



## Mega-Project 5

### Poverty and Livelihood Analysis and Impact Assessment in Dry Areas

#### Introduction

Poverty, in its broadest sense (income, water, educational opportunity, gender equity, and vulnerability) is widespread in the dry areas, particularly in the CWANA region. A deeper understanding of the determinants of poverty, and of the livelihood strategies adopted by rural communities, is necessary to continually refine the targeting of ICARDA's research, enhance and track its impact, and identify pathways out of poverty.

Mega-Project 5 seeks to contribute to the identification of research pathways to implement technological, institutional, and policy options to reduce rural poverty in the dry areas globally. This is being done through, among other approaches, improved characterization of the rural poor (assets, context, depth and duration of poverty, vulnerability, basic needs, and choice of liveli-

hood strategies) in relation to agriculture and the environment, and studying patterns of adoption and the impact of improved varieties and natural resources management practices. Another important dimension is understanding the structure, conduct and performance of domestic markets for agricultural commodities across different countries to evaluate the implications of market imperfections for small farmers. Efforts are directed toward the involvement and active participation of end-users in development, testing and verification of new technologies, so that relevance and adoption by individuals, communities and institutions of new options and pathways is maximized. Frameworks and methodologies for participatory and community-based research are being developed and implemented in partnership with NARS to enhance the impact on rural livelihoods.

#### Characterizing rural livelihoods: targeting research to reduce poverty in marginal areas

Research and development work often neglects dry marginal environments. Because of low and erratic rainfall, infertile soils, limited groundwater, and land degradation, these areas contribute only small amounts to national production. As a result, they receive less agricultural investment from governments for strategic crops and farming technologies.

Rural households in dry marginal areas are also poorly served by social services and basic infrastructure. Many depend on wages from unreliable off-farm employment. As they have few capital assets, they are also regarded as high-risk borrowers. As a result, when they need loans they are forced to pay excessive interest to local money lenders.

#### Classifying rural livelihoods in Khanasser Valley, Syria

To help identify technologies and institutional and policy options that could help people living in dry

marginal areas, researchers conducted a rural livelihoods study of households in the Khanasser Valley, Syria. This integrated study used qualitative and quantitative surveys, rapid appraisal interviews, and wealth-ranking exercises based on local people's assets and perceptions.



Livelihood surveys help understand the context of rural poverty in marginal dryland areas.

To better understand the different dimensions of poverty in the area, researchers collected information on five categories of household resources. These resources were 'natural' (land, water); 'physical' (farm equipment, livestock); 'financial' (cash, use of micro-finance and loans); 'human' (labor, level of education, migration); and 'social' (organizations, associations and connections to migration options).

Researchers then classified households into three types, based on their resources and their main livelihood strategies. The household types identified were (1) agriculturists who integrate crop production with fattening lambs and also work for wages; (2) wage-laborers, who own little or no land, mostly rely on off-farm earnings

and migrate for employment; and (3) pastoralists who rely on extensive herding, occasionally fatten lambs intensively, and also migrate for employment. Each of these three groups has two sub-groups (Table 1).

Researchers found that per capita disposable incomes in the study area were below US\$2/day, while those of wage-laborers (50% of households) were less than US\$1/day. The poorest households – those with lowest per capita income and few assets – were the wage-laborers who farmed a little land, the wage-laborers who worked as herders, and the pastoralists with no additional income from employment. These should be considered the poorest of the poor.

### How different household types would benefit from agricultural research

In general, the study found that wage-laborers rely on farming to a very small extent, and that people in this category were most likely to give up farming for other occupations. Researchers also found that about 30% of households in the study area (mainly wage-laborers with no agricultural assets) would benefit little from agricultural research, although they might benefit from the spillover effects of such research.

This means that agricultural research centers may not play a direct role in alleviating poverty in these groups. However, they are well-placed to identify and promote other options for improving

Table 1. Household typologies in the Khanasser Valley, Syria.

