Mega-Project 3
Improved Land Management to Combat Desertification and Increase Productivity in Dry Areas

Introduction

Desertification has been defined as land degradation in arid, semi-arid and sub-humid areas resulting from various factors, including climatic variations and human activities. The drylands cover some 41% of the global surface area and are home to around 2.1 billion people. More importantly, 72% of drylands are in developing countries and approximately half of the worlds' poor live in drylands. At a conservative estimate, 10-20% of land is already affected by desertification. This means that in terms of the number of people affected, desertification is larger than any other environmental problem.

Earlier definitions failed to emphasize that desertification is a development problem and not specifically an environmental problem. This is now clearly recognized by the United Nations Convention to Combat Desertification (UNCCD), which states that 'national action programs, designed to combat desertification, must be fully integrated into other national policies for sustainable development' and that 'combating desertification is really just part of a much broader objective: the sustainable development of countries affected by drought and desertification.'

Given the complexity of causal factors, an integrated approach with broad stakeholder participation is essential if the livelihoods – and security needs – of the people inhabiting drylands are to be improved without further degrading their environments. Technological, institutional, and policy options are required to prevent further land degradation and build viable livelihoods.

Mega-Project 3 aims to identify options for rehabilitating degraded land resources and, at the same time, improve and strengthen systems of land management to control degradation and sustain future production in order to contribute to sustainable livelihoods. Major elements of the Project include: the development and testing of an integrated approach to natural resources management; understanding the causes and driving forces of land degradation, including regional assessments of desertification; 'best-bet' technologies for the management of land, water and watersheds, vegetation and rangelands; policy and institutional research to create an enabling environment for combating desertification; and institutional strengthening and capacity building in integrated approaches to sustainable land management.

Combating desertification in marginal dryland areas

Syria's Khanasser Valley (80 km southeast of Aleppo) is a typical marginal dryland area prone to desertification. It receives little rainfall (220 mm per year on average) and even this is unpredictable, varying greatly from year to year. Poverty and degraded soils are widespread. Between 2001 and 2005, ICARDA used an integrated natural resources management (INRM) framework to address the Valley's complex and inter-related problems.

Funded by BMZ (Germany) and the Flemish Government, researchers gained a clear understanding of the major agro-ecological strengths, weaknesses, opportunities, and threats found in the Valley (Table 1). The different options for sustainable development identified through this work are likely to be applicable in similar marginal dryland areas throughout West Asia and North Africa.

An interactive multi-stakeholder process

Many different stakeholders were involved in the research. Through voluntary 'farmer interest groups' (FIGs), for example, farmers worked with researchers to analyze problems and select possible solutions, which they then tested and evaluated on-farm. Researchers also worked with Syria's Atomic Energy Commission and the country's Olive Research Department to study the area's natural resources and develop best-bet technologies. Other partners included Bonn University, which supported water resource assessment and water management work, and the Jabel Al-Hoss development project, which developed micro-credit systems.

This multi-stakeholder approach required extra consultation to achieve consensus and plan activities. It also ensured that only appropriate technologies were developed and that full use was made of local expertise and knowledge. The approach also increased partners' commitment to the project, by increasing their sense of ownership.

Khanasser Valley farmers have complex and integrated strategies to cope with the dry marginal environment.

A toolbox of options

Even small differences in soil, slope, rainfall, assets, livelihood strategies, and community dynamics can cause a development option to fail. Partners therefore developed a range of technological, institutional and policy options (TIPOs) for use in the Valley and similar areas.

Reducing rainfall-related risk

The project explored three main strategies for coping with low and variable rainfall: crop diversification, development of drought-resistant varieties, and better use of available water.

Diversifying into new crops such as olive, cumin, home-garden vegetables and wheat, ensures that all crops will not fail simultaneously. Researchers worked with local FIGs to assess produc-

Table 1. SWOT analysis of the Khanasser Valley, a typical marginal dry area.

