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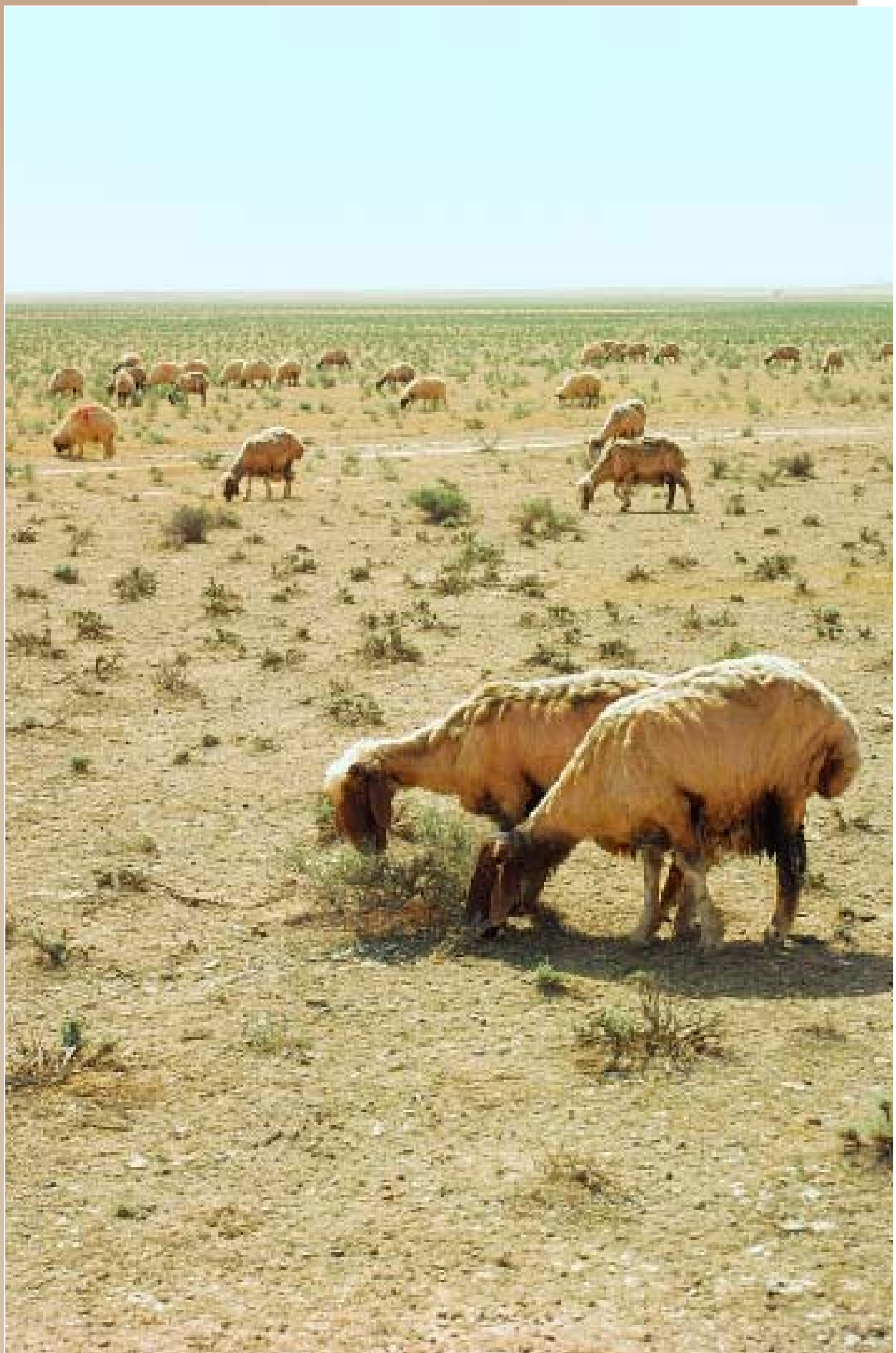
ICARDA

Review of agriculture in the dry areas



Special issue on

International Year of Deserts and Desertification

ICARDA Caravan
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Contents

Cover photo: Desertification threatens 41% of the world's drylands, and the livelihoods of over 2 billion people. ICARDA's research helps understand the processes and impacts of desertification, and develop sustainable technology, policy and livelihood options for the affected communities.

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From the Director General

Desertification is an extreme form of land degradation, usually caused by a combination of climatic factors and human activity. The damage to the ecosystem increases progressively, eventually crossing a threshold, beyond which restoration becomes impossible or prohibitively expensive. According to the Millennium Ecosystem Assessment, 41% of the world's land area is threatened, to varying degrees. Over 2 billion people are affected.

The United Nations has declared 2006 as the International Year of Deserts and Desertification (IYDD). Many national and international organizations are helping to create increased awareness among policy makers; and build stronger links between research institutions, and between research and development agencies, to understand the causes and combat desertification. Knowledge is being created and shared; but much more remains to be done. As the global Center for agricultural research in the dry areas, which are the most vulnerable, ICARDA is at the forefront of the battle against desertification.

One problem is the level of complexity. Desertification is not simply about high temperatures or low rainfall. Economic and social factors, land use policy, topography, biodiversity, local institutions, all play a role.

This issue of *Caravan* looks at different aspects of desertification; and how ICARDA and its partners are working together to help farming communities find effective, sustainable solutions. These collaborative efforts have generated significant impacts at community level – higher crop yields, more sustainable farming systems, more income-generating opportunities for the poor. Equally important, they have yielded insights into the basic processes and impacts of desertification, and on factors that determine the success or failure of interventions to arrest land degradation. These research products are international public goods.

In Syria's Khanasser Valley, for example, ICARDA introduced the concept of an Integrated Research Site, where a multi-institutional, multidisciplinary team is working with farmers and pastoralists to identify technology options suited to the area, and institutional mechanisms to ensure that these technologies will work. This concept is spreading to other countries in the dry areas. In Lebanon and Jordan, ICARDA and its partners are using a mechanized system for rapid large-scale restoration – greening dry, degraded areas and building a network of water-harvesting structures. In Central Asia, new crops and improved tillage methods are helping to arrest long-term soil degradation and build a healthier, more diverse farming system. Multidisciplinary studies are exploring innovative payment-based schemes for rangeland conservation, and testing simple, cost-effective ways to improve soil fertility – often the key issue in degraded areas. New tools such as GIS are being used to improve the analysis and presentation of information, for scientists as well as policy makers.

One common thread runs through all this: the importance of community participation, and of a holistic or integrated perspective, including policy and institutions, as opposed to a narrow focus on a single crop or one scientific discipline. Unless scientists from different disciplines and institutions work together, they will not succeed in developing technologies that work. And unless the community is involved, adoption rates will be poor. ICARDA's work rests on these two pillars, participation and integration. We call this Integrated Natural Resource Management (INRM). To "mainstream" this approach – to make it standard practice in all development projects – we have helped develop a framework for INRM. The framework, explained in this issue of *Caravan*, can help plan and monitor projects, identify weak links, and determine key characteristics that drive change within the system.

Ultimately, research must lead to change – which is why ICARDA places great emphasis on its work on policy and institutions. Research findings must feed into policy development, by providing policy makers with practical, viable technology options to fight desertification. Regional, national and local institutions must be strengthened to remove the impediments to technological change. Human capacity must be developed through training and empowerment. All these components must come together, in order to arrest, and gradually reverse, the process of desertification.

The impact of ICARDA's work demonstrates that degradation can be controlled, and rural welfare and livelihoods improved, even in the harshest environments. However, ICARDA is only one player among many. We welcome the opportunity to engage in dialog and cooperation with national, regional and international organizations.

Mahmoud Solh
Director General, ICARDA

International Conference on Drylands

A number of global meetings in which ICARDA was involved, were held in 2006, to mark the International Year of Deserts and Desertification. The first major event was the 8th International Conference on Dryland Development, held in Beijing, China, in February 2006. The conference was organized by the International Dryland Development Commission, hosted by the Chinese Academy of Sciences (CAS), and cosponsored by the United Nations University in Tokyo, ICARDA, and other institutions.

Panel discussion on UNCCD implementation, co-chaired by Prof. Dr Hans van Ginkel, Rector, United Nations University, and Prof. Dr El-Beltagy, ICARDA Director General (third and fourth from right, respectively).

The theme of the conference: 'Man and Nature – working together for sustainable development in the drylands'. There were over 200 participants from 26 countries and five international organizations; and a total of 150 presentations. A panel discussion involving some of the world's leading experts, focused on ways to strengthen implementation of the UNCCD.

The discussions covered a range of issues: soil and water conservation, dust-storm processes, range management, forage and livestock production, biodiversity and ethnobotany, stress physiology, renewable energy, indigenous/traditional knowledge, sustainable development of oases, socioeconomic studies of desert communities, the role of NGOs, and application of new technologies and technology transfer methods for crop improvement in dry areas.

ICARDA was well represented at the conference. Director General Prof. Dr El-Beltagy and Board Chair Dr Margaret-Catley Carlson chaired or co-chaired several key sessions. Assistant Director General Dr Mohan Saxena played a key organizational role as Executive Secretary of the International Dryland Development Commission. A number of ICARDA scientists made presentations: future challenges to sustainable resource management, agricultural water consumption in relation to aridity and drought incidence, the potential of biofuels, development of forage legumes in China, and protected agriculture in the Arabian Peninsula.

Prof. Dr Li Jiayang, Vice President of CAS, described some of the efforts being made to combat desertification – a significant problem in China. Later, participants visited CAS research units, where considerable work is being done in geography and resource management research, remote sensing and GIS, and biotechnology.

New South-South Partnership

ICARDA and the United Nations University, Japan, announced a new South-South partnership to combat desertification. The initiative, named 'CWANA-Plus Partnership', was launched at the International Conference on Dryland Development in Beijing. CWANA-Plus aims to strengthen research and development in countries with large dryland areas prone to desertification. This includes the vast CWANA region (Central and West Asia, North Africa), as well as large parts of China, South Asia, and sub-Saharan Africa.

The objectives include sharing expertise and facilities, training developing-country scientists, expanding post-graduate degree programs in integrated land management, and promoting improved practices among small-scale farmers. UNU and ICARDA will use existing networks to link national R&D agencies with relevant centers of excellence; identify gaps in research and technology transfer; and select appropriate partners to support dissemination efforts. A Secretariat will be established at ICARDA headquarters in Aleppo.

CWANA-Plus aims to provide poor dryland households with new technologies and viable livelihood options, enabling them to use resources sustainably and reduce their vulnerability to desertification and drought. It also aims to incorporate these options into national policies to reduce poverty and combat desertification.

If Deserts are Expanding, so is Oasis

A renewed CGIAR System-wide initiative called Oasis, involving eleven CGIAR Centers, is helping to integrate global desertification research more effectively. Oasis was launched at a UNESCO meeting in June 2006, and is led jointly by ICARDA and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). It will network over 100 desertification experts worldwide, providing technical expertise to strengthen the UNCCD's global efforts to combat desertification.

In September 2006 the Oasis consortium held a consultation meeting at ICRISAT's research station in Sadore, Niger, attended by over 50 participants from West and Southern Africa. During the meeting, H.E. Hama Amadou, Prime Minister of Niger, met an Oasis delegation led by H.E. Ambassador Arba Diallo, UNCCD Executive Secretary – underlining the high level of commitment to fight desertification.