Capital			Wage-laborers		Agriculturists		Pastoralists	
			With farming	Herders	Without off-farm labor	With off-farm labor	With off-farm labor	Little or no off-farm labor
Social, human	People	Average persons /household	9.17	6.64	6.75	11.29	10.43	11.00
	Educated males	% males	68	66	88	63	61	32
	Educated females	% females	46	28	11	30	15	33
	Members of associations	% households with membership	25	9	50	52	57	80
	Migrant members	% households with migrants	75	73	0	62	43	0
Natural, physical	Land owned or used	Total (ha)	6.83	3.73	7.55	11.30	0	0
	Well owners	% of total households owning wells	58	9	25	71	71	40
	Sheep	Head	4.2	3.7	91.8	62	79.3	41
Financial	Average credit use	US\$/year/household	490	310	810	415	1420	1280
	Per capita income	US\$/day <sup>1</sup>	0.82	0.48	1.72	1.30	1.43	1.15
Main livelihood activities	- Crop production	% income	9	5	23	9	0	0
	- Livestock		7	19	29	13	82	76
	- Sheep fattening		0	0	48	50	3	15
	- Off-farm labor		84	76	0	28	15	9

<sup>1</sup> Based on an exchange rate of SP51=US\$1 (2002).

these people's livelihoods. Ways forward include promoting initiatives to develop skills, create jobs in non-farm sectors, and improve access to capital through micro-finance schemes. Pastoralists could also benefit from research and development that considers their nomadic existence, as they rely on extensive herding in remote steppes where there are few opportunities for off-farm work.

Agriculturist households were relatively better off, as they had sufficient land and labor to make a living mainly from farming. They were, however, still poor. This group would benefit both directly and indirectly from agricultural research. They are, for example, more likely to adopt new crop and livestock production technologies because (1) they have access to water and land, (2) they are better educated, and (3) they have more household members who are wage earners. These households account for about 45% of those in the Khanasser study area, and are the most likely to be able to use their resources to improve their livelihoods.

Wage-laborers who farm less than 4 ha (about 25% of households) were placed in between the poorest and the relatively better-off households. They have enough land to be able to increase their agricultural income if they could farm more intensively, and could



Participants at a workshop on rural livelihood analysis at ICARDA.

benefit directly from new technologies to improve crop and livestock production. They could take advantage of both direct and indirect opportunities to improve their livelihoods without leaving farming. Agricultural research can and should target these households.

Several technologies show potential impact in the dry marginal areas. These include feed options such as production of vetch for lamb fattening and dairy flocks, intercropping of *Atriplex* shrubs with barley, improved barley and wheat varieties, water harvesting techniques for production of olives on hillslopes, and modern irrigation practices for small-scale vegetable production. Institutional innovations such as micro-finance can help the poorest households

participate in the more profitable enterprises of sheep production.

Rural households in dry marginal environments are not homogeneous. They have a variety of assets and capabilities. The household typologies and livelihood strategies identified in this study will help ICARDA focus on the research that will be most useful in lifting rural households out of poverty.

This study has shown how research for development can reach the dry marginal areas; and provided evidence of the diverse potential impacts on different household types depending on their asset base. The findings, as well as the approach used, will be relevant in other dry marginal areas.

## Agrobiodiversity conservation and use: assessing impacts

Since 1999, ICARDA has been coordinating a five-year Global Environment Facility (GEF) funded project to promote *in situ* con-

servation of dryland agrobiodiversity and its sustainable use. The project, which ended in 2005, was implemented in Jordan, Lebanon,

Palestine, and Syria. It focused on conserving landraces and the wild relatives of barley, wheat, lentil, alliums, feed legumes (*Lathyrus*, *Medicago*, *Trifolium*, and *Vicia* species), and fruit trees (olive, fig, almond, pistachio, plum, peach, pear, and apple).



A nursery established in Lattakia, Syria, for landraces and wild relatives of fruit and forest species.