Strengths
- Indigenous knowledge and local innovations
- Strong social networks and rich local culture
- Comparative advantage for small ruminant production
- Salt lake with rich bird biodiversity
- Relatively unpolluted environment
- Reasonable mobility and accessible markets
- Improved basic services (electricity, roads, mobile-phone network)

Weaknesses
- Cash-flow problems (resulting in lack of long-term investment)
- Poor nutritional status of children
- Limited experience with non-traditional farming enterprises
- Lack of adapted germplasm
- Decreasing productivity
- Degraded natural resource base (soil, groundwater, vegetation) + unsustainable management practices
- Land degradation is 'masked' by variations in rainfall
- Poor extension services and limited research

Opportunities
- Investing off-farm income in productive resources
- Better education levels and expertise
- Increased awareness of the risks of resource degradation
- Cooperatives
- Improved market information via mobile phones and other media
- Out-migration and off-farm opportunities
- Sheep fattening
- Potential to improve the traditional barley system
- Improved germplasm
- Diversification for cash and subsistence purposes
- Agro-, eco- and cultural tourism
- Runoff water harvesting and efficient small-scale irrigation systems
- Soil fertility improvement
- Rangeland rehabilitation and medicinal plant collection
- Better government services and a greater focus on poverty alleviation and environmental services in marginal areas

Threats
- Average age of working population increasing, and greater numbers of men working outside the Valley
- Weakening of social networks
- Neglect of traditional 'beehive' houses
- Increased population pressure and land holdings that are too small
- Depletion of groundwater resources
- Recurring droughts
- Further decline of soil fertility and groundwater levels
- Declining groundwater quality and salinization of irrigated fields
- Pollution from intensive sheep fattening and untreated village sewage
- Degradation and pollution of the fragile Jabul salt-lake ecosystem
- Unreliable export markets for sheep

Blue: livelihoods-related; red: enterprise-related, green: natural-resources-related; black: governance-related.

tion constraints for these new crops and find ways of overcoming them. These were then tested in farmers' fields. Researchers also organized extension days, to teach farmers how to prune olive trees and grow cumin.

Scientists have also worked closely with farmers to develop drought-resistant varieties. To date, over 200 lines of barley alone have been evaluated in a participatory breeding project run in three villages in the area. The superior varieties of barley identified are well adapted to the harsh conditions found in the Valley.

The project has also addressed the need to use available water resources more efficiently, by estimating groundwater reserves, calculating sustainable extraction rates, and testing the feasibility of drip irrigation. Researchers also found that harvesting runoff water in gently-sloping olive groves means that growers only have to irrigate their trees once in summer.

Building on comparative advantages

Syria's marginal dryland areas are well suited to rearing small ruminants—which gives producers there an advantage over those living elsewhere. Sheep fattening is expanding in the Valley as a result, and researchers are working with producers to test economical ways of producing feed on-farm.

Comparative advantages could also be exploited by producing mushrooms and medicinal plants. The Valley's rich history and unique biodiversity also mean that agro- and eco-tourism are income-earning options.

Participatory technology development combines local knowledge with scientific expertise.

Sustaining natural resources

Researchers also worked with farmers to find sustainable ways of rebuilding and maintaining the Valley's natural resource base. Options already identified include the application of phosphogypsum to soil, pre-summer tillage to reduce wind erosion, the construction of runoff harvesting structures, and better use of available manure.

Cropping vetch in rotation with barley, and planting *Atriplex* (saltbush) species as an alley crop in barley fields improved forage resources. However, for *Atriplex* alley-cropping to be attractive to farmers, subsidies would be needed.

Institutional options

Researchers also explored ways of using local organizations and arrangements to improve livelihoods. For example, support to dairy producers could potentially be channeled through *jabbans* – traditional cheese-makers who usually provide credit and sell cheese on the producer's behalf. The Jabel Al-Hoss project has recently introduced micro-credit facilities (*sanadiq*) to Khanasser. These allow poor households to take part in profitable enterprises that were previously beyond their reach.

Upscaling the lessons learned

Researchers are now working to ensure that the experience gained in Khanasser is applied elsewhere. Efforts to date include a policy briefing at Damascus and a multi-stakeholder workshop at ICARDA for research, development, and policy organizations. These have made decision-makers better aware of the solutions and opportunities that exist for dry marginal environments.