The meeting helped identify the factors determining the success (or otherwise) of desertification interventions, and the priorities for future research. Dr Richard Thomas, Director of ICARDA's Mega-Project on desertification, presented an analysis of how Oasis could contribute to UNCCD goals, using examples from ICARDA projects in West Asia and North Africa. Such impact studies will be a priority for the future.

A delegation from Oasis met the Prime Minister of Niger during the consultation meeting in September.

The Oasis Inception Meeting, to develop the initial strategy and work plan, was held in Nairobi, Kenya, in October 2006. Eleven CGIAR Centers participated – CIAT, CIFOR, CIMMYT, ICARDA, ICRAF, ICRISAT, IFPRI, IITA, IPGRI, ILRI, and WARDA. The consortium will focus on six themes: Dynamics, causes and effects of dryland degradation; Development pathways out of poverty; Land, soil, nutrient and water management strategies to combat desertification; Livelihood strategies; Policy, marketing and institutional strategies; Co-learning, innovation, and up-scaling systems.

Combating desertification essentially means ensuring sustainable development in the world's drylands – where the CGIAR devotes nearly one-fourth of its resources. Oasis brings together the complementary skills and expertise of the CGIAR Centers and their partners worldwide, to develop and promote new technologies in the most cost-effective way.

Brussels Conference

The Royal Academy of Overseas Sciences, Belgium, organized an international conference 'Desertification: migration, health, remediation and local governance' in Brussels in September 2006. The conference focused on the less-studied aspects of desertification: human-environment dynamics in drylands (migration, health) and sustainable management of natural resources (remediation, local governance).

Dr Mahmoud Solh, ICARDA Director General, presented the keynote address, in which he described ICARDA's approach to R&D, which emphasizes multi-disciplinarity, partnerships, community participation, and a focus on livelihoods of the poor.

He also highlighted ICARDA outputs that are helping to fight desertification and land degradation. These include: the Marsa Matrouh project in a semi-desert region in Egypt; new feed technologies for sheep production in dry areas; development of drought-resistant forage crops; the eight-country Mashreq and Maghreb project for integrated crop/livestock production; simple methods for harvesting rainwater; biodiversity conservation in areas threatened by desertification; village-level agribusinesses for the poor; and policy studies on land tenure and women's rights.

Global efforts to fight desertification are coordinated by the United Nations Convention to Combat Desertification (UNCCD), which is administered from Bonn, Germany. The UNCCD was adopted in 1994, and came into force in December 1996. To date, 191 countries have ratified the agreement.

The objectives of the UNCCD are to: "combat desertification and mitigate the effects of drought.. contribute to sustainable development... through long-term integrated strategies that focus on improved productivity of land, and rehabilitation, conservation and sustainable management of land and water resources, leading to improved living conditions, in particular at the community level."

News from the Drylands

International Symposia in Japan

A series of meetings in Japan in August 2006 helped expand research partnerships to fight desertification, and raise public awareness about the problem. The meetings were organized as part of the activities to mark the International Year of Deserts and Desertification.

- Living with the desert II – Dryland science and practices on the ground: international symposium at United Nations University (UNU) Tokyo, in collaboration with UNCCD
- Role of citizens in combating desertification: symposium at Tottori University
- Outlook of agricultural research for dry areas: international seminar organized by the Japan International Research Center for Agricultural Sciences (JIRCAS), Tsukuba.

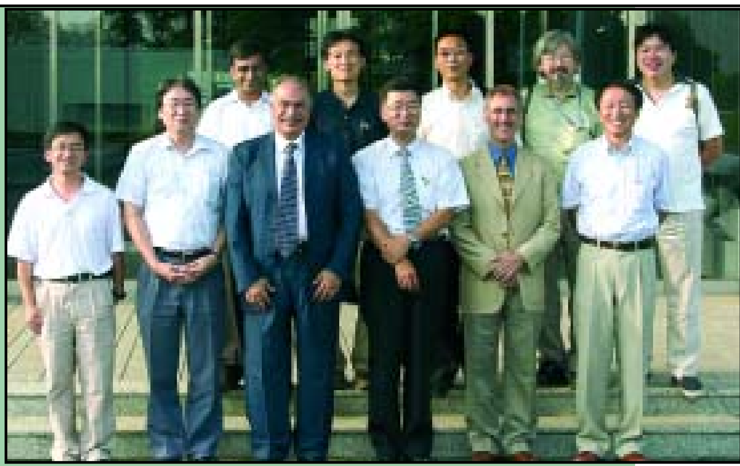
These events brought together more than 600 participants – national policy makers, scientists and administrators from universities and research institutes, and others. ICARDA actively participated in all three meetings.

Dr Mahmoud Solh, ICARDA Director General, delivered the keynote address at the UNU symposium, highlighting the causes and impacts of desertification, and possible solutions – for example, innovative dryland management methods that ICARDA and its partners have successfully introduced at pilot sites in West Asia.

The symposium at Tottori University discussed the role of citizens and networks in combating desertification. It recognized that even Japan was potentially at risk, since the Japanese food market has close links with several countries affected by desertification.

Dr Solh described how ICARDA has successfully used R&D networks to develop and implement innovative technologies to combat desertification. Public awareness and support is vital; and participants at the meeting reiterated the need to educate citizens and encourage their involvement in anti-desertification efforts.

The JIRCAS seminar focused on technical issues: regional water balance predictions, the use of saline water for irrigation, use of wild relatives in breeding for drought tolerance, and the possibility of adopting marginal-area policies similar to those in developed countries. Dr Solh's presentation reviewed ICARDA's experiences in an ecoregional perspective.



Dr Mahmoud Solh (third from left) visited JIRCAS in August, to discuss expanded collaboration with Japanese institutions. Dr Akinori Noguchi, Vice President of JIRCAS, is to his left.

Building on these meetings, discussions with Japanese policy makers and research institutions have helped broaden cooperation. The Japanese government and JIRCAS have long supported ICARDA's work. Dr Solh met senior officials from two government ministries (Foreign Affairs, and Agriculture, Forestry and Fisheries) to further expand this collaboration.

Similarly, meetings at the Arid Land Research Center at Tottori University led to two new initiatives: a Master's degree program on integrated drylands management involving UNU and research institutes in Tunisia and China; and an international network to exchange information on dryland studies, proposed jointly by ICARDA and six other internationally reputed organizations.

Seminar on Drought Mitigation

ICARDA, FAO and the Mediterranean Agronomic Institute (CIHEAM-Zaragoza) organized a seminar on drought mitigation, held in June 2006 at ICARDA's headquarters in Aleppo, Syria. There were 24 participants from 14 countries: Albania, Algeria, Egypt, Iran, Italy, Jordan, Lebanon, Morocco, Palestine, Portugal, Spain, Syria, Turkey and Tunisia. Resource persons were drawn from Algeria, Italy, Spain, USA, and ICARDA.

The seminar focused on methodologies, tools, and management options for improving drought preparedness, planning and mitigation.

The organizers of the seminar, FAO, ICARDA and CIHEAM, jointly established the NEMEDCA Drought Network in 2002. The network now operates in some 30 countries in Central Asia, West Asia, North Africa, and the northern Mediterranean region.

Desertification:

Heading for Catastrophe?

Richard J. Thomas

Desertification is a growing threat worldwide. Two prerequisites for successful interventions: ensure the local community is fully involved, and combine modern technologies with local knowledge.

The world's drylands are often associated with misery, starvation, and conflict. They are home to about 2 billion people who depend on agriculture and natural resources for their livelihood – and are the hardest hit by desertification, drought, and poverty.

Dryland communities are often accused of causing desertification, by extracting resources without fully replacing them. But this is not necessarily true. Many dryland farmers have used traditional methods to conserve resources within their natural environment. Some of these methods are innovative and sustainable; but discriminatory policies at national and international levels have often undermined farmers' capability and intent to implement them. Policies that encourage artificially cheap imports, taxes on the agro-economy to support urban priorities, and neglect of rural infrastructure and institutions, all hamper conservation of natural resources.

Far from being a cause of misery, drylands actually yield higher returns to investments than other areas. A better understanding of desertification will enable us to develop more appropriate, effective solutions.

What is desertification?

The United Nations Convention to Combat Desertification (UNCCD) defines desertification as 'land degradation in arid, semi-arid and dry sub-humid areas, resulting from various factors, including climate variation and human activities'. Desertification is among the biggest environmental concerns today, globally and especially in drylands, which cover over 40% of the world's land area. Over 2 bilion people are afected; and the UNCCD has declared 2006 as the 'International Year of Deserts and Desertification'.

Desertification dates back to the beginning of agriculture 7000 years ago and was noted during the collapse of Mesopotamia and the Roman Empire. In the region of the 'hundred dead cities' near Aleppo, Syria, 1-2 meters of soil was washed away in the first century following the invasion of armies and disuse of conservation structures.

More recent manifestations include the dust bowls of the American mid-west in the 1930s, the shrinking of the Aral Sea from the 1960s onwards, and debilitating dust storms in China in the 1990s that continue today (costing the country US$ 2-3 billion every year). All these occurred during attempts to increase agricultural productivity!

What is land degradation?

Land degradation, like desertification, is hard to define. It is complex and involves biodiversity, soil health, water resources, landscape, and agricultural productivity dimensions. Definitions can be contradictory, but degradation generally refers to a temporary or permanent decline in productive capacity of the land.

Dryland environments are fragile, and vegetative cover is sparse. Grazing, excessive tillage, or wood harvesting exposes the soil to wind and water erosion. The soil surface becomes crusted or 'sealed'; water runs off instead of being absorbed into the soil. Runoff also leads to heavy loss of the limited stock of essential plant nutrients, and the land soon loses its productive potential.

The Khanasser Valley in Syria, site of a long-term research project to improve resource management and fight desertification.

Can we prevent desertification?

It is far cheaper to prevent desertification, through preservation and enhancement of soil cover and soil organic matter, than to rehabilitate degraded land. Sustainable solutions include better crop and soil management, increased use of mixed crop-tree-livestock systems, water harvesting and conservation, and judicious use of fertilizer and organic manure.

These and other methods have been tried for many years, but often failed. Why? Because they involved 'silver bullet' technological solutions implemented using a top-down approach. What is needed is a more holistic approach, combining technology, policy and institutional options with the participation of land users. We must involve communities more closely in development planning, and motivate them to adopt improved practices. Governments and institutions must work *with* them and not *for* them. They must provide opportunities and the enabling environment that encourage and reward wise stewardship of the land.

