaborative project through multiple seasons, multiple location trials using a farming systems-research approach. The objective was to assess the biological responses and economic viability of fertilizer use on barley in dry areas. Trials on farmers' fields were conducted over a period of four years, to investigate whether the large yield response to fertilizer obtained on research stations could be reproduced under the highly variable soil and rainfall conditions that farmers face. The results obtained were positive confirming the results from research stations. Economic analysis indicated that fertilizer use on rainfed barley is profitable at the farm level (farm yield can be increased by around 114-211%, and benefit-cost ratio ranged from 1.33 to 4.27), with positive impact at the national level in terms of production and net revenue (the estimated annual yield increase due fertilizer application was 261,000 tons increased the net national income annually by abut US$ 20 million), and is not risky under a range of variability of rainfall and relative prices, in terms of net benefits and benefit-cost ratios, and there are certain fertilizer options with minimum risk. Fertilizer is also simple to incorporate into the current barley/livestock farming system, easy to experiment with on a limited basis, observable, compatible with farmers' beliefs, and environmentally sustainable. It is thus an appropriate technology for farmers of rainfed barley.

As a result of this research, the Syrian agricultural policy-makers have changed their fertilizer allocation policy and allocated fertilizer to the dry parts of the barley producing areas, and disseminated this positive information to farmers through an extension project to encourage farmers to use fertilizer on rainfed barley. This has direct benefits to poor farmers in marginal areas.

The policy impact of interdisciplinary research on adoption of IPM for Sunn pest in Wheat production in Iran, Syria and Turkey

Wheat is a "political" crop for many countries in the CWANA region, so wheat prices are supported. In all three countries sunn pest is considered a public pest and, traditionally, it has been controlled by the state and farmers have had very little role in the control of this insect. That means farmers have not had to pay any costs regarding the control of this pest. As a result of IPM project that ICARDA implemented in the three countries some policy changes have taken place. These policy changes are described below:

- In Iran, the attitude towards Sunn pest management is changing. Recently a pilot program was put in place in 2 provinces where farmers are given full control of the pest management. Current policy trends call for farmers' participation as a central piece of Sunn pest control, farmers' share of the cost of treatment is now mainly partial but this will increase over time. Government is encouraging alternative methods of control (integrated approach) through research and farmer education. Aerial spray is declining and replaced by ground spray, about 50% in 2004. This is perceived to be reducing pollution.
- The control of Sunn pest, in Syria, is highly centralized; it is the responsibility of the Plant Protection Department of the Ministry of Agriculture. This responsibility starts from the monitoring to spraying stages, without considering any role for farmers. Farmers are not satisfied with the current control measures due to lack of consultation. Similarly, many professionals and extension staff surveyed consider control measures not effective. Given this poor performance assessment, policy changes on Sunn pest management, although relatively slower, may occur. There are indications that the integrated approach is gaining strength particularly in research and teaching. For example, one area is designated currently for ground control evaluation and aerial spraying is not allowed in that areas.
- In Turkey, policy awareness is changing rapidly. There is a steady shift from aerial to ground spray (2 regions, Trace and Konya, are being tested). Aerial spray has declined from 61% in 2002 to 44% in 2003. The government's vision is to transfer Sunn pest management to farmers by providing technical information and equipment step by step. The shift from aerial spray to ground spray and gradual devolution of control to farmers has now become a national policy. Now the profile of the application of IPM has been raised in the Minister of agriculture, and the Minister himself has attend and inaugurated field days. Turkey has now developed a new national Sunn pest project in the south of Turkey, which is basically an expansion of this DFID-supported ICARDA project.