Nationally, project activities were implemented by different research institutes in each of the countries involved: the National Center for Agricultural Research and Technology Transfer (NCARTT) in Jordan, the Lebanese Agricultural Research Institute (LARI) in Lebanon, the General Commission for Scientific and Agricultural Research (GCSAR) in Syria, and the Ministry of Agriculture in Palestine. Farmers and herders were fully involved throughout the project.

The project has increased awareness of the need to conserve agrobiodiversity at all levels. This has led tourism and education ministries to collaborate with relevant projects and non-governmental organizations. It has also prompted research institutions in Jordan, Lebanon, and Syria to implement their own agrobiodiversity programs, and has resulted in Jordan's Forestry Department and the Palestinian Authority's Ministry of Agriculture setting up agrobiodiversity units. The governments involved have also now

officially recognized key sites rich in agrobiodiversity, via processes which took into account the needs and wishes of local communities.

The project has also collected many target-species accessions. These have been added to genebanks and databases developed to hold the results of ecological and botanical surveys in the countries involved. Importantly, standardized methods of managing these databases were also developed and shared between the partner countries. In addition, the project's efforts to encourage the use of the wild relatives of fruit trees in afforestation efforts led to the number of fruit-tree seedlings planted in Syria to rise from 30,000 in 1999 to 500,000 in 2003. To review the project's progress, a full socio-economic assessment of its impacts was conducted in 2004 and 2005.

#### Impacts on livelihoods

To assess the project's impact on livelihoods, ICARDA researchers and national partners surveyed 276 households that had partici-

pated in the project and 294 households which had not. These surveys were conducted in the eight project locations (two per country) in August and September 2004, using a questionnaire which had been tested in June 2004. This dealt with a range of topics and allowed researchers to characterize household livelihood strategies.

The researchers wanted to compare livelihood strategies, agrobiodiversity use, and incomes (1) within and across all the countries studied and (2) among poorer and better-off households. To do this, they used factor analysis to create a wealth index that took into account all five types of capital a household can have: human, natural, financial, physical, and social. The survey covered household assets such as cropland, rangeland, livestock, vehicles, and houses, as well as on- and off-farm incomes, and access to credit, cooperatives, and healthcare. Based on this, households were classified into four wealth groupings (quartiles), each corresponding to 25% of the range of values obtained for the wealth index.

#### Livelihood strategies

To benefit the people in an area, conservation practices and investments need to be appropriate to local people's livelihood strategies – as well as to agro-ecological conditions and the production systems being used. The project's impact assessment therefore considered the different sources of income used by households in the study areas. In all four countries, the poorest households (those in the lowest wealth grouping) mainly obtained their income from crop production, although off-farm

labor and government employment were also important (Fig. 1).

By contrast, households in the highest wealth grouping mainly depended on the income obtained from selling livestock products and live animals, though they also practiced crop production, worked off-farm, and took advantage of government employment. Over all wealth groupings, livestock provided the main source of on-farm income in Jordan, while crops and fruit trees were the major source of on-farm income in Lebanon, Palestine, and Syria.

Overall, off-farm income was an important source of livelihoods in all the target areas, accounting for 43-68% of household incomes. Clearly, although agriculture is not the only source of household income, it is still a major compo-



Simple water-harvesting techniques to conserve agrobiodiversity were demonstrated extensively to local communities.

nent of livelihoods in the dry areas.

#### Importance of target crops by wealth group

The agrobiodiversity project targeted different crops; their impor-

tance to the household depended on the wealth group (Table 2). Wheat and barley were more important for better-off farmers, while apricot and apple were more important to poor farmers. In all groups, fruit trees were generally more important to farmers than field crops.