Surveys by ICARDA also showed that care needs to be taken when applying these lessons—as certain groups will benefit more from agricultural development than others. To avoid inequity, therefore, development efforts should also include investments to improve social services (e.g. health and family-planning centers, schools, and sanitation) and provide vocational training (to improve off-farm work opportunities). They must also take into account the effects that various development options have on women—as they contribute a significant amount of labor but have little decision-making power.

Soil erosion and conservation in olive orchards in hilly areas

In northwest Syria, olive cultivation has expanded over the last few decades into marginal areas, including fragile mountain regions with marl or chalky limestone soils. However, farmers are still using traditional land-husbandry techniques, which are not suited to olive growing on steeper slopes. This is resulting in tillage and water erosion, which is causing soil fertility to decline and is damaging olive productivity and economic growth.

As part of a plan to develop efficient and effective soil-conservation strategies, ICARDA has evaluated the long-term effects of growing olives on steep slopes. The Center also analyzed how farmers decided whether to apply soil-conservation measures, and assessed the soil-conservation advantages of natural vegetation strips on hillsides.

Long-term impact on land degradation

Researchers have evaluated the impacts that olive cultivation on steep slopes has had over a 50-70 year period. To do this, they compared the properties and profiles of soils in olive orchards with those of an adjacent reference forest.

The study showed that deforestation followed by cultivation causes a severe drop in soil quality. Soil depth had declined by at least 31% relative to the forest soil, while the soil organic matter content had dropped by 62%. Soil nutrient levels were also considerably lower: cultivated soils contained 62% less nitrogen, 48% less phosphorus, and 58% less potassium. The physical properties of orchard topsoils had also deteriorated significantly in comparison with those of forest soil: soil was more compacted (bulk density was greater) and more prone to water erosion (aggregate stability was lower).

The level of degradation was also strongly linked to topography. Most severe degradation was found on the steepest parts of the hillsides. In these areas, losses of soil organic matter and increases in bulk density were significantly greater than on the flat section at the top of the slope.

Overall, the study highlighted the severe level of historical degradation, and the need to stop further erosion by using simple alternative management practices. Only in this way will hillside olive production become sustainable.

Farmers' decision-making

Working with farmers in hilly olive groves in northwest Syria, ICARDA and its partners explored how farmers perceive land degradation. They also investigated what soil-conservation practices farmers used, and how they decided to apply them. In all, 43 villages were visited and 73 in-depth interviews conducted with farmers, extension workers, and other stakeholders in the area.

Based on these interviews, a holistic framework was constructed which describes farmers' decision-making with regard to soil conservation. This will be used to guide future development and research efforts.

The long-term impact of land use on soil was assessed by comparing undisturbed forest soils with orchard soils in northwest Syria.

Farmers' decision-making processes were found to be linked to the driving forces at the household level: the household's capital (financial, human, physical, social, and natural), and the household's social environment (including its social status). The study also took into account the three basic strategies that farmers used to cope with a fall in household resources triggered by land degradation.

These strategies were (1) non-farm activities (in the long or short term), (2) improved crop husbandry (short term), and/or (3) soil conservation (long term). Whether farmers adopted one or several strategies depended on their perceptions about the need for a particular strategy, how feasible it was, and how the strategy would affect their household capital.

Within the framework of these basic strategies, the decision making process was described in three dynamic stages: (1) motivation to farm, (2) motivation to tackle land degradation, and (3) motivation to apply a soil-conservation strategy. In our study we observed that the higher the motivation to farm, the higher the motivation to tackle land degradation and to apply a soil-conservation strategy.

Landowners who were more motivated to farm were more likely to observe, reflect on, and discuss the factors influencing agricultural production. As a result, they were more aware of land degradation. Farmers who were more motivated to tackle land degradation, observed, reflected on, and discussed soil-conservation strategies more. They were therefore more likely to experiment with soil-conservation innovations.

Controlling erosion with natural vegetation strips

To increase rainfall infiltration and control weeds, most farmers prefer to plow their olive orchards. However, this results in tillage erosion (the downhill movement of soil as a result of tillage). The extent of tillage erosion depends on factors such as soil type, the steepness of the slope, and the tool used to till the soil.

