BENEFITS OF SUSTAINABLE LAND MANAGEMENT

WOCAT
World Overview of Conservation Approaches and Technologies

UNCCD

Foreword

In our era of escalating crisis and economic downturn, where the 2007-2008 food crisis is now a dormant but "forgotten crisis" and where governments are striving to implement bailout policies with little attention to the potentials of land and soils, it is of crucial importance to highlight the "Benefits of Sustainable Land Management" policies.

Desertification, land degradation and drought affect more than 2 billion people and the situation might worsen due to the unsustainable use of soil and water under present scenarios of climate change. The UNCCD 10-year strategy points out the importance of science, knowledge sharing systems and awareness raising to support policymakers in reversing this trend. Sustainable land management practices, including sustainable agriculture, provide important local, regional and global benefits. They also contribute positively to fundamental ecosystem services such as regulating water cycles, sequestering carbon, and helping to preserve agrobiodiversity.

This document aims to highlight local, regional and global benefits of sustainable land management (SLM). I do hope that it will become a helpful tool to improve the knowledge and understanding of policy- and decision-makers about the benefits of SLM in the frameworks of relevant national policy areas.

Luc Gnacadja
Executive Secretary of the UNCCD

Global Facts	Drylands: a special concern
2.6 billion people depend directly on agriculture	1.2 billion people live in areas where physical water is scarce
52% of the land used for agriculture is moderately or severely affected by soil degradation	41% of the Earth's surface area is drylands
4-6 million ha of cultivated land are lost annually due to anthropogenic soil degradation	2.6 billion people (44%) are affected by desertification
Cropland in developing countries decreased from 0.43 ha to 0.26 ha per capita in the period form the 1960s to the 1990s	Population growth was 18.5 % in dryland areas in the 1990s
	The GDP in dryland areas is 50% lower than in non-dryland areas
	Natural regeneration of vegetation cover and soils in arid areas takes 5-10 times longer than in favourable areas with greater and more regular rainfall.

Land use types and their challenges

The main agricultural land use types in dryland areas are cropland, irrigated land, and rangeland. Different land degradation problems occur depending on the type of land use.

Cropland

Total cropland worldwide: 1.5 billion ha
Cropland affected by soil degradation: 38%
55% of the gross value of food is produced under rainfed agriculture. Cropland in dry rainfed areas is used primarily by smallholder farmers to cultivate field and cash crops.

Challenges
- Expansion of cultivated fields and diminishing of natural vegetation cover
- Insufficient amounts of organic material and nutrients
- Burning of organic material (harvest residue, brush fires)
- Soil erosion (wind and water)

Intensive rainfed crop production on sloping land, well conserved by vegetative strips along the contour (Tanzania).

Irrigated land

Total irrigated cropland worldwide: 252 million ha
Irrigated cropland as percentage of total cropland: 20%
Irrigated land affected by salinisation: 20%
Water demand for agricultural production: cereals 1000-1500 l/kg, meat 15,000 l/kg

Irrigation often causes depletion and contamination of surface and groundwater, leading to water conflicts. Irrigated land is often severely affected by salinisation and waterlogging. The main causes of salinisation are inadequate drainage and excessive water application. It is estimated that salinisation costs farmers US$11 billion annually in lost income.

Challenges
- Overuse of water resources
- Inefficient use of water
- Soil erosion
- Salinisation
- Water conflicts

Intensive cultivation based on irrigation of drylands in Cape Verde.

Rangeland

Total rangeland surface worldwide: 3.4 billion ha
Rangeland affected by soil degradation: 73%

The livestock population has increased dramatically in rangeland areas in recent years. Rangeland in arid areas includes tree, bush and grass savannah, steppes in temperate zones, and high pastures. Nomadic pastoralists graze pastures extensively over large areas, whereas sedentary smallholder farmers use pasture land intensively over smaller areas.

Challenges
- Overgrazing, burning and increase in undesirable plants
- Insufficient soil organic carbon
- Soil degradation: erosion, compaction, crusting
- Free grazing, no clear land use rights

Rangelands with boys looking after a mixed herd in Kenya.

Maintaining ecosystem functioning/services is a prerequisite for sustainable land management (SLM). SLM harbours great potential for preservation and enhancement of ecosystem services in all land use systems. Degradation of water, soil and vegetation, as well as gas emissions contributing to climate change, can be limited by SLM practices that simultaneously conserve natural resources and increase yields. The ecosystem services provided through SLM include three different types, namely provisioning services, regulating and supporting services, and cultural/ social services.

PROVISIONING SERVICES

Provision of food, fodder, fibre, fuel and freshwater provision

Percentage of global population without secured access to fresh water	19%
Percentage of global population without secured access to energy supply	30%
Reduction of global yields due to soil degradation and water scarcity	16%
Potential yield increase through SLM practices	30-170%
Potential yield increase by means of carbon sequestration	10-150%
The greatest potential for yield increases is in agriculture systems with low yields of around	1t/ha
Estimated loss of income due to desertification and degradation (US$ billion per year)	
- Rainfed areas	8.2
- Irrigated areas	10.8
- Rangeland	23.3

Long-term productivity is threatened by increasing soil degradation and water scarcity, which is severe enough to reduce global yields. Drought and other extreme climatic events can lead to extreme losses of production that primarily affect smallholder farmers whose livelihood depends to a high degree on subsistence agriculture. Most farming in arid areas is done by smallholder farmers practicing subsistence agriculture. Poverty is widespread. Access to clean drinking water and energy is frequently difficult. An optimised water, nutrient/carbon and biomass cycle is the prerequisite for productivity.