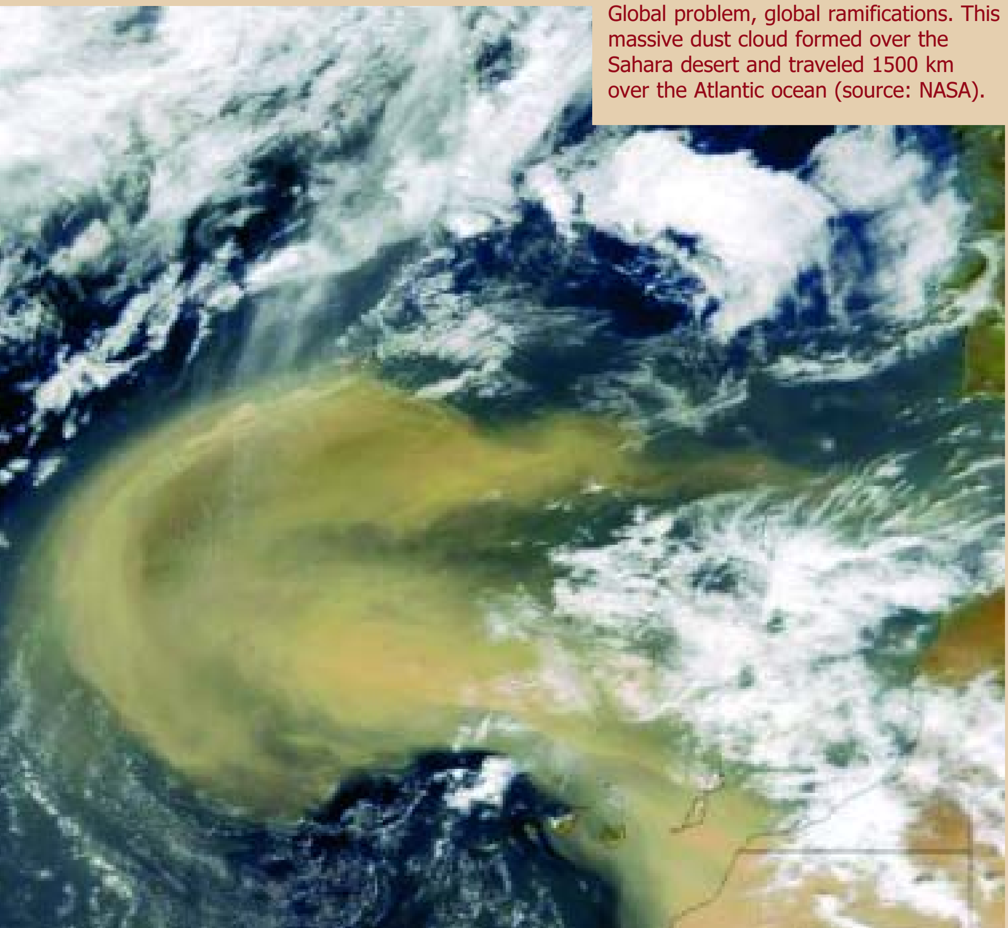
Dryland communities are diverse and complex; so interventions must be carefully designed. We need to build on the wealth of local knowledge, with a clear understanding of local priorities and constraints. Many development projects take little consideration of community views and local knowledge. For example, policies on building large reservoirs and water conveyancing often ignore the ways in which water is allocated at farm level. We need an integrated approach that links communities, governments, regions and the international community in order to overcome these limitations.

New consortium against desertification

To address these issues, ICARDA and ICRISAT have formed a new consortium, known as Oasis, comprising over 100 desertification experts worldwide.

The consortium framed two core questions: How can poverty in resource-poor desertification-prone areas be reduced? How can the poor achieve stable, secure livelihoods without undermining the ecosystem goods and services (natural resource base) that they depend on? To find the answers, the consortium will focus on six priority areas.

1. Improving understanding of the nature, extent and severity of desertification and dryland degradation; combining new technology with local priorities and values through user participation and ground-truthing.
2. Study of institutions and policies (formal and informal, local and larger-scale) that constrain or foster sustainable dryland development.
3. Increased understanding of how dryland agricultural and natural ecosystems function, and the degree to which productivity can be enhanced by improving soil fertility and water management, integrated crop-tree-livestock systems, and other innovations.
4. Participatory breeding: developing crop, tree and livestock varieties/breeds with improved adaptation, stress tolerance, product quality, and other traits.
5. Building on dryland traditions of diversification to develop new income sources: new and domesticated indigenous crop/tree species, farming systems, products, markets, and supporting enterprises.
6. Improving the exchange of information, expertise, tools, and solutions in ways that can engage the poor and address their needs.



Global problem, global ramifications. This massive dust cloud formed over the Sahara desert and traveled 1500 km over the Atlantic ocean (source: NASA).

In each of these six areas, cutting-edge science will be blended with field research, by scientists from multiple disciplines and multiple institutions working with local communities and government agencies. Details of this approach, called Integrated Natural Resources Management (INRM), are provided in another article in this issue.

Recent studies have challenged the common assumption that investments in drylands deliver lower payoffs than in favorable areas. On the contrary, the relative neglect of drylands in the past has probably left major gains unrealized, which are now ripe for picking.

The dryland poor have demonstrated their ability and eagerness to learn, adopt, and invest in new technologies and practices that will help them move out of poverty. The research and development community cannot afford to ignore these opportunities any longer.

Dr Richard Thomas (r.thomas@cgiar.org) is Director of ICARDA's Megaproject on Improving Land Management to Combat Desertification.

Focus

Fighting Desertification in Jordan and Lebanon

A new OPEC-funded project works with farm communities in Jordan and Lebanon to test simple water harvesting technologies to fight desertification.

Akhtar Ali, Ahmed Bulad, Anwar Kozah, Theib Oweis, and Adriana Bruggeman

Lebanese farmers build basins on rocky slopes, to harvest water for fodder shrubs.

Desertification is an extreme form of land degradation caused by a combination of climatic factors and human activity. Over 2 billion people in more than 100 countries are directly or indirectly affected. Each year, 6 million hectares of farmland are forced out of production. Dry areas are especially vulnerable. According to the UNEP, some 3.5 billion hectares of drylands are affected by desertification. In Jordan, Lebanon, Syria and Yemen, 80-90% of rangelands and 56-70% of rainfed croplands are degraded.

Desertification is often irreversible, and always frighteningly expensive. Losses in the Middle East and North Africa are estimated at US$38 per hectare for rainfed crops and US$7 per hectare for rangelands, at 1990 prices. And this is just the value of foregone benefits and loss of productivity; it does not include the cost of human suffering, lost livelihoods, and damage to the environment.

In 2000 the United Nations Convention to Combat Desertification (UNCCD) launched a Sub-Regional Action Program to combat desertification and drought in West Asia, involving several national and international partners including ICARDA. As part of the program, ICARDA works with national research and extension agencies in Jordan and Lebanon. Together, we engage with local communities to test and implement interventions for combating desertification. This article describes progress made in the initial project phase.

Jordan

A pilot site was established in cooperation with the National Center for Agricultural Research and Technology Transfer (NCARTT). The site is the Mahelleh catchment, a 15 km^2 watershed with steep slopes, numerous gullies, and shallow, easily eroded soils. Curiously, water is the major cause of desertification in the catchment! Rainfall is only 160 mm per year, but runoff generates and dissipates quickly in the upper catchment, causing heavy erosion.

The erosion is accelerated by tillage for barley cultivation on slopes and gully margins. Soil productivity is rapidly declining. Livestock production – a major part of the local economy – has declined, because degraded rangeland no longer provides enough grazing for animals, and farmers cannot afford to buy feed concentrates. Limited rainfall also means shortages of water for crops, vegetable gardens or livestock.

Correspondingly, the main focus of the project is on management of rainwater and runoff. Several methods have been tested with community participation: water harvesting strips, contour ridges, gully check structures, biological control of rills and small gullies by planting cactus, rehabilitation of rangeland by planting shrubs in the upper catchment, a water harvesting pond for animals, small dams for irrigating home gardens and cash crops.

Strips: alternating strips of cropped and fallow area, where the fallow strips act as miniature rainwater catchments. The ratio of cropped to catchment area varies from 1:1 to 1:3 depending on slope, soil type and rainfall. This method can harvest enough rainwater to double crop yields.

Contour ridges: parallel stone ridges are built 5 to 10 m apart to stop runoff water (and the soil it carries) from damaging downstream areas. Each ridge collects runoff water from the area immediately upstream/uphill, and the water is channeled to a small plantation of fodder shrubs. With a combination of well designed ridges and drought-tolerant shrubs, project communities were able to meet a large proportion of their fodder requirements.

Control of rills and gullies: a combination of vegetative cover (to slow down runoff) and physical structures (to stop and divert runoff water) is a cheap, effective way to prevent rills and gullies from expanding.

Water reservoirs: small ponds are easy to build, even on slopes, by selecting a suitable depression, and sealing off the lower end with a masonry wall. On a slightly larger scale, a low-cost earthen dam can meet most of the community's needs for domestic purposes, supplemental irrigation, or livestock. Reservoir size can be matched to runoff conditions (total amount, flow rates) and the labor and material available for construction.

This check structure halts runaway water, helping to stabilize a gully in Jordan.

Lebanon

Two pilot sites, Yemouneh and Deir El-Ahmar, were established in the mountains of Lebanon in cooperation with the Ministry of Agriculture. Because of their topography, mountainous areas are often affected by flash runoff events, resulting in sheet and gully erosion. Erosion reduces the soil's capacity to store water, so soil moisture levels are generaly low.

Yemouneh represents the high mountainous area: 1360 m above sea level, significant snowfall, and average precipitation of 650 mm per year. The community has 3500 people, with 541 ha of the 2950 ha area under cultivation. The other pilot site, Deir El-Ahmar, is mainly rangeland and forest, and is managed by the community. The population is around 15,000.

The project began with a series of formal and informal community meetings at both sites, facilitated by the Ministry of Agriculture. Farmers identified their main constraints – degradation of forest and rangelands on the hillsides, and water shortages. The project team then proposed interventions tailored to the area, which were discussed by the community. This participation was key, because the interventions require collective community action; for example planting and managing forest trees and shrubs on communal land, for water and soil conservation.

Other interventions included terraces, stone dikes for fruit trees, and ridges for forage shrubs. Agricultural extension workers and farmers were trained on these technologies. Two reservoirs were built with help from local organizations. They will harvest winter precipitation and surplus flows for use in summer (mainly for irrigation and livestock). Maintenance, water allocation etc. will be managed by the respective communities.

- Small basins are dug on hillsides, across the slope, to collect runoff water. The basins are semi-circular in shape, 1 to 3 m in diameter and about 30 cm deep. Shrubs are planted in the basins, and grow rapidly with assured water availability, enabling control of soil and water erosion.

Stone dikes in Lebanon harvest water for fruit trees, and also reduce erosion.

- Contour terraces, made of locally quarried stone, are built across the slope, or on flat land near waterways. Terrace bunds are 50-100 cm high; distance between terraces varies depending on slope, crop water requirement and rainfall.
- Fruit trees are planted on the terraces: usually olive and almond trees, or apples and apricots if supplemental irrigation is available.

Lessons learned

- Local institutions play a key role; first in mobilizing the community, and later in continuing implementation in the absence of external funding.
- Communities cannot be forced to participate, but when successful technologies are demonstrated, community involvement progressively increases over time. This requires a long-term perspective and capacity building of local organizations, which can continue the work.
- Intervention packages must include actions that directly improve local livelihoods.
- Runoff and erosion affect both upstream and downstream areas. Farmers in these areas may have different resource constraints and capacities; these differences must be factored into the project design.
- Communal lands are often highly degraded because there are no standard rules or accepted norms to manage them. To rehabilitate such areas, the key is enhancing the community's capacity to develop and implement management practices.
- Water harvesting is vital. It can produce both immediate (more water for crops) and long-term benefits (re-establishment of degraded rangeland).