Tillage also increases water erosion, especially when farmers plow up and down the slope. Tillage erosion is now a very common problem in Afrin (north-west Syria), and a major threat to sustainable olive production. Simple cultivation systems to conserve the soil have therefore been tested.

In the natural vegetation strip system, farmers plow along the contour lines of the slope and leave a strip of natural vegetation between the trees untilled. This strip reduces tillage erosion and obstructs water flows—thus reducing water erosion.

To test the method, researchers at Tel Hadya measured the amount of tillage erosion caused by different methods of tillage. On a 12% slope, use of a natural vegetation strip and contour tillage reduced tillage erosion by 75% in comparison with a downhill tillage pass. In addition, the new technique also caused soil to accumulate on the uphill side of the vegetation strip, further reducing the risk of water erosion.

Formation of natural vegetation strips as a result of selective contour tillage in Khanasser Valley, Syria.

Simple and low-cost conservation measures, such as natural vegetation strips, enable more farmers to tackle land degradation. When the vegetation-strip system was discussed with farmers in Yakhour and Khaltan (north-west Syria), they concluded that it would be useful in fields where trees had been planted more or less along the contours of the slope. As a result of these discussions, one farmer began to test the system in his field during the following spring.

Outscaling integrated natural resources management

Based on increasing demand from national partners, ICARDA is working to mainstream its integrated natural resources management (INRM) framework and tools. Several hurdles have to be overcome to do this, as certain skills are needed to apply INRM and people often think that the method is complex. What is more, most partner research institutions have a single-discipline focus and lack the expertise needed for participatory and multi-stakeholder approaches.

As part of its INRM outscaling efforts, the Center has produced publications, and delivered seminars during regional meetings with NARS. The NARS staff have also been introduced to the concept during in-house training courses on natural resource management. Importantly, ICARDA is also providing practical training to its project partners through workshops and through the direct application of INRM during project implementation.

INRM training workshops

Through workshops, training on specific aspects of INRM was provided to senior staff from the Conservation Tillage and Mountain Agriculture projects in Morocco. Trainees were asked to decide which of the diagnostic tools, problem-solving tools, and process INRM tools were most appropriate to their needs. Brainstorming sessions were then used to help trainees learn how to apply those tools within their projects. The results of this group work were then fed directly into project-planning exercises.

Learning by doing

Iran's Karkheh River Basin Project falls under the CGIAR's Challenge Program for Water and Food. INRM has been built into this project from the start. As it progressed, therefore, staff were provided with hands-on training when necessary. In addition, 'reflection' points were used to assess the project's progress as part of a learning cycle. This approach encouraged collective learning and helped to identify any adjustments to the projects or further training that might be needed.

Lessons learned

Various lessons have been learned from the outscaling of INRM and these have already been fed into the design of future training programs. Key factors for success include ensuring that INRM workshops occur early in the project cycle, involve participants from different disciplines, and draw on actual examples of INRM in practice. There is also a need to ensure that project managers and facilitators are committed to providing follow-up after training, especially in the early stages of projects.

Bringing integrated natural resource management theory into practice in Iran.

Vegetation types and rangeland degradation in communities on the Syrian steppe

As part of its work to improve rangeland management, ICARDA recently assessed the impact that communities have on the natural resources they depend upon. Researchers studied rangeland degradation around 50 settlements in six provinces on the Syrian steppe: Aleppo, Hama, Homs, Damascus County, Raqqa, and Deir Ezzor.

A sample of rangeland species at a site in a dry area environment.

The study recorded vegetation types and indicators of rangeland health and degradation along three transects radiating from each of the 50 settlements. Positioned at 120° intervals in a circle around each settlement, these transects crossed both native rangeland and previously cultivated areas. The direction of the first transect from each settlement was selected by a village representative, who also advised researchers where each of the transects crossed the boundaries of community rangelands.

Researchers sampled 750 sites in the 50 communities, by choosing five sampling points on each transect. The first of these was 50 m from the settlement, and the last at the end of the transect on the community boundary. The other three were then equally spaced in between.