**Table 2. Importance of different crops targeted in an agrobiodiversity project, classified by wealth group.**

Country/crop	Wealth index category				All groups
	Lowest 25%	25-50%	50-75%	Highest 25%	
<b>Lebanon</b>					
Grapes	6	9	13	6	8
Apricot	19	28	25	16	22
Apple	15	5	3	7	7
Olive	0	3	3	2	2
Wheat	5	7	14	9	9
Barley	3	6	6	11	7
Chickpea	3	6	5	7	5
Lentil	2	2		1	1
<b>Syria</b>					
Grapes	16	17	9	22	17
Apple	12	11	8	25	15
Olive	8	11	10	8	9
Wheat	15	19	27	16	19
Barley	7	6	8	2	5
Chickpea	7	13	14	15	13
<b>Palestine</b>					
Grapes	11	12	11	9	11
Apple	3				1
Olive	31	24	19	37	28
Wheat	23	38	28	37	31
Barley	0	0	6	3	2
Chickpea	0	0	0	3	2
Onion	3	9	11	0	6

Numbers show the percentage of sample farms growing a particular species under each wealth-index category.

This finding has important implications for national and international efforts to conserve agrobiodiversity. It suggests that the focus of *in situ* conservation of cereal crops should be on the fields of well-off farmers; whereas fruit tree conservation is more appealing for poorer farmers. Appropriate conservation strategies will improve the livelihoods of all farming groups, especially the poor, and directly contribute to poverty reduction.

#### Project impacts on agricultural incomes

The study found that average household incomes ranged from US\$2200 to US\$9000 per year, equivalent to a daily per capita income of less than US\$1 to US\$5.