Runoff strips (brown) between patches of crops act as miniature water catchments.

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The Vallerani Water Harvesting System

The Vallerani plow at work in Jordan.

Tractors, engineering savvy, and community participation… the Vallerani water harvesting system is helping to rehabilitate degraded rangelands in Syria and Jordan.

Akhtar Ali, Theib Oweis, Atef Abdul Aal, Mohamed Mudabbar, Khaled Zubaidi, and Adriana Bruggeman

The *badia* is the traditional grazing ground of the native herder population in Jordan and Syria. These rangelands cover over half of Syria and 90% of Jordan; but increases in sheep numbers have left the *badia* in varying stages of degradation. In Jordan, plowing of rangelands for barley cultivation has added to the problem. *Badia* areas generally receive less than 200 mm of rainfall per year, largely in a few heavy showers. Degraded land is unable to absorb the rainwater, so much of it is lost to runoff and evaporation. Surface flows also carry away valuable topsoil. During the hot, dry summer, wind erosion further degrades these fragile lands, and wind-blown dust affects the environment and the health of the population.

Water harvesting systems can help capture runoff flows and rebuild vegetation in degraded areas. One promising option is the Vallerani mechanized system, a special tractor-pulled plow that automatically constructs water-harvesting catchments, ideally suited for large-scale reclamation work. ICARDA first tested this system successfully for several years in the Syrian steppe, in collaboration with the General Commission for Scientific Agricultural Research (GCSAR). The next stage, scaling out to more communities, involves additional partners including the National Center for Agricultural Research and Technology Transfer (NCARTT) in Jordan. In cooperation with GCSAR and NCARTT, the system is being tested with three communities in Jordan and Syria.

Qaryatein is a low-rainfall (120 mm per year), highly degraded area at the center of the Syrian *badia*. The land is owned by the state, but herders have communal grazing rights. The community nominated 20 farmers to work with project researchers to plan and implement the interventions. Using the Vallerani system (see box), about 10,500 fodder shrubs were planted on a 100-hectare area within a small 2.5 km^2 catchment. Over 85 km of contour ridges were made in just four days!

Sheikh Hilal is a small community on the edge of the Syrian *badia*, 100 km northeast of Hama. Its 200 families depend on livestock, but the rangelands provide adequate grazing only in spring; animals require supplementary feeding during the rest of the year. The community worked with project staff to plant 2000 fodder shrubs on an area of about 35 hectares. The Aga Khan Foundation is a key partner at this site.

The site in Jordan is located 65 km southeast of Amman, among the small *badia* communities of **Mharib and Majedieh**. Average rainfall is 150 mm per year, falling mainly in intensive showers. The soils are poor in structure, with moderate permeability, and they form a thick surface crust when exposed to rain. Gullies are common, reflecting the high rate of soil erosion. Some of the local families are nomads, traveling long distances with their flocks (especially in summer) in search of feed, because the area provides grazing only for 3-4 months in the winter.

Testing, implementation, and impact

The Vallerani water harvesting system is flexible, offering a range of alternatives. Which alternative is the best? To find out, we tested various combinations at the three sites: continuous versus intermittent contour ridges, closely spaced vs widely spaced shrubs, and closely vs widely spaced ridges (4 m to 12 m apart). With these combinations the size of the micro-catchment varied between 8 and 24 m^2. We also compared three indigenous shrubs (*Atriplex halimus, Atriplex lecuclada, Salsola vermiculata*) and two planting methods (planting seeds vs planting seedlings).

For each experiment, we measured runoff, soil loss, soil moisture, shrub growth, and climate parameters, and the corresponding figures for a 'control' plot where no water harvesting was done. By the end of the first season, shrub survival rates were 75 to 95% in different water harvesting treatments, but less than 30% in the control plots.

Capacity building and dissemination are important components of

Assessing performance of a water-harvesting treatment at sub-catchment scale.

How it works

The Vallerani implement is a modified plow, pulled by a heavy-duty tractor. First, contour lines are marked on the slope. The tractor follows a contour line, and the plow makes a furrow about 50 cm deep. A normal plow on flat land excavates a symmetrical furrow, and earth piles up equally on both sides of the furrow. The Vallerani plow creates an angled furrow and piles up the excavated soil only on the lower (downhill) side. This soil forms a ridge that stops or slows down runoff water as it flows downhill.

The plow can dig a long continuous furrow. Alternatively, as it moves forward, the plow blade can also move up and down (i.e. in and out of the soil), creating a series of small basins, each with a ridge. The size and spacing of basins will depend on the frequency of the up-and-down movement of the plow, which can be adjusted.

When a furrow or pit fills up, the overflow enters the next micro-catchment, flows into the next furrow or pit, and so on. Shrubs are planted in pits along the ridges. With moisture readily available, they grow rapidly, providing livestock fodder and helping to conserve the soil. The furrows/basins also slow down runoff flows, preventing erosion.

The Vallerani plow can 'treat' 30 ha in a single day, building scores of micro-catchments. For example, the 100-ha Qaryatein site was developed in 4 days. Preparation of pits and transplantation of shrubs took another 15 days. Once the project had invested in the tractor and the plow, the remaining cost of implementation – layout, planting shrubs, training farmers to build and maintain the system – was about US$1250, i.e. about $13 per hectare. That's a small price to pay for sustainability.

the project, helping users gain the full benefits and creating awareness among non-users. A series of field days showcased the value of the system. Exchange visits, where farmers visit other communities to see similar sites in operation, further accelerated adoption and enabled farmers to share ideas on problem-solving. Formal and informal on-the-job training helped farmers as well as research and extension staff operate the system more efficiently. Stakeholder workshops monitored implementation and impact, and helped disseminate the results widely.

In Jordan, high-level policymakers and development leaders have participated in community meetings at the project site, and are planning to use the system to improve *badia* areas elsewhere in the country.

Three MSc/PhD researchers are studying different aspects of the system in detail – water management, soil loss, economics of the system, and the social and institutional impacts. These studies will help develop recommendations for optimal design and management, build or strengthen the institutions needed to support such systems, and identify policies that can help poor farm communities combat desertification.

Engineers from ICARDA and NCARTT discuss the design of a water harvesting site in Jordan.

Viva Vallerani

The Vallerani system is named after its inventor, Italian agronomist Venanzio Vallerani. Dr Vallerani is a visionary who believes poverty in dryland areas can be fought by increasing the productivity of marginal and abandoned lands. But desertification cannot be rolled back by hand; and no suitable machinery was available. So he developed a special plow that can build contour ridges and semi-circular water harvesting catchments at user-selected intervals. The system can create up to 7500 micro-catchments per day, dramatically improving rainwater retention and erosion.

At 80 plus, Dr Vallerani still travels around the world to convince donors, development organizations, policy makers, researchers, and farmers of the importance of fighting desertification. Since its inception in 1988, the Vallerani system has been implemented in many countries, including Burkina Faso, Chad, Egypt, Jordan, Kenya, Morocco, Niger, Senegal, Sudan, Syria and Tunisia.

Project staff and farmers at the inauguration of the Qaryatein site.

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Focus

Protection Money:

a New Approach to Rangeland Management

Céline Dutilly-Diane, Nancy McCarthy, Francis Turkelboom, Adriana Bruggeman, Jim Tiedeman, Kenneth Street, and Gianluca Serra

Degradation of natural resources affects not only those who directly use these resources, but many others as well. Solution? Pay users to use resources more sustainably.

Livestock herders have little incentive to prevent over-grazing and rangeland degradation.

Rangeland degradation is an acute problem throughout the CWANA region (Central and West Asia, North Africa). Most previous interventions – introducing new range management technologies, strengthening local institutions – have not proved effective. But there is a possible alternative, known as Payment for Environmental Services, PES. A multi-disciplinary team from three institutions – ICARDA, the International Food Policy Research Institute and CIRAD, the French Agricultural Research Center for International Development – is studying the PES concept. Will it work in dry areas? Can it promote more sustainable management of rangelands in CWANA? Under what conditions?

What is PES?

The services that a healthy natural ecosystem provides are rarely appreciated until the damage becomes obvious. Often, land users do not consider these services when they make decisions on resource use, since they do not pay for them and receive no compensation for conserving them. And even when they understand the consequences, they are often forced to over-exploit resources simply to survive. For example, livestock can accelerate rangeland degradation in dry areas. Herders keep more animals than the land can support and often over-exploit grazing areas, because grazing is free, while animal feed is expensive.

A well-managed rangeland provides not only grazing for livestock, but various other services: carbon sequestration, conservation of plant and animal biodiversity, reduction of wind erosion (by reducing the frequency and severity of dust storms), and better water management (reducing surface runoff, reducing flood damage, recharging groundwater). Correspondingly, rangeland degradation affects not only the direct users (livestock herders) but also millions of others who benefit indirectly from environmental services. The basic idea behind PES is that indirect beneficiaries should pay the direct users, thus providing them with a clear financial incentive to protect the range.

PES has been used elsewhere to manage forests and watersheds. If it can work on rangelands, the implications would be huge. Rangelands cover more than 750 million hectares across CWANA, and are the main source of livelihood for poor rural households. But most rangelands are degraded, and getting worse. Better management would improve food security and sustainability for millions of people; and even small improvements will yield enormous pay-offs.

The problems of implementation

PES is fine in theory, but various problems must be sorted out before it can work in practice. Rangeland services operate at various scales, from local to global (see page 18). That can make it hard to identify who should pay, and how much. For example, carbon sequestration and biodiversity conservation benefit everyone including future generations. Since specific beneficiaries cannot be identified, it is impossible to recover payment. Nonetheless, as awareness grows, governments, international NGOs and even private companies are now willing to pay for these 'global' services.

Other environmental services are beneficial at local or regional scales, so beneficiaries could perhaps be identified and charged. For example, reduction in sedimentation will prevent damage to reservoirs and waterways and benefit specific communities who use this water.

The next requirement will be to establish the infrastructure needed for a 'market' in environmental services to develop, and to minimize transaction costs, e.g. the costs of identifying potential buyers, negotiating and enforcing contracts, monitoring and quantifying environmental services in order to set 'prices'. If transaction costs are high, livestock herders will receive a smaller share of any funds collected through PES schemes.

If it is hard to identify who will pay, it is equally hard to identify who will receive PES payments. Most rangelands in CWANA are owned jointly by the community; and some are completely open-access, shared by several communities. Some users traditionally have more rights than others (e.g. residents vs seasonal migrants).

So how will PES payments be shared? First, effective mechanisms must be established for identifying current rights holders, to make sure poor and marginalized groups do not lose their pre-existing rights. These mechanisms must be developed keeping in mind possible changes in property rights systems, which are being discussed in several countries. Also, ways must be found to identify and enforce the responsibilities of each group of users, to manage the ecosystem sustainably.

Collective community action

To develop a PES framework, we need to understand what factors affect capacity at the local level to provide environmental services. Both individual and community are important. Capacity will depend on

Who benefits? Well managed rangelands provide a range of services at different scales.