Policy changes as a result of ICARDA seed systems work in Afghanistan

To help rebuilding agriculture in Afghanistan, the Future Harvest Consortium to Rebuild Agriculture in Afghanistan (FHCRAA), led by ICARDA, assisted the Government of Afghanistan to carry out its regulatory function with regard to assuring that quality seed reach farming communities. To support this policy objective a "Code of Conduct" for seed production and marketing was developed and published:

http://www.icarda.cgiar.org/Afghanistan/conductworkshop.html. In the absence of a national seed policy and seed law and regulations, this Code of Conduct is governing all activities with regards to seed production, seed marketing and seed importation. This work had an impact on the national seed policy as described. *A Seed Law and a National Seed Policy draft has been prepared*. Essential aspects of the government's regulatory function are an appropriate national seed policy and seed law. A draft National Seed Policy and Seed Law has been submitted to the Government. Both the National Seed Policy and the Seed Law take into account that Afghanistan cannot isolate itself from developments that are taking place in the seed industry around the world, but at the same time appreciate that Afghanistan has specific conditions, which may require a different approach. FAO has finalized these documents through the services of a legal consultant and consultations. The National Seeds Policy of Afghanistan has officially been issued by the Ministry of Agriculture, Animal Husbandry and Food at a signing ceremony on 13 September 2005.

Examples of policy and legislation changes induced by the West Asia Dryland Agrobiodiversity Project

The GEF-funded project on "Conservation and sustainable use of dryland agrobiodiversity in Jordan, Lebanon, the Palestinian Authority and Syria" coordinated by ICARDA aimed to develop technological, socio-economic, institutional and policy options to promote *in situ*/on-farm conservation of landraces and the wild relatives of species which originated from the West Asia center of diversity (wheat, barley, lentils, *Allium*, forage legumes, olive, fig, pistachio, pear, prune, almond). The project has contributed over the six-year period to induce several institutional changes and to recommend policy and legislation reforms. It has helped countries to better understand the various treaties and agreements related to biodiversity conservation and exchange of genetic resources. Below some of these changes are highlighted:

Case one: Drafting of national agrobiodiversity policies and legislations

Jordan, Syria and Lebanon have ratified the three international conventions (UNCCD, UNCCC and CBD) and are among the first to sign the International Treaty for Plant Genetic Resources (ITPGR). The project has first developed a logical framework which can help countries and other projects to develop national policies and legislation related to the conservation of local agrobiodiversity. It has helped to draft national policies and legislations in the four countries which are now being proposed to government for review and adoption.

Case two: Use of native fruit tree wild species in afforestation efforts

To use wild relatives of almonds, pistachio, pear, prune and other neglected forest species such as *Crateagus, Barbaris, Rhus*, etc in at least 30% of the planned afforested areas, annually. Following this order, the government forestry nurseries in Syria, Palestine and Jordan are respectively multiplying annually since 2004 approximately 3.5 millions, 1 million and 180,000 seedlings of these species. In Lebanon, different local and international NGOs are multiplying and distributing the species.

Additionally in Jordan the Forestry Directorate of the Ministry of Agriculture has established a biodiversity unit.

Case three: Introduction of biodiversity conservation within the education systems

One of the main achievements of the dryland agrobiodiversity project is the success in introducing biodiversity conservation within the education systems in the four countries. This activity was planned within the project output related to increasing public awareness. A specific thematic group was established including representatives from the respective Ministries of Education and Agriculture. School curricula and the teachers' methodological guides were produced and published by each country using a unified format and the teacher's scientific guide was drafted at the regional level. The application of the biodiversity curricula has already started in Syria for the 9th and 10th grades and is being initiated in Palestine. For Jordan and Lebanon, the curricula will be implemented with the application of new education reforms in 2006 or 2007.

Case four: Signing of a Memorandum of Understanding for a regional alliance to conserve agrobiodiversity and exchange plant genetic resources

Within its existing strategies and in response to recommendation from policy workshops, the West Asia Dryland Agrobiodiversity Project culminated its activities with the organization of a ministerial meeting on 29 June 2005 to sign a Memorandum of Understanding to promote the conservation of agrobiodiversity and the exchange of genetic resources among the four countries.

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