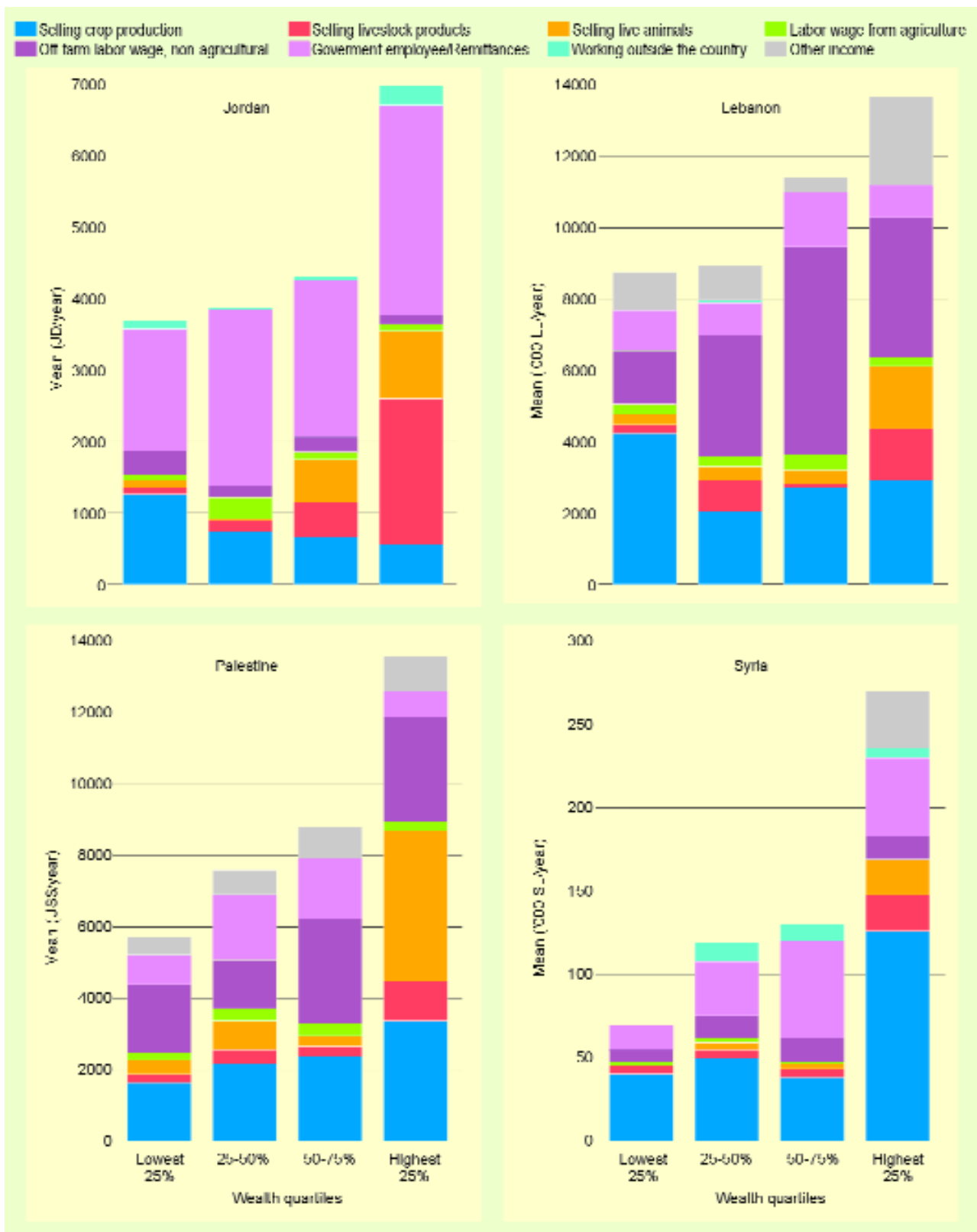


Fig. 1. Sources of income for farm households in different wealth quartiles in Jordan, Lebanon, Palestine, and Syria.

In general, per capita incomes were around US\$2/day in Jordan, Lebanon, and Jenin (Palestine), but less than US\$2/day in Syria and Hebron (Palestine). Income from agriculture accounted for 32-57% of these amounts.

In the majority of cases, the households that had participated in the project had average agricultural incomes that were greater than those of non-participating

households—by US\$1148, US\$1754, and US\$1914 on average, in Syria, Jordan, and Lebanon, respectively.

Researchers also calculated Gini coefficients to assess the equity in incomes within participating and non-participating households in each country. The values were not significantly different, indicating that enhancing agrobiodiversity did not increase inequalities

between poorer and more well-off farmers.

The results highlight the importance of agrobiodiversity conservation in improving the livelihoods of farming communities. However, to be effective, research should be based on the importance of targeted species to different farming groups. This study provides clear indications on such targeting.

## Gender dimensions of conserving and using local agrobiodiversity

ICARDA's five-year West Asia Dryland Agrobiodiversity Project, which ended in 2005, promoted the conservation and sustainable use of local agrobiodiversity at eight sites in Syria, Lebanon, Jordan, and Palestine. To ensure that efforts were targeted properly, the project included work to analyze the gender-related aspects of agrobiodiversity use and management.

Men and women usually play different roles in the growing, collecting, processing, and selling of plants and plant products. Consequently they hold different knowledge about important wild species and genetic resources. Furthermore, women's knowledge, and the contributions that plants make to families' food supplies and livelihoods, tend to be ignored in rural-development efforts and are often not well understood.

Rapid rural appraisals and surveys of around 70 households at each project site were used to study women's and men's roles as resource users and managers. We found that both groups are respon-

sible for different agricultural activities, and that women were intensively involved in agrobiodiversity management and conservation.

### Women's roles

Women and children were mainly responsible for collecting medicinal plants. This was true in 75% of the households surveyed in Palestine (Table 3), and an even higher proportion in other countries.

Women were also responsible for processing agricultural crops and wild species to make food. This was true in 96 to 100% of households surveyed (Table 3).

Responsibility for the sale of medicinal plants, however, was shared by men and women. In Jordan, Syria, and Lebanon, 60 to 88% of women sold plants that they had collected and processed. In Palestine, however, this figure fell to 42%, because of security issues at the project sites.

Researchers also found that women play an important role in selecting, drying, and storing



A woman in Ajloun, Jordan, tends her medicinal and herbal plants, which she established after receiving training offered by the project.

seeds. By implication, seed interventions targeted at women, could generate more income.

### Wild species: gender-related benefits and responsibilities

The project also studied the uses of 37 types of wild plant, and determined whether women or men were responsible for collecting, processing, and marketing them. The species considered were either used to make herbal teas (for medicinal or everyday use), were eaten as food, or used as spices. *Khobayzeh* (*Malva sylvestris*), for example, was made into a popular dish in all four countries, while *Silybum marianum* and *Raphanus* sp. were often eaten in salads in Syria. *Rhus coriaria* was widely used as a spice in Jordan, Lebanon, and Syria.