Scale	Environmental services supplied	Benefits	Beneficiaries/users
GLOBAL	Carbon sequestration	Mitigates global climate change	International community, countries, private firms
GLOBAL	Plant and animal biodiversity	Healthier resources for future generations	Conservation groups, tourism industry, private firms
GLOBAL / NATIONAL	Reduction in dust storms	Improved health, lower maintenance costs for infrastructure and industry, less damage to farming systems	Tourism industry, urban populations, governments
NATIONAL / LOCAL	Aquifer recharge	Increased water availability	Water users
NATIONAL / LOCAL	Flood reduction	Less damage to infrastructure	State (public infrastructure), utility companies, downstream population
LOCAL	Increased water productivity Decrease in soil degradation Increase in plant biomass	Higher livestock productivity	Local herders

the individual's incentive to preserve or rehabilitate rangelands, as well as the community's ability to organize the supply of environmental services and enforce management/rehabilitation plans. Individual incentives will in turn depend on the technical options chosen. It is, therefore, crucial to make a proper economic analysis of the technologies and management options available.

PES planners must also consider how heterogeneity among rangeland users will affect individuals' incentives to comply with conservation/management programs. Rangeland users are usually a heterogeneous group, differing in terms of what rangeland products they rely on (forage, fuel wood, medicinal herbs), exploitation levels (herd sizes), degree of access and use, or total wealth (additional sources of income). Different types of users will obtain different benefits, so negotiating costs amongst them – and costs of collective action for implementing the program – will probably be high. The costs/benefits to an individual will determine whether the individual will participate; and will also affect the costs of monitoring and enforcement that the group as a whole will have to bear.

Will PES work?

Most rangelands in CWANA are affected by desertification, but solutions are not easy, for two reasons. First, most rangelands are communally owned, not private, and this raises a host of social, legal and economic issues. Second, this is a dry region, so many of the rangeland management options available in favorable areas are ruled out. This makes it all the more important to identify and evaluate alternative management and institutional options.

PES could be viable, provided it is carefully planned and implemented. ICARDA plans to develop a series of pilot sites in West Asia and North Africa, for more detailed studies on different approaches to rangeland management (including PES), and particularly on the institutional issues related to the provision of environmental services.

Poor pastoral communities contribute to rangeland degradation – but are also its first victims.

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New Technologies for Central Asia

No-tillage direct drill equipment plants legumes on wheat stubble, leaving most of the straw on the soil surface.

Traditional cropping systems in Central Asia produced bumper harvests – at the cost of long-term degradation. New technologies offer a combination of higher returns and healthier land.

Mekhlis Suleimenov, Mustafa Pala, Raj Paroda, Kanat Akshalov, Firuza Khasanova, Luidmila Martynova, and Rakhim Medeubaev

Central Asia was once part of the Soviet grain machine, producing food crops efficiently in huge quantities. But decades of monoculture and deep tillage have led to severe land degradation and loss of soil fertility. The impacts are being felt in every country in the region.

In 2004 ICARDA and its partners launched a research project to arrest land and soil degradation in Central Asia, with funding from the Asian Development Bank. The partners include CGIAR centers, governments, and national institutions. The project focuses on two areas – conservation tillage and crop diversification. Two years into the project, the impacts are already becoming evident.

To till or not to till?

Conventional tillage is the process of turning over the soil with a plow, to increase aeration and water infiltration, improve texture, and control weeds. In principle, that's good. But in practice, the disadvantages of heavy and/or frequent tillage often outweigh the benefits. A better option is conservation tillage – a more environment-friendly approach that can reduce costs and slow down land degradation, without sacrificing yield.

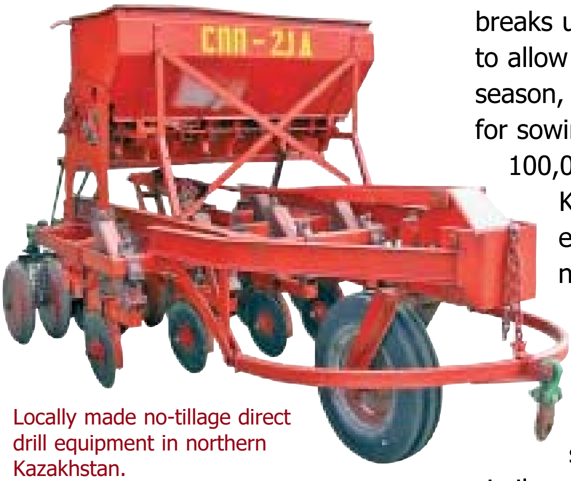
Plowing in Central Asia (and most parts of the world) is usually done with a moldboard plow, which overturns the soil, burying organic matter from the previous harvest and bringing fresh soil to the surface. It was originally designed for 'sod busting' when bringing new land under agriculture. But when used on previously tilled land, the benefits are limited; and regular heavy tillage can cause soil damage.

One alternative is zero tillage – crops can be successfully grown for several years with no tillage at all, but this requires large investments in equipment and herbicides. Instead, ICARDA promotes **conservation tillage**, which is more suitable for resource-poor small-scale farmers. The aim is to reduce the number of tillage operations to the minimum needed to maintain yield; and to leave organic matter (e.g. crop residue) on the soil surface instead of burying it. Conservation tillage saves time, effort and tractor diesel, reduces erosion (because the soil surface is not left bare), and also prevents long-term damage to soil structure.

Different systems, different solutions

Central Asia consists of three climatic zones: the icy northern steppes of Kazakhstan, the somewhat warmer foothills (Kazakhstan and Kyrgyzstan), and the southern region comprising Uzbekistan, Tajikistan and Turkmenistan, with long hot summers. The farming systems are correspondingly different. Agriculture in the northern steppes is based on rainfed spring wheat. The middle region has a mixture of rainfed and irrigated agriculture and grows winter wheat. The south produces mainly cotton and wheat under irrigation.

The project aims to promote conservation agriculture in all three regions, by developing and testing solutions tailored to each zone.



Locally made no-tillage direct drill equipment in northern Kazakhstan.

In **spring wheat** systems, field experiments have shown that tillage can be greatly reduced without reducing grain yield; but continuous zero-tillage is bad for heavy textured soils. The key question is the soil's permeability to water during the planting season in early spring. Because the soil is generally frozen at this time, snowmelt water runs off the surface unless the soil is broken up by tillage, allowing water to penetrate. The project has introduced "zero-tillage planters", which are actually a form of minimum tillage, where the mechanized planter breaks up the surface sufficiently to allow water penetration. Last season, these planters were used for sowing spring wheat on about 100,000 hectares in northern Kazakhstan, and more farmers are keen to acquire the new equipment.

Demonstration plot showing alternatives to monocropping: more diverse, productive, and sustainable.

In **rainfed winter wheat** systems, the project has shown that conservation tillage produces similar yields to moldboard plowing, at the same depth. We tested a conservation tillage system in southern Kazakhstan for four years: zero tillage at planting and minimal tillage in the off-season, for mulching and leveling. The results showed how complex the problem can be. Yields actually fell in low-rainfall areas, because reduction in tillage led to more soil compaction, reduced availability of nitrates, and more weeds. However, the yield loss was partly compensated by savings in labor and fuel. In areas with higher rainfall, conservation tillage increased yields, and adoption is growing.

In **irrigated cotton-wheat** systems, experiments showed that replacement of moldboard plowing with minimum tillage reduced cotton yields, but not wheat yields. So we developed and tested a modified system – use the moldboard plow for cotton, as before; later, use minimum tillage for wheat, i.e. broadcast wheat seeds (without tillage) into standing cotton, and bury the seeds during the tillage operation normally done to control weeds in the cotton crop. Thus, the extent of tillage is reduced, but not eliminated. This practice has been adopted very widely. It is popular with farmers in 50-60% of wheat areas in Uzbekistan and Tajikistan, and 20% in Turkmenistan.

The project is also introducing another innovation into cotton-wheat systems, where plants are grown on raised beds. Because the beds do not cover the entire field, less seed is needed – but raised beds improve yield, so the harvest is the same as before. On-farm tests in southern Kazakhstan and Azerbaijan show that raised beds give a slight increase in output, while cutting seed requirements by half, and water consumption by 30%.

The problem is that these technologies require **mechanized equipment**, which is not locally available. The project is working with Indian manufacturers of raised-bed planters, to develop a modified version that will be manufactured in Kazakhstan. Similarly, no-till planters from India and Brazil were tested in Kazakhstan, Uzbekistan and Tajikistan, and can be used for planting winter wheat as well as cotton and double crops.

In Uzbekistan the project tested new conservation tillage equipment specially designed to plant wheat on cotton fields. The machinery can perform several tillage operations in one run: uprooting cotton plants after harvest, chopping them up and spreading the pieces on the soil surface, sowing wheat seeds, and cutting irrigation furrows. Initial results are highly promising.

In summary, conservation tillage is recommended for every region in Central Asia; but efficiency and cost-effectiveness will depend on soil conditions, rainfall, temperatures, and crops grown. By tailoring solutions to each farming system, the project is helping farmers maximize yield without destroying their soils.

Simultaneously, the project is also looking at ways to increase the efficiency of conservation tillage, for example by applying optimum fertilizer and plant protection chemicals in small quantities.

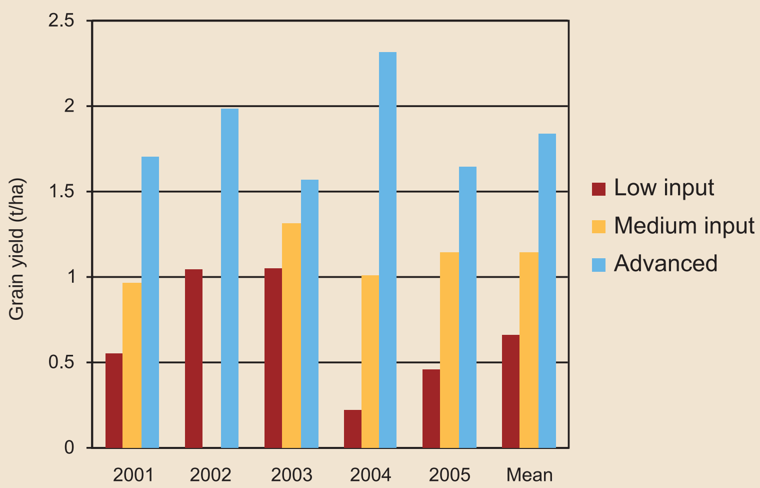
Crop diversification for sustainable farming

Traditional cropping systems have developed over many years to suit local conditions and minimize climate risk. However, new crops can offer substantially better returns without increasing risk. ICARDA and its partners are promoting new crop options in each of the three zones in Central Asia.

In the **spring wheat** systems of northern Kazakhstan, the project is testing new technologies that could double or triple farmers' incomes. Traditionally, wheat and/or barley is planted in spring (second half of May) and harvested in September. Every three to five years, the land is left fallow for almost 2 years; typically 21 months, September to May. The project is testing a more profitable alternative: Rotate wheat/ barley with other crops such as small grains (oats, millet, buckwheat), food legumes (dry pea, chickpea, lentil), and oilseeds (sunflower, rapeseed, mustard). Equally important, instead of leaving land fallow in summer, grow legumes – an extra crop that also increases soil fertility.

The project studied various options for summer cropping. Chickpea and dry pea gave particularly good results; both are adapted to local conditions, rich in protein, and could become valuable cash crops. A crop management package was developed and tested, and proved to be highly effective (Fig. 1).