Soil erosion and rangeland degradation were assessed based on the presence of pedestals and terracettes, rills and gullies, and invasive plants, and on flow patterns, root exposure, litter cover, ground cover, wind erosion, and soil compaction.

To estimate how intensively rangelands were grazed, researchers also evaluated the quantity of animal droppings present and the degree of trampling by animals. All assessments were scored on a scale that ranged from 1 (none to very low) to 5 (very high).

Rangeland vegetation types were classified according to the domi-

Table 2. Dominant vegetation types and degradation levels at 750 sites in 50 Syrian steppe communities, sampled February–April 2005.

	No. of sites	% of sites
Vegetation type		
Previously cultivated	186	24.8
Noaea mucronata	136	18.1
Artemisia herba-alba	129	17.2
Anabasis syriaca	78	10.4
Native	51	6.8
Haloxylon articulatum	43	5.7
Haloxylon salicornicum	38	5.1
Barley	18	2.4
Salsola vermiculata	17	2.3
Wheat	16	2.1
Astragalus spinosus	12	1.6
Peganum harmala	9	1.2
Achillea conferta	7	0.9
Capparis spinosa	5	0.7
Tamarix penpindra	1	0.1
Native *Badia* species	4	0.5
Total	750	100
Level of degradation		
None to very low	30	4.0
Low	245	32.7
Moderate	331	44.1
High	136	18.1
Very high	8	1.1
Total	750	100

nant species in native rangeland, or the main land use. Previously cultivated land accounted for 25% of the rangeland in the study area (Table 2). *Noaea mucronata* dominated 18% of the study areas and *Artemisia herba-alba* 17%. *Anabasis syriaca*, a species that invades disturbed land, dominated 10% of the sample sites. Results showed that 20% of the sites were severely degraded (Table 2). Moderate degradation was found at 44% of the sites. The remaining 37% showed little or no degradation.

Mobility and feeding strategies of Syrian pastoralists

Throughout most of West Asia and North Africa sheep numbers are rising and overgrazing is causing rangeland to degrade. To help communities find the best ways of managing their range, ICARDA has been working to better understand rangeland management and pastoral systems in the region.

In 2005, ICARDA and Syria's Ministry of Agriculture surveyed six Syrian provinces: Aleppo, Hama, Homs, Raqqa, Deir Ezzor, and Damascus.

In these areas, researchers mapped *Bedouin* communities' rangeland, identified the main types of rangeland, and then characterized their vegetation. They also conducted socio-economic surveys, collecting information on livestock production and livestock-related movements from 313 typical households in 50 steppe communities.

Range use was characterized by asking herders how frequently they used rangeland sites over a six-year period (1999-2004) and how long they spent on a site each year. Researchers also studied the feeding strategies used and the intensification of production systems. Herders using more intensive systems were identified as those who gave their animals supplementary feed, and who were therefore less dependent on the range.

Defining categories of herders

The survey identified five types of community rangeland user (Table 3): 'opportunist', 'regular', 'less mobile', 'sedentary', and 'intensive'. Opportunist herders only use community rangeland in years when there is abundant forage, while regular herders use it every year for set periods and regularly move their herds between the steppe rangelands and the cropping zone.

Less mobile herders also use their community's rangeland site every year. However, they differed from the more mobile regular herders in that they had spent at least one whole year in their community (i.e. without moving to the cropping zone) during the six years covered by the study. Sedentary herders, on the other hand, never moved from their community rangeland site, even during dry years.

The intensive herders were drawn from all the above categories. What distinguished them was the fact that, to boost productivity, they had all provided their flocks with supplementary feed in April 2004 when grazing was at its best.

Factors determining herders' strategies

Researchers also developed a model to estimate how probable it was that a household would fall into one of the five herder categories identified. The model used household characteristics (age, composition, education, and assets) and community characteristics (such as population density

Movement of *Bedouin* communities in search of feed for their sheep and goats is guided by several factors which have a direct bearing on rangeland management. ICARDA is studying the herder categories and their strategies for moving their flocks.

and distance from markets, watering points and the cropping zone).