Because knowledge of these species is shared between men, women, and children, the project took all these groups into account in its research, awareness-raising, and development activities. This involved working closely with schools, NGOs, and women's groups.

### Market access for women

For women to earn money from selling the products they have collected or processed, they often need access to a market close to home. Researchers assessed how accessible markets were in and around the study sites.

In Lebanon, half the men and women surveyed were able to sell their products at a market in their own village. This figure dropped to around one-third and one-quarter of the people interviewed, respectively, in Palestine and Jordan – and only 8% in Syria, where respondents either used a city market or a combination of different markets close to the village.

Across the sites, between 10% and 20% of households surveyed were forced to sell their products at a low price to people within their village, as they were unable to sell them anywhere else. Improving product marketing was therefore one focus of the project.

### Adding value and raising incomes

To add value to local products, the project set up food-processing and handicraft units for women. Women were taught how to improve the quality of locally processed foods through the use of better hygiene, packaging, and

labeling. Training also covered alternative sources of income, such as growing medicinal plants, herbs, and mushrooms, and developing nurseries. More than 1480 women were trained over five years.

The project also provided women with in-kind incentives such as seedlings (herbs and medicinal plants), containers for locally processed products, and technical and business advice. Products processed by women from a local Women's Union are now being sold in a new 'agrobiodiversity shop' set up near Salaheddin Castle, a major tourist site in

Syria. In Palestine, women's groups are now producing and selling honey and shinglish cheese (a dried cheese covered with herbs).

The 278,000 medicinal plant seedlings distributed in Palestine have helped 2240 households become self-sufficient in the medicines derived from them. These households are also selling surplus produce at local markets. Medicinal plants and a new agrobiodiversity nursery are also providing significant incomes for women in Jordan, while in Lebanon women's groups are processing and selling wild plums.

Table 3. Gender-related responsibilities at eight sites in four countries in West Asia (% of households in which a particular group was responsible for the activity).

Activity	Jordan	Lebanon	Palestine	Syria
<b>Collection of edible and medicinal plants</b>				
Women & children	88	100	75	88
Men	12	0	25	12
<b>Preparing food</b>				
Women	98	100	96	100
Men	2	0	4	0
<b>Processing and use of wild plants</b>				
Women	100	100	92	70
Men	0	0	8	30
<b>Sale of medicinal plants</b>				
Women & children	88	60	42	65
Men	12	40	58	35
<b>Seed selection</b>				
Women	75	100	86	10
Men	25	0	14	90
<b>Seed drying</b>				
Women	50	100	60	100
Men	50	0	30	0
<b>Seed storage</b>				
Women	75	100	40	50
Men	25	0	60	50
<b>Seed exchange</b>				
Women	100	-	40	0
Men	0	-	60	100

## Alley-cropping with *Atriplex* and cactus: adoption and impacts in North Africa

Unlike agricultural research investments in high-potential areas, the rate of return to research investments in marginal areas is not so clear. Adoption of new technologies in these environments is low because of the variable returns from such technologies, high level of risk, and institutional constraints such as land rights issues. It can be hypothesized that unless public incentives are provided, the potential benefits of new NRM technologies will not be realized. In particular, if the technologies require investments, governments may have to provide subsidies to help establish them. Subsidies are justified if the value of public benefits generated exceeds the amount of the subsidy. The main objective of this research was to assess the uptake and impact of crop/livestock NRM technologies under relevant policy contexts.

ICARDA's Mashreq and Maghreb (M&M) Project has developed and disseminated many new technologies to farmers and herders in WANA. Successes include improved barley varieties, nutrient-rich feed blocks for sheep, and techniques to boost sheep fertility and restore degraded rangeland. In 2005, researchers assessed the impacts of two alley-cropping technologies already disseminated to farmers: barley with *Atriplex* (saltbush) and barley with spineless cactus. Both cactus and *Atriplex* provide animal feed and can protect the soil.