Figure 1. Chickpea yields in Shortandy, Kazakhstan



Low input: no fertilizers or chemicals
Medium input: common agronomic practices for tillage and snow management, use of phosphorus fertilizer and some herbicide
Advanced: more intensive snow management, application of Nitrogen in addition to Phosphorus, better chemical weed control

Chickpea is a new crop and adoption is still limited; with some government support to establish markets, it could take off.

Oilseeds, also being promoted by the project, are taking hold. Sunflower area is increasing, because an internal market is available and prices are good. The Kazakhstan government also plans to promote rapeseed production on a large scale (about 160,000 hectares in 2006) and provide subsidies to producers and processing industries for the next three years.

In the **winter wheat** zone, farmers are gradually shifting away from wheat to safflower in rainfed areas and soybean and common bean in irrigated areas. Safflower is an excellent cash crop. Adoption is growing not only in southern Kazakhstan and Kyrgyzstan but also in the drylands of Uzbekistan; the size and speed of this expansion generally depends on government policies. In Kazakhstan the government began aggressively promoting soybean cultivation in 2003; area has increased almost nine-fold in the past three years (currently 43,000 hectares). Soybean and common bean production is also increasing in Kyrgyzstan.

Another new crop is alfalfa. Long-term trials in southern Kazakhstan showed that alfalfa could be adopted on a large scale in semi-arid conditions to improve land productivity, economic efficiency, and sustainability; the main constraint is lack of seed and seed production equipment.

Conservation tillage in northern Kazakhstan, leaving residues on the soil surface

Finally, the irrigated **cotton-wheat** system in the southern zone. Land availability is limited; so double cropping is probably the best option to introduce new crops. Several crops have done well in field trials in all three countries: food legumes, mung bean, soybean, common bean, maize, sesame, groundnut, and melons. However, governments in these countries do not promote widespread adoption of double cropping because of competition with cotton for water. Double cropping (sugar beet and rice) is being promoted only in Turkmenistan.

New systems

New crops and modified cropping systems offer a range of benefits – higher incomes, better nutrition, less degradation, and a healthier farming system. Low-cost technologies are available, and have been tested on a pilot scale. But to scale them out, specific constraints must first be resolved. In some cases the problem is lack of seed, equipment, or funds. But more often it is lack of policy support. Development agencies must work with government policy makers to ensure that systems diversification and conservation agriculture are given the emphasis they deserve.

Sunflower cultivation is growing rapidly, thanks to strong domestic markets and good prices.

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Restoring Soil Fertility in Dry Areas

Hanadi El Dessougi

Soil fertility decline is a major problem in dry areas worldwide. But it can be tackled, provided researchers work together with farmers and other stakeholders.

Over one-third of the world's land area is classified as 'dry'. These regions are characterized by severe water shortages and extreme hot and cold temperatures. The soils are shallow, alkaline and often stony, with inherently low fertility, poor nutrient and organic matter content, and low water-holding capacity. Dry areas are an important part of the global ecosystem, home to one-third of the world's population – and highly vulnerable to desertification. Clearly, it is imperative to improve the productivity and sustainability of agriculture in these areas – which in turn means improving soil fertility.

Studied, published… but used?

We know a great deal about how to use fertilizers and legumes to enhance soil fertility in dry areas. Published studies cover various aspects – timing and amount of fertilizers, application methods, crop responses, effects of crop rotations, dryland fallowing, and water-use efficiency. But many of these technologies remain on the shelf. Technologies that require capital investments, or were developed without farmer involvement, have limited potential for adoption. This is largely because farmers have to cope with specific micro-ecological or socio-economic conditions that were not factored into the research.

Scientific recommendations that work in one area may not work in another. To ensure adoption and practical applicability of new soil fertility technologies, farmers must be fully involved, and research must build on farmer experimentation.

This farmer-participatory approach has many advantages. First, technologies developed this way are more likely to spread, because adoption is farmer-led.

Second, the approach allows researchers to incorporate indigenous knowledge when they make recommendations or design technologies to cope with adverse (and highly variable) environmental conditions. Third, it recognizes that for poor farmers, avoiding risk is as important as increasing output. For example, they may choose not to buy fertilizer, preferring less risky options (e.g. crop rotations) to maintain fertility.

Finally, farmer participation helps researchers characterize the bio-physical, socio-economic and political environment. This is a basic prerequisite for analyzing land use systems, understanding their history and impact on soil fertility, and finding practical solutions that farmers will adopt.

Not just soil, but the system

The main concern for soil fertility researchers: how to increase output and quality of food production without damaging the environment or disrupting the supply of ecosystem services? Research that focuses narrowly on soil health without considering soil as one part of a large complex system, is unlikely to meet these objectives. Hence the concept of integrated soil management, which looks at the entire continuum of soil, pest and crop management. For example, good soil management will include manipulation of a range of physicochemical and biological soil processes, which in turn influence hydrological flows and water storage, gaseous exchange, carbon sequestration, regulation of nutrient cycles, biological pest control, and microbial biodiversity.

Organic resources

The health of an ecosystem often depends on how much organic matter the soil contains. Soil organic matter represents a large fraction of the soil's fertility. It also forms and maintains soil structure, thus facilitating aeration, nutrient storage and uptake, plant growth, and erosion control. Organic matter is lost through decomposition, but this can be compensated by adding organic inputs. However, some important research questions remain unanswered, for dryland conditions. How does the cropping system influence the quality and quantity of organic matter; what amounts and types of organic inputs are required in different soils; how does synthesis and decomposition occur?

The community is involved at all stages, from planning through dissemination of results.

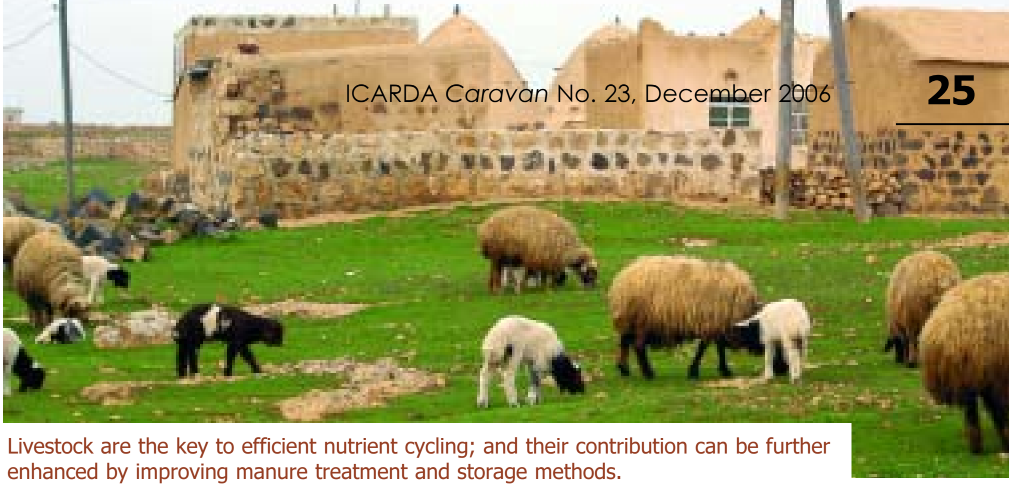
Resource maps, drawn by farmers, are the starting point for designing interventions.

Nutrient cycling

Most dryland farmers keep livestock, as part of an integrated system: livestock feed on crop residues and native vegetation, and return nutrients to the soil in the form of manure. The research question is, how to improve this system; for example, what crop/animal husbandry practices will maximize nutrient recycling?

Nutrient recycling can also be improved by better resource management, to maximize nutrient recovery and uptake and use inputs more efficiently. Low-cost organic inputs (e.g. compost made from household waste) can improve soil properties and restock nutrients. Planting crops with differing root architecture, or the ability to solubilize specific nutrients, will increase the efficiency of nutrient capture. Incorporating crop residues into the soil, or planting fields with green manure crops instead of leaving them fallow, can also improve nutrient cycling.

These methods should go hand in hand with research to understand the chemical and biological



Livestock are the key to efficient nutrient cycling; and their contribution can be further enhanced by improving manure treatment and storage methods.

processes governing nutrient flows, and develop practical management methods to enhance these processes. Such knowledge for drylands is very scarce.

Water management is equally important. In many dry areas, water scarcity, rather than soil fertility, is the most important factor limiting nutrient availability. Hence the need to use water more efficiently, for example by harvesting rainwater, recycling wastewater etc.

Soil micro-organisms

The integrity and productivity of any ecosystem depends on micro-organisms, which are responsible for many key processes: decomposition; nutrient acquisition, storage and cycling; soil organic matter synthesis and mineralization; modification of soil structure; and regulation of atmospheric composition. Some soil micro-organisms also produce bioherbicides that control parasitic weeds and soilborne pests and diseases. Choosing appropriate crops and fallow systems, and managing residues, can help build up and maintain micro-organism populations, and thus increase crop yields and soil fertility.

Researchers must quantify the role of micro-organisms in dryland agriculture; and develop management strategies to optimize the quantity and quality of organic inputs so as to create conditions favorable for beneficial micro-organisms.

Managing rangelands

Rangelands are the single largest component of dryland areas, and the most important resource for livelihoods. But vast rangeland areas suffer from poor soil fertility, and varying levels of degradation. As a result of misuse and overgrazing, severe cutting of trees and removal of vegetation, valuable species are dying out and being replaced by less valuable species unpalatable to livestock.

Simultaneously, lack of property rights leaves individuals and communities with no motivation to conserve rangelands, and hinders the development of efficient management strategies to conserve and regenerate them. Numerous measures are available: reseeding, water harvesting, increasing water use efficiency, enhancing soil fertility, policy reform on land tenure. The challenge is to implement some or all of these measures in poor dryland communities.

Solutions that work

How to arrest the decline in soil fertility and prevent further degradation of dryland soil systems? This will require integrated management approaches that make efficient use of all available resources, and do not make excessive demands on household resources, e.g. large-scale application of expensive fertilizer.

Instead, solutions must focus on nutrient cycling and efficient use of water and nutrients. They should seek to manipulate soil biological processes for farmers' benefit – by designing more efficient agro-ecosystems, improving the quality of organic resources and soil microflora, and encouraging crop diversification, crop-livestock integration and tree production. Research must provide an understanding of nutrient fluxes and cycling under water-scarcity conditions, and of interactions between soil fertility, pests and diseases. Ultimately, research must lead to policies that motivate farmers and pastoralists to conserve natural resources.

These solutions must be developed by all stakeholders working together. In particular, they should build on indigenous knowledge, and the innovations and experiences of farmers, who are the best managers of their soils.

Field experiments help link modern science with farmers' perceptions and practices on fertility management.

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Focus

A Framework for Integrated Natural Resources Management

More inclusive, more relevant, more likely to succeed… The concept of Integrated Natural Resources Management is changing traditional thinking, and dramatically increasing success rates in development interventions.

Richard J. Thomas

In many dry areas, current water extraction rates far exceed sustainable levels.

Degradation of natural resources is now recognized as a major global development issue, not just an environmental problem. The challenge is how to manage and conserve the resource base (land, water, biodiversity) while simultaneously improving the livelihoods of the poor. To make progress, we must address these problems using a multi-sectoral, cross-disciplinary approach. This is the only way to avoid piecemeal solutions that have failed in the past.