Results showed that households were more likely to practice opportunist herding if they lived far away from the cropping zone but owned some land within it. By contrast, households close to the cropping zone were more likely to be regular herders. Less mobile herders tended to come from communities with high densities of animals and small areas of land that had been cultivated before cropping was banned on Syria's rangelands in 1994. Households were more likely to be sedentary if the household head was relatively old or if the household contained a large number of women. They also tended to be situated relatively far from the cropping zone.

Sedentary households also tended to be close to towns and to have better access to watering points. This was also true of the intensive herders, whose flocks were usually larger than the average for their community.

The model also showed that households that depended on barley cultivation before the rangeland cropping ban now rely heavily on the stubble available for grazing in the cropping zone. Overall, it was clear that the various herding strategies used were not a matter of choice, but were to a great extent forced on herders as a result of where they lived and what resources were available.

The study showed clearly that great variation exists within Syria's rangeland communities. Efforts to improve rangeland management will therefore be carefully targeted to ensure that any new systems developed are appropriate for particular communities and the types of households they contain.

Table 3. Characteristics of the five categories of herders identified during a study of community-rangeland sites in Syria.

	Opportunistic	**Regular**	**Less mobile**	**Sedentary**	**Intensive**
Number of households	**31**	**75**	**106**	**41**	**60**
Mobility pattern, 1999–2004					
Total no. of months on site in past 6 years	25.4*	32.2*	51.5*	72*	42.0
Coefficient of variation in length of residence	0.51*	0.06*	0.28*	0*	0.18
No. of months on site in 1999 (low-rainfall year)	2.8*	4.3*	6.7	12*	5.1*
No. of months on site in 2004 (medium-rainfall year)	7.8	5.9	9.8*	12*	8.9
Total no. of moves in past 6 years	4.0*	11.7*	6.3	0*	7.5
Feeding strategies, 2004					
Concentrate use (% of herders)	46.8	33.8*	44.7	49.5*	49.8*
Crop residue use (% of herders)	16.9*	46.8*	22.5*	18.1*	27.4
Grazing on community rangeland (% of herders)	36.3*	19.4*	32.8*	32.4	22.8*
Productivity indicators, 2004					
Productivity index†	0.46	0.43*	0.48	0.48	0.50
Total production cost per ewe (SP)‡	2,142	2,155	1,834	1,623	2,412*
% of lambs fattened	33	42	40	22*	54*
Community-level mobility and fattening patterns, 1999-2004					
Average 'herder presence'§ 1999-2004	0.40*	0.43*	0.56*	0.59*	0.53
Variation in 'herder presence' 1999-2004 (coefficient of variation)	0.66*	0.41	0.42	0.37	0.39
'Herder presence' in 1999 (low-rainfall year)	0.28*	0.30*	0.40	0.49**	0.36
'Herder presence' in 2004 (medium-rainfall year)	0.52*	0.52*	0.68*	0.65	0.62
% of residents fattening their lambs	63.4	77.6	65.5	61.3	86.1*

*,** Significantly different from all other means at the 5% and 1% probability level, respectively.
† Indicator of productivity obtained through a factor analysis from four variables (mortality rate, lambing rate, milk production per ewe and per year, percentage of ewes that gave birth to twins).
‡ SP = Syrian pound; in 2005, 1US$ = 50 SP.
§ Indicator of use of community rangeland, calculated as (No. of households with sheep x months spent on community-rangeland site per year)/(total no. of households who use community-rangeland site x 12)

Sheep behavior and preferences for rangeland shrubs

Rangeland rehabilitation in CWANA often involves planting drought-tolerant shrubs to supplement native vegetation and provide grazing for sheep and goats. In the summer of 2005, ICARDA researchers at Tel Hadya, Syria, assessed this practice by studying sheep behavior and grazing preferences on a native rangeland area planted with rows of drought-tolerant shrubs six years before.

Every day, for nine weeks—from the end of June to the end of August 2005—90 female sheep were allowed to graze the rangeland area. Researchers observed the behavior of five marked sheep for 10 minutes each week. As well as recording the number of seconds they spent displaying different behaviors, such as walking, drinking, sleeping, and browsing, the researchers also recorded the species of shrubs grazed.