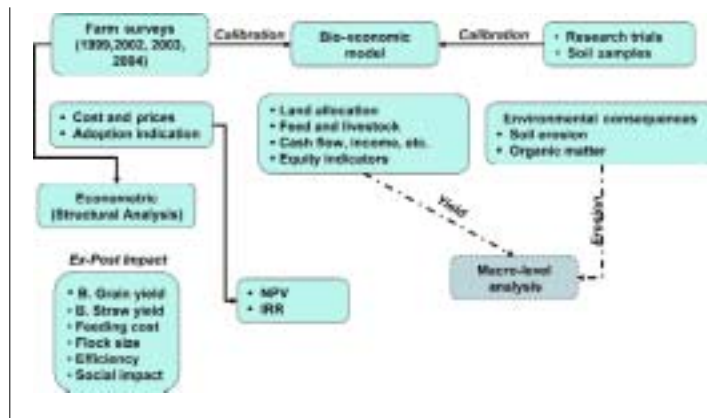
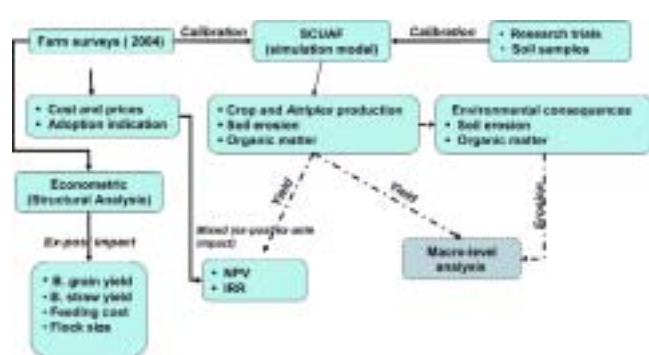
Researchers assessed the impacts of alley-cropping *Atriplex* and barley in Irzain, a community in northeast Morocco. Alley-cropping using cactus was assessed in Zoghmar, in central Tunisia. Both places receive less than 300 mm of rain per year and suffer periodic droughts. Local people rely on a

combination of livestock and crop production.

Researchers used econometric models (Figs. 2 and 3) to assess the impact of alley-cropping on barley yields, farmers' use of alternative feed resources, feed costs, and flock size; and also to assess how the provision of a subsidy affected uptake of alley-cropping. Probit, logit, and tobit models were used to determine what factors influenced farmers' decisions to adopt each technology. A range of factors were considered, from the production systems farmers used to policy variables and the areas' natural resources. Community models were also used to assess technology performance at the farm and community levels.

### *Atriplex* alley-cropping in Morocco: adoption and impact

In Morocco, 33% of farmers had adopted the technology on nearly 24% of the land in the community. Researchers found that the area



Source: Adapted and modified after Trewin, 1997. ACIAR Project Workshop, Bogor, 7-8 July 1997, 47 pp.

Fig. 2. Conceptual framework used to assess the impacts of *Atriplex* alley-cropping in Morocco. B = barley; NPV = net present value; IRR = internal rate of return; SCUAF = 'Soil Changes under Agroforestry'.

Fig. 3. Conceptual framework used to assess the impacts of cactus alley-cropping in Tunisia. B = barley; NPV = net present value; IRR = internal rate of return.

under alley-cropping increased as farm size and flock size increased. The net impact of the subsidy provided, according to the model used, was an increase of 79% in the area devoted to *Atriplex*.

Overall, barley grain and straw yields were 17% and 97% higher, respectively, in the alley-cropping system than in the traditional barley-fallow system. And, because adopting farmers had a more secure feed supply, they increased the size of their flocks by 25% more than non-adopters during the period 2001-2004.

Adopting *Atriplex* alley-cropping also meant that farmers had to buy less feed for their animals—reducing feed costs by 33% on average. Adopters' animals consumed 90% less wheat bran, 36% less barley grain, and 23% less sugar beet, than the animals kept by non-adopting farmers.