Since 1998, ICARDA has been developing a more holistic approach to natural resources management, and working with other CGIAR centers to develop a conceptual and operational framework for Integrated Natural Resources Management (INRM). This is a broader perspective, and takes full account of interactions and synergies between biological processes, government policies, and economic and cultural factors. It breaks down disciplinary barriers. Soil scientists who measured nutrient levels, and economists who measured household incomes, now work together more closely; and this integration provides a better understanding of a large and complex system.

INRM is "a conscious process of incorporating the multiple aspects of natural resource use into a system of sustainable management to meet the production goals of farmers and other direct users (food security, profitability, risk aversion) as well as the goals of the wider community (poverty alleviation, welfare of future generations, environmental conservation)".

The goal is to improve livelihoods, system resilience, system productivity, and environmental services. We aim to reach this goal via a three-step process. First, decide what type of science to do where: what *don't* we know, which geographical areas are most vulnerable. Then commit ourselves to a learning approach: establish a system for researchers and their partners to adapt and learn.

Finally, and most difficult, re-organize the research system (even the way researchers think about management of natural resources) to effectively address development problems. This could include new incentive systems to encourage cross-disciplinary work; better management of information, both modern and indigenous; wider use of information and communication technologies – such as farmers using cell phones for marketing. These three steps could be in sequence, but more often proceed in parallel.

Flash floods are common in many dry areas, and cause severe and rapid erosion.

The learning approach

Individual and social learning is key, particularly in complex multi-actor systems. Researchers need to be more involved in solving 'real' problems and become a part of the social learning process. The community must learn too, participating fully at every stage from problem identification to testing solutions and monitoring results. Research and development must move closer to each other, eventually becoming indistinguishable.

The intervention must aim to improve the capacity of the system (land, people, natural resources) to ensure a flow of products and environmental services. To do this, we must provide land users with tools and methods to increase their capacity to adapt to changing conditions. Monitoring and evaluation must be done at the local level using simple, cheap tools. This will enable the community to see what is happening to their environment and allow them to take remedial and preventive actions.

Management of grazing areas is a key part of INRM.

No simple answers

NRM problems are complex. Often there is no single correct answer, but a range of options, each suited to the aspirations of a different group, and which sometimes may be in conflict. Therefore, the emphasis is on co-management with compromises, and on balancing "hard" versus "soft" science, i.e. the contrasting approaches of, say, plant breeders and sociologists. All this requires considerable analysis of biophysical processes as well as institutional and organizational issues at various levels: government policy, local customs, presence or absence of farmer groups and social networks, availability of credit.

To make sense of this complexity, we need to use a systems approach that takes various factors into account. But we also need to identify the main driving factors, which are usually only 3 to 5. This will require new forms of integrative science using modern tools such as simulation models and geographic information systems, to spatially characterize and visualize problems.

The INRM framework

To move INRM from concept to practice, an operational framework was built. Hundreds of experts were asked to identify, in hindsight, exactly why their previous NRM projects had succeeded or failed. Their answers helped develop the framework, which identifies 11 cornerstones, or prerequisites for success (see box), grouped under three broad categories:

Working together
Build effective partnerships around a shared vision. Form cross-disciplinary teams that will identify the

Focus

main driving variables or key limiting factors. Ensure that team leaders have the special skills (facilitation, negotiation) needed to hold a diverse team together.

Establishing an institutional and organizational framework
'Mainstream' the issue of land degradation – ensure it gets the attention it deserves, from the local community, from administrators, and from national policy makers. Mobilize communities and local organizations to develop their own solutions, and to get their opinions heard.

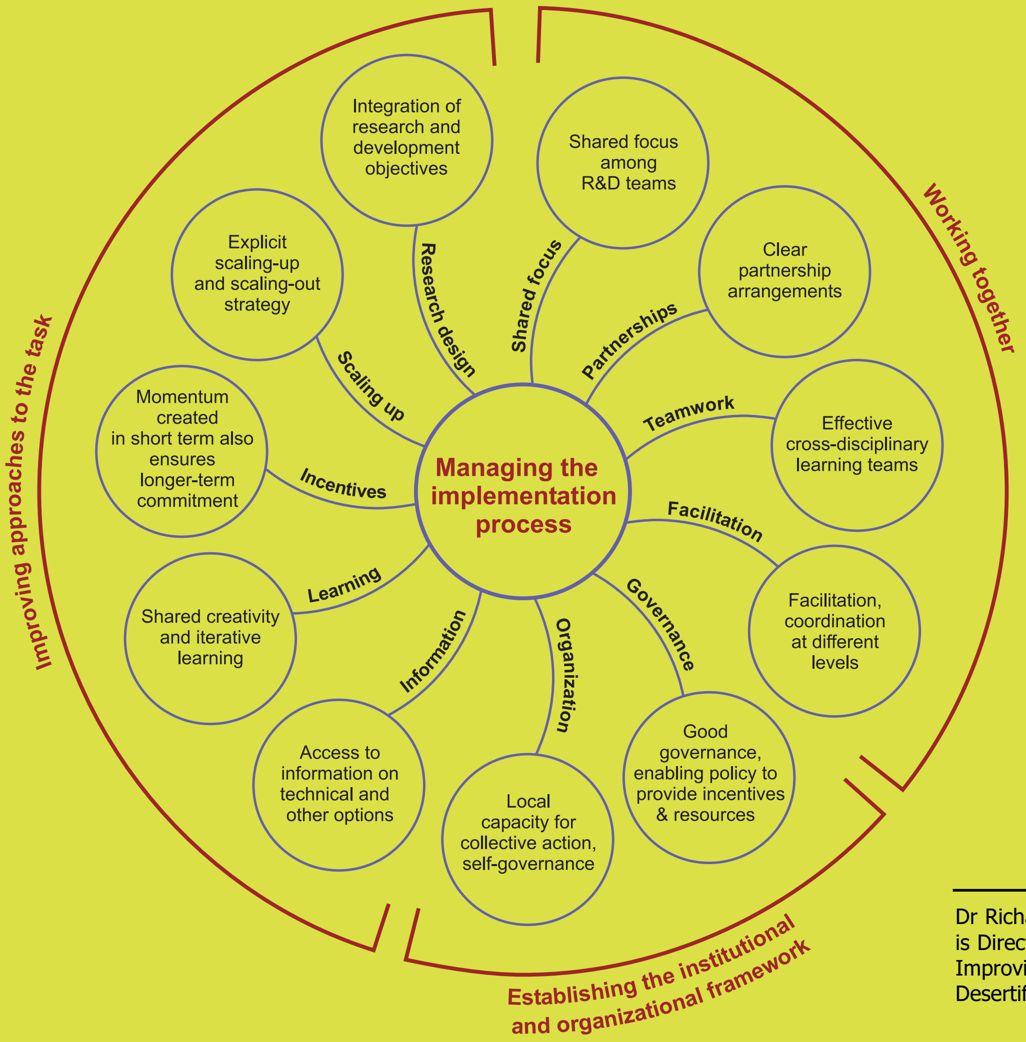
Improving approaches to the task
Learn by doing. The key is an iterative learning, monitoring and evaluation process that involves all the main actors. Ensure that information on technical, institutional, market and policy options is available, so that interventions are better designed and targeted, and yield quicker results.

Scaling out

ICARDA has been implementing the INRM approach to combat land degradation in the marginal drylands of West Asia and North Africa. Our objective was not simply to study degradation, but to establish institutional and policy mechanisms to improve dryland management.

In Syria's Khanasser Valley, a multi-disciplinary team of over 20 scientists works with communities, government extension officers and NGOs. A range of nine technology options have been tested with land users. Simultaneously, we analyzed institutional and policy options suitable for Syria's marginal drylands. The findings were presented to government departments.

The project is currently being scaled out with national programs in Morocco and Iran. Building on past experience, we are identifying appropriate technologies and institutional and policy options, quantifying trade-offs, and building national/ community capacity to ensure that skills as well as institutional structures are in place to disseminate, absorb, and effectively use the new options.



The cornerstones of INRM

This framework of 11 cornerstones is a useful guideline for designing INRM projects. In a given system or intervention, it can help identify which specific area or cornerstone needs strengthening. It can help reduce the complexity of the system under study, identify gaps in knowledge, identify project partners and their roles, and provide a check-list for monitoring progress.

This framework does not provide instant recipe-type solutions to NRM problems; but it does provide a starting point. INRM projects can begin by devising their own teams, elements and strategies, using the cornerstones as checklists, and putting in a strong monitoring and evaluation system.

Dr Richard Thomas (r.thomas@cgiar.org) is Director of ICARDA's Megaproject on Improving Land Management to Combat Desertification.

Mapping Desertification for Decision Makers

Geographic information systems can help policy makers design and target interventions, by converting a confusing mass of data into formats that clearly identify problems and potential solutions.

Eddy De Pauw

Different countries (even different parts of the same country) use different methods to collect, analyze and report data on land degradation. This makes it hard for development planners and policy makers – but perhaps researchers can help.

How to bring together diverse and multi-thematic information in such a way that it can be used by policy makers for policy and management interventions in *specific* areas with *specific* degradation problems? The answer: use of Geographic Information Systems, or GIS.

Planners and decision-makers are not particularly fond of thematic 'pixel' maps, which they find difficult to interpret and combine for practical use. Instead, they want maps with a limited number of cartographic units, in which specific problems and potentials are clearly stated, so recommendations for action can be formulated.

To address this need, ICARDA's GIS Unit has been developing the concept of '**agricultural regions**'. These are integrated spatial units in which available water resources, climate, terrain, and soil conditions combine to create unique environments, which are associated with distinct farming systems and land use and settlement patterns. Agricultural regions are therefore holistic spatial entities with their own 'personalities'. Unlike thematic maps, they are real, not artificial constructs.

Agricultural regions can be characterized and quantified in terms of any biophysical or socioeconomic factor that has a spatial dimension. Within this spatial framework, desertification features can easily be accommodated as database elements. To test the feasibility of the concept, we mapped the agricultural regions of Syria using a combination of remote sensing and expert knowledge: satellite maps, interpreted by experienced field researchers. The boundaries between adjacent mapping units were delineated by visual interpretation of

Focus

Table 1. Sample extract from the attribute table for the agricultural regions of the limestone hills in north-west Syria

Agricultural region	Severity of land degradation							
	WAT	WIN	SAL	LOG	GWT	FOR	RAN	SOI
With 'red soils' and olive-based cropping systems	Moderate	None	None	None	Severe	Moderate	None	Moderate
With 'white soils' and olive-based cropping systems	Severe	None	None	None	Severe	Moderate	Moderate	Severe
Afrin Valley and sedimentary plains	Light	None	Moderate	Light	Moderate	None	Light	Light

WAT: water erosion, WIN: wind erosion, SAL: salinization, LOG: waterlogging, GWT: lowering of the groundwater table, FOR: forest degradation, RAN: rangeland degradation, SOI: soil fertility decline

recent satellite imagery, plus secondary information including geological, soil, landform, and climate maps. Figure 1 shows the results: a provisional map of Syria's agricultural regions. The limited number of mapping units (27 in this case) is typical of this kind of synthesis map. The legend consists of 'labels' to which large attribute tables can be attached, including those related to desertification.