Around 48 native species were found in the study area, including wild oats, clovers, herbs, and grasses. The 19 non-native species of shrubs planted in the area consisted mainly of saltbush (*Atriplex*) with some *Salsola, Haloxylon*, *Kochia*, medic (*Medicago*), and *Coluteal* species, as well as five legumes.

The sheep grazed the very dry, brown, and over-mature native plants and palatable leguminous species first. They only began to graze the non-leguminous shrubs after the fifth week, once most of the native plants had been eaten (Table 4). Even then, they spent more time walking than grazing these shrubs.

Rangelends support a diverse range of native species, but sheep and goats have their own preferences for grazing. This research is helping ICARDA identify the species preferred by small ruminants and use them to rehabilitate degraded rangelands.

Table 4. Sheep behavior (seconds spent on each activity), when given free access to a rangeland of native vegetation rehabilitated with non-native shrubs, over nine weeks at Tel Hadya, Syria.

Week	Grazing shrubs	Grazing native species	Grazing roots of native species (after digging)	Walking	Stopping	Drinking	Sleeping
1	65.2	495.0	0.0	25.2	2.2	12.4	0.0
2	33.2	438.4	0.0	103.4	10.0	8.8	6.2
3	13.8	498.6	0.0	85.4	1.0	1.2	0.0
4	23.6	445.8	0.0	128.8	0.0	1.8	0.0
5	178.0	279.2	9.6	105.6	15.6	12.0	0.0
6	108.0	326.4	23.2	128.8	3.2	10.4	0.0
7	117.8	278.0	36.6	158.0	7.4	2.2	0.0
8	9.2	306.6	140.6	141.0	2.6	0.0	0.0
9	17.2	49.2	63.8	289.2	175.8	4.8	0.0
Mean (over 9 weeks)	62.9	346.4	30.4	129.5	24.2	6.0	0.7
% of total observation time	10.5	57.7	5.1	21.6	4.0	1.0	0.1

Researchers also noted that once sheep had eaten all the native vegetation above ground, they preferred to dig for underground rhizomes, forbs, and grass stems rather than browse the abundant foliage on the shrubs. Once they began grazing the non-leguminous shrubs (after week 5), they mostly grazed *Salsola* species and a Spanish variety of *Atriplex halimus*, which is similar to the native saltbush.

Sheep showed a clear preference for native vegetation throughout the trial (Table 3), spending 60-97% of their time grazing native species and only 3-38% grazing shrubs. This means that native vegetation could be heavily grazed, and even eliminated, before sheep will resort to browsing saltbush. The intense grazing pressure placed on native vegetation as a result may explain why it is so sparse and degraded.

This means that projects that aim to rehabilitate rangelands by planting shrubs may have the opposite effect, causing the remaining native vegetation to degrade completely. In the worst-case scenario, the land could become completely barren once plantations of non-native shrubs eventually die. This could happen after a couple of decades, as the non-native shrubs have a life span of around 20 years and do not re-seed naturally.

In addition, rehabilitation projects often target the least-degraded areas of rangeland, which have adequate native shrub cover. This aggravates the situation.

Researchers found one case, for example, where *Atriplex* was planted in an excellent stand of native *Artemisia* because this was the only land available and the project managers needed to meet a quota. Such cases are common in Syria and Lebanon. Clearly, therefore, rangeland rehabilitation efforts must take account of the habits and preferences of grazing animals.

A new partnership for sustainable land management in Central Asia

A lack of agricultural inputs and market opportunities is forcing rural communities in Central Asia to over-exploit their natural resource base. As a result, both highland and lowland areas are degrading at an alarming rate. Deforestation is increasing, as is rangeland overgrazing—especially near villages. At the same time, soil and water quality are falling and crop yields are declining.

To address these threats, ICARDA is working with the Central Asian Countries Initiative for Land Management (CACILM) Task Force. This aims to implement the United Nations Convention to Combat Desertification in five Central Asian countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. CACILM is led by the Asian Development Bank (ADB) with support from agencies from Canada (CIDA), Germany (GTZ), and Switzerland (SDC), and the International Fund for Agricultural Development (IFAD).