Using a mixed *ex-post/ex-ante* assessment (Fig. 2), researchers also estimated the internal rate of return (IRR) for the period 1992-2015. This took into account all



Alley cropping with *Atriplex* (above) and spineless cactus provides substantial financial gains to farmers, and greatly reduces soil erosion.

relevant costs, including research, extension, and the subsidy provided by the development project that promoted the technology. The biomass produced by *Atriplex* was valued in relation to the amount of barley grain that farmers would otherwise have had to buy to feed their animals. Using a discount rate of 10%, the IRR was calculated to be 25%.

Additional 'pessimistic' scenarios were used to calculate alternative

IRRs. These scenarios included low *Atriplex* yields due to farmer mismanagement, and low barley grain and straw yields due to bad weather. Another such scenario involved valuing *Atriplex* biomass in relation to the price of barley straw (not grain). However, the IRR estimates were still not less than 18%. This further justifies past investments in *Atriplex* alley-cropping research.

In Morocco, researchers also used the SCUAF (Soil Changes under Agroforestry; Fig. 2) model to assess the environmental impacts of alley-cropping over 15 years. This showed that, in comparison with farmers' usual land-use practices, alley-cropping systems reduced soil loss and greatly improved soil organic carbon levels. Researchers found that the financial benefits of this reduction in soil loss far outweighed the cost of the subsidy provided to farmers who switched to the new system.

Even using very conservative adoption rates of 6%, researchers calculated that alley-cropping



ICARDA researchers interviewing farmers in Morocco on *Atriplex* alley-cropping.

could be expanded to cover 350,000 ha in northeast and central Morocco. The potential benefits of this – in terms of higher barley yields and lower feed costs – would be almost US\$60 million.

Furthermore, *Atriplex* alley-cropping could be adopted in other Mashreq and Maghreb countries, as they have similar production systems, natural resources, and socio-economic characteristics.

### Impacts of alley-cropping using spineless cactus in Tunisia

Just two years after cactus alley-cropping had been introduced, it was being used by 31% of farmers in Zoghmar in Tunisia, on around 30% of the land in the community. Researchers also found, however, that many farmers waited until they received a subsidy before planting cactus. They also showed that in dry years, when cereal yields are low, the cost of this subsidy would be greater than the returns obtained by farmers.

However, it was also found that the availability of cactus as a feed in dry years meant that farmers did not have to sell off as many

animals as usual – and so did not lose so many assets. At the farm level, this drop in de-stocking was around 6% on average.

Furthermore, cactus alley-cropping led to a 5% fall in the amount of marginal land cropped in drought years, and so helped to conserve the area's natural resources.

The assessment showed further financial benefits from alley-cropping: farm cashflows rose by 7%, feed costs fell by 13%, and farmers were less dependent on the market for feed. What is more, impacts on the poorest group of farmers were very positive. They no longer fell so far below the poverty line, and their incomes fluctuated less during the year. The technology also increased barley yields, as well as plant cover on eroded lands (because the cactus shelters plants from the wind). This increase in cover led to improved soil organic matter and carbon, phosphorus, and potassium levels, which will help to reduce soil loss through erosion.

Overall, in the two areas studied, the assessments showed that *Atriplex* and cactus alley-cropping

could greatly reduce soil erosion, restore soil organic matter, boost crop yields, and provide high returns on farmers' investments.

The development of cactus and *Atriplex* alley-cropping has encouraged public investments in agriculture in the dry areas. This in turn has increased the productive capacity of households' main natural asset, which is land. This will lead to sustainable improvements in the livelihoods of rural communities.

Results clearly show that incentives provided by development projects are important to stimulate technology adoption. Such subsidies can be justified because the internal rates of return are satisfactory if these costs (incentives) are accounted for. In addition, there are environmental benefits. In the case of Morocco, conservative valuation shows that the environmental benefits justify the additional investments that governments are making. The results of this study will help policy makers make decisions leading to investments in productive assets, like drought-resistant shrubs, rather than on feed subsidies.