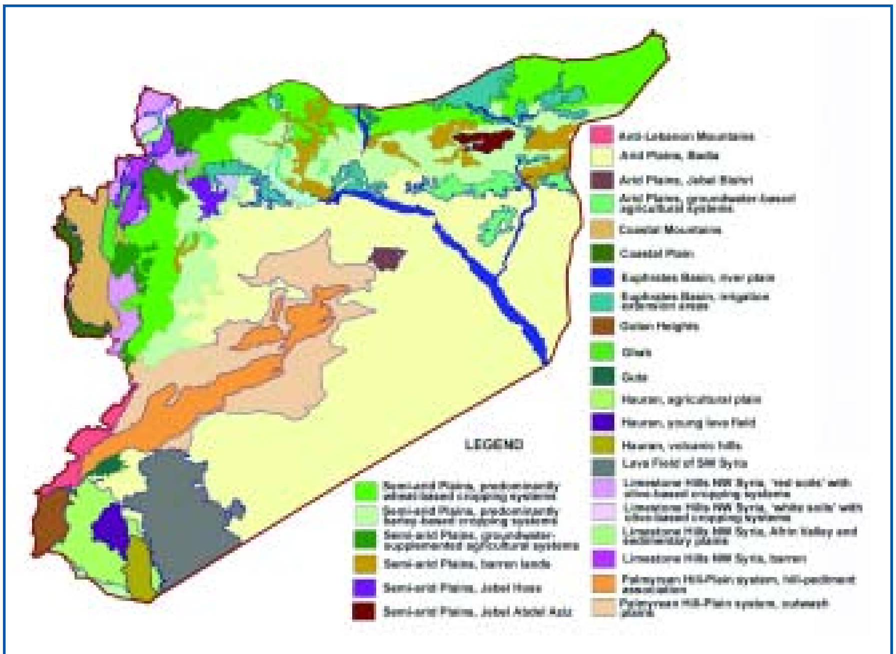
An example of part of the attribute table, related to desertification, is shown in Table 1.

The next step was to develop a similar spatial framework for the whole of Central and West Asia and North Africa. Obviously, the same approach (manual interpretation of remote sensing data, with validation by experts) was impossible for this huge area. Instead, we developed a 'proxy' method based on the overlay capabilities of GIS. Four spatial themes were combined: climate, soils, landforms, and land use systems.

The overlaying process may seem simple – the GIS software does it automatically – but it is actually fairly tricky. The data layers selected for overlaying need to match each other in resolution. Otherwise, if you combine layers with very different patterns of spatial variability, you might end up with many new mapping units that have no basis in reality. To avoid this, appropriate classifications had to be developed. And after overlaying, several 'cleaning' procedures were necessary to remove 'spurious' units.

After all these steps, we still ended up with 677 agricultural regions. This is both good and bad news. The good news is that complex dryland environments can be represented in a realistic way by combining a carefully selected (but limited) set of biophysical data layers. The bad news – at least for desertification researchers – is that there are many dryland environments and, therefore, the task of outscaling research from benchmark sites will be more difficult, and take much longer, than we had imagined.

Figure 1. Provisional map of agricultural regions in Syria



Dr Eddy De Pauw (e.de-pauw@cgiar.org) heads the GIS Unit at ICARDA, providing technical support to scientists from various disciplines.

Investors in ICARDA, 2006 (in descending order of investment amount)

1. USA
2. United Kingdom
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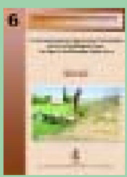
11. Switzerland
12. Syria
13. Sweden
14. Germany
15. The Netherlands
16. Japan
17. Denmark
18. FAO
19. Morocco
20. Gulf Cooperation Council
21. Belgium
22. Turkey
23. Asian Development Bank
24. Pakistan
25. France
26. IDRC
27. Iran
28. Austria
29. Global Crop Diversity Trust
30. Egypt
31. UNCCD
32. India
33. Mauritania
34. UNESCO
35. UNEP
36. OPEC Fund
37. South Africa
38. China
39. Korea
40. Ethiopia

New publications

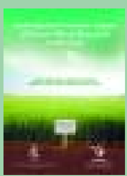
Technical guidelines for quality seed production. 2005. Z. Bishaw, A.A. Niane, and A.J.G. van Gastel. 23pp. ISBN 92-9127-181-1.

This manual aims to assist farmers involved in village-based seed enterprises. It describes the various steps in seed production, from site selection, land preparation and isolation distances, to production and plant protection methods, use of inputs, harvest and post-harvest procedures, quality criteria, and seed testing.
Price: US$10.



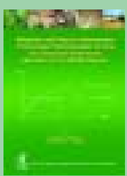
Ex ante assessment of agricultural technologies for use in dry marginal areas: the case of the Khanasser Valley, Syria. 2005. R. La Rovere and A. Aw-Hassan. viii + 102pp. ISBN 92-9127-175-7.

This publication analyzes a number of technological innovations for resolving poverty and ecological problems in the Khanasser Valley in Syria. It examines the determinants and implications of adoption differences between different groups of farmers, to draw lessons for marginal agricultural areas elsewhere.
Price: US$10.



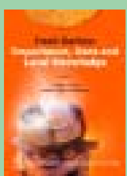
Assessing the economic impact of durum wheat research in Morocco. 2005. A. Belaid, N. Nsarellah, A. Laamari, M. Nachit, and A. Amri. 50pp. ISBN 92-9127-168-1.

This publication assesses the impact in Morocco of a regional durum wheat program. It provides an overview of durum production and research, and highlights the importance of efficient seed delivery systems to encourage farmers to adopt new varieties.
Price: US$10.



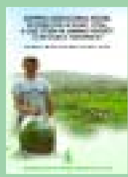
Adoption and impact assessment of improved technologies in crop and livestock production systems in the WANA region. 2005. K.H. Shideed and M. El Mourid (eds). viii + 160pp. ISBN 92-9127-180-3.

The Mashreq/Maghreb project aims to improve integrated crop-livestock production systems in low-rainfall areas in West Asia and North Africa. This publication documents the adoption and impact of new technologies developed and disseminated under the project, and the constraints to adoption.
Price: US$10.



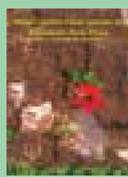
Food barley: importance, uses and local knowledge. 2005. S. Grando and H. Gomez Macpherson (eds). x + 156pp. ISBN 92-9127-173-0.

This publication contains presentations made at an international workshop on food barley improvement held in Tunisia in 2002. It highlights experiences from 14 countries, including a review of food barley-based farming systems, production constraints, research efforts and needs, and quality and other characteristics of major cultivated varieties.
Price US$35



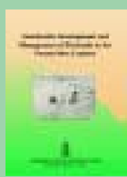
Mapping agricultural income distribution in rural Syria: a case study in linking poverty to resource endowment. 2005. J.A. Szonyi, E. De Pauw, A. Aw-Hassan, R. La Rovere, and B. Nseir. viii + 48pp. ISBN 92-9127-182-x

This publication outlines a study on poverty mapping using a combination of agricultural statistics and indicators of resource endowment. It analyzes the distribution of agricultural income in relation to various socio-economic factors; and examines population dynamics and the impact of population pressure on resource endowment and irrigation.
Price: US$10.



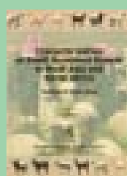
Major native plant species in Khanasser area, Syria (Al-Hass and Shbeith mountains). 2005. M. Al-Oudat, A. Khatib Salkini, and J. Tiedeman. viii + 147pp. ISBN 92-9127-172-4.

This publication describes the major plant species found in the Al-Hass and Shbeith mountains in Syria, and part of the Khanasser Valley adjacent to the mountains. It contains information on 133 native species, including names, common characteristics, taxonomic description, and uses.
Price: US$10.



Sustainable development and management of drylands in the 21st century. Proceedings of the 7th International Conference on the Development of Drylands, 14-17 September 2003, Tehran, Iran. 2005. A. El-Beltagy and M.C. Saxena (eds). xiv + 517pp. ISBN 92-9127-179-x

This publication contains the presentations made at the 7th International Conference on the Development of Drylands, held in Iran in 2003. The papers describe the challenges of sustainable development of dryland areas and ways to strengthen scientific networks to tackle these problems.
Price US$50



Characterization of small ruminant breeds in West Asia and North Africa. Volume 1, West Asia. Volume 2, North Africa. 2005. L. Iniguez (ed). Volume 1: vi + 462pp. ISBN 92-9127-164-9. Volume 2: vi + 196pp, ISBN: 92-9127-177-3.

This two-volume publication catalogs the available genetic variation of small ruminants in West Asia and North Africa, one of the most important centers of domestication. It contains information on 75 sheep and 32 goat breeds; and discusses issues of matching genetic diversity with the production base and market opportunities; identifying useful traits; and combating genetic erosion.
Price US$60 (Vol 1), US$20 (Vol 2).

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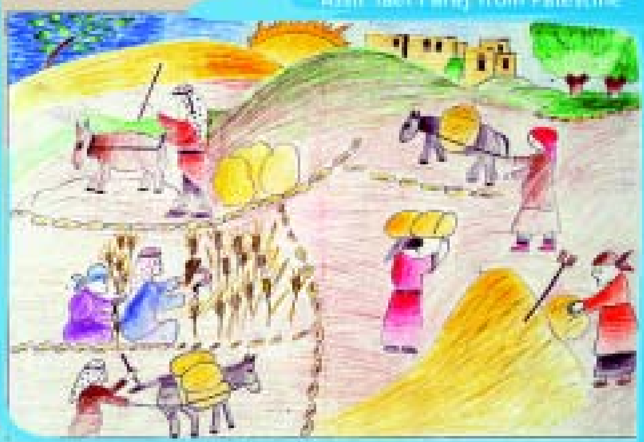


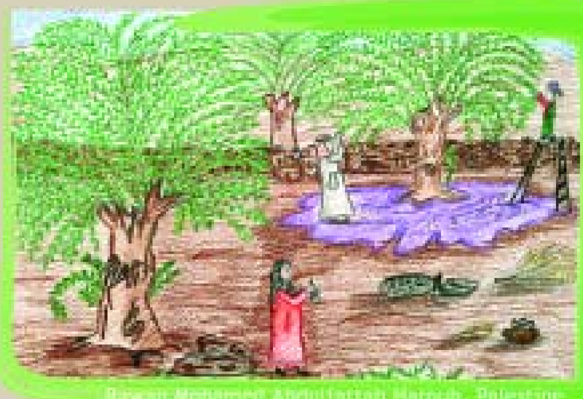
Assil Tael Faraj from Palestine

Yazan Sayjary, Syria

Razan Mohammed Ajlouni from Jordan

Ghanem Yahiya from Lebanon

Zanoubia Ali El Khalil from Syria



Rawan Mohamed Abdullattah Maroub, Palestine

Biodiversity loss will affect future generations – so it is important that children learn about the issues involved. ICARDA's Dryland Agrobiodiversity Project worked with the Ministries of Education in Jordan, Lebanon, Palestine and Syria, to introduce agrobiodiversity into school curricula.

The project helped supplement teaching efforts with lectures, field visits, films and brochures. It also organized a painting contest for children (10-14 years) from the four countries. The paintings clearly showed the huge pool of creative talent, and also the effectiveness of the program in raising awareness.