By assessing the ecological, institutional, and economic aspects of land management, working groups in each of the Central Asian countries have already ana-

A new consortium in Central Asia is helping communities move towards sustainable use of natural resources.

lyzed the root causes of land degradation. This work has helped them identify priorities for action as well as a suite of sustainable land-management options. It also clarified various research needs. In all countries, it was concluded that research is needed to develop better agronomic and soil and water conservation practices, and to diversify crop and livestock production to boost incomes.

Germplasm collection will also be important, as researchers need to develop crop varieties that can tolerate drought, salinity, and extreme temperatures.

The working groups also called for research to improve water-use efficiency, water allocation, and rangeland, feed and livestock-management strategies. New policies and institutional options are also needed, as are better ways of managing forests, and rapid and inexpensive methods to assess and monitor land degradation.

To address these research needs, ICARDA has developed an appropriate research framework, which is now being discussed by CACILM partners. This will be used to develop and apply innovative and sustainable land-management practices and to integrate sustainable land management into government development priorities and policies. The framework will also help the program's partners to strengthen human, technical, and institutional capacity, and encourage greater public and private sector investment in already-degraded areas, thus preventing further degradation.

Indigenous forage crops for the Arabian Peninsula

Large areas of the Arabian Peninsula suffer from some form of desertification. The primary cause is overgrazing. Since the 1960s, livestock production has increased sharply, thanks to better veterinary services and provision of subsidies that enable farmers to purchase processed feed and baled hay. In 1998 there were an estimated 24 million animals, mainly sheep, goats and camels. Overgrazing reduces the productivity of the ecosystem as well as the nutritional value and relative abundance of plant species. Rangelands do not provide sufficient forage, so farmers extract groundwater to produce irrigated forage – further exacerbating water shortages.

ICARDA's Arabian Peninsula Regional Program aims to address these problems by promoting indigenous forage species that can provide forage for livestock and simultaneously rehabilitate degraded rangelands. Collection missions were carried out in different countries in the Peninsula. Several of the species collected have high water-use efficiency and great potential value as forage crops.

More and more farmers in UAE's Central Agricultural Region want to grow the new forage Buffel grass or Leybid (*Cenchrus ciliaris*). To cope with the increasing demand, ICARDA and the Ministry of Agriculture are using

Overstocking can exhaust vegetation cover on rangelands (left), but stricter control of grazing allowed pasture to recover rapidly in Al Jouf, Saudi Arabia (right).

Seed production fields at Dhaid Research Station, UAE, December 2005.

direct seeding, rather than planting seedlings. This method requires frequent irrigation and good weed/pest control. However, once established, Leybid can be harvested ten times per year, with an average dry matter yield of up to 20 t/ha.

The water-use efficiency of Leybid (quantity of water to produce 1 kg of dry matter) is 25 to 50% higher than Rhodes grass, a popularly used forage. The Dhaid Research Station has intensified seed production of Leybid and Da'e (*Lasiurus scindicus*); around 1.7 tons were produced in the past two seasons. The station's seed unit – jointly established in 2002 by ICARDA and the UAE Ministry – is also producing several other indigenous forages.

Similarly, in Saudi Arabia, ICARDA and the Ministry of Agriculture are establishing a seed technology unit to enhance seed production of native range plants, particularly shrubs. A seed scarifier and a seed cleaner will soon be installed, and additional equipment for the unit is being procured.

In Oman, varieties of spineless cactus introduced from Tunisia in 2004, are now well established at the Rumais Research Station; and will be distributed to other countries in the Peninsula. Leybid seed is being multiplied at the Livestock Research Center in Rumais, for an ongoing program to re-seed degraded rangelands. Sixteen sites (0.25 ha each) were seeded in December 2004, and are being monitored.

Rangeland in the highlands of Yemen is being rehabilitated in collaboration with the Wallan community.

In Yemen, rangeland rehabilitation efforts in the Wallan community are continuing, using a combination of indigenous shrubs and water harvesting techniques. Pasture productivity has increased from 0.5 t/ha in 2003 to 1.8 t/ha in 2005.