SLM helps to:
- Increase food security, primarily for smallholder farmers
- Provide local energy
- Provide local fresh and clean water
- Increase productivity

REGULATING AND SUPPORTING SERVICES

Healthy soils and good vegetation cover – for water, carbon and biodiversity

Worldwide, 75 billion tonnes of soil matter are lost due to wind and water erosion every year	
Cumulative loss of productivity due to soil degradation during the post-Second World War period	
- Cropland	12.7%
- Rangeland	3.8%
Percentage of yearly burned savannah in Africa	30-50%
Average annual soil formation rate	1 t/ha
Estimates of average annual soil loss through soil erosion on cropland in Africa, South America and Asia	30-40 t/ha
Estimated soil nutrient depletion of agricultural land in Sub-Saharan Africa	22 kg N/ha 2.5 kg P/ha 15 kg K/ha

Soil development and nutrient cycling

Increasingly intensive soil use for cultivation and livestock production, expansion of open fields, and burning of grass and bush savannah are resulting in significant loss of vegetation cover. The effects can be seen in greater runoff and increased soil erosion by wind and water, loss of soil organic carbon, crusting and desiccation of soils, and related declines in groundwater and surface water levels. Soil nutrients are excessively depleted by erosion and leaching.

SLM helps to:
- Mitigate soil degradation
- Increase soil moisture, enabling soil development and functions
- Enhance primary production and nutrient cycling
- Preserve biodiversity at the farm level through agroforestry, intercropping, fallow, and preservation of locally adapted seed

Soil C sequestration

Expansion of cultivated areas, increasingly deeper tillage, and loss of vegetation cover owing to deforestation and overgrazing have led to accelerated loss of soil organic matter. This process is further accelerated by hot brush fires over extensive areas. Large amounts of gases that contribute to climate change, such as CO_2 and methane, are released. The restoration of degraded soils and ecosystems and adoption of recommended land management practices are viable options for reducing CO_2 in the atmosphere. Degraded soils in drylands often have less than 1% of soil organic carbon (SOC), whereas through good land management the SOC can be significantly increased (to 2-3%).

SLM helps to:

- Reconstitute carbon pools in soil and vegetation cover
- Decrease atmospheric CO_2 and global warming

Global carbon (C) pools - in soil organic carbon (SOC) - in living vegetation - atmospheric	 1550 Gt 540-610 Gt 760 Gt
Cumulative historic global C loss in managed ecosystems	55-78 Gt
SOC pool to 1 m depth - average global range - in arid climates	 50-150 t/ha 30 t/ha
Decrease of SOC pools after conversion from natural to agricultural ecosystems	– 60-75%
SOC sequestration through improved land management - annual potential rate in dry and warm regions in humid and cool regions - potential offset of global fossil-fuel emissions by C-sequestration	 50-150 kg C/ha 100-1000 kg C/ha 5-15%

Water regulation

Inappropriate land management can seriously affect water availability and supply by changing the water cycle in drylands. A decrease in the surface cover of biomass and litter dramatically lowers water infiltration in the soil, which results in higher surface runoff. Bare soil also leads to increased evaporation loss from the soil surface. The result is reduced soil moisture and reduced groundwater recharge.The water cycle can be optimised by means of appropriate management.

SLM helps to:

- Preserve soil moisture (for plant production)
- Increase primary production
- Regulate river, lake and groundwater levels
- Regulate water discharge from highland to lowland areas, reducing floods and drying up uf rivers

Global freshwater reserves of which - groundwater - rivers and lakes - soil moisture Total usable freshwater supply (< 1%)	35,000,000 km^3 28% 0.26% 0.05% 200,000 km^3
Global recharge rates Soil water Rivers and lakes Groundwater	 2 weeks – 1 year 2 weeks – 10 years 2 weeks – 10,000 years
Rate of water used in agriculture from water stored in the soil (soil moisture)	80%
Rate of water withdrawals for agriculture	70%
Loss of rainwater in drylands due to runoff and soil evaporation	50-80%
Water use efficiency can be increased by up to	100%

CULTURAL/ SOCIAL SERVICES

Benefits for culture and society

Cultural landscapes embody traditional values, proven knowledge, and experience gained over centuries. Cultural and natural landscapes provide cultural identity.

SLM helps to:

- Keep alive cultural and natural landscapes and protect cultural heritage
- Valorise indigenous knowledge and production methods
- Enhance ecotourism

55 of the World Heritage sites are classified as cultural landscapes so far.
According to UNESCO, cultural landscapes represent the "combined works of nature and of man".
Many cultural and natural landscapes on the UNESCO World Heritage List and in the Ramsar Convention are in dryland areas.

Good SLM practices help to maintain and improve ecosystem services. Selected SLM practices are discussed on the following pages in relation to the three ecosystem services presented above. These practices were chosen to illustrate a specific service, but all of them also offer other services.

Benefits for food, fiber, fuel and fodder production and fresh water provision

Integration of crop and animal production: Co-existence of cultivators and herders in Syria. Photo: Hanspeter Liniger

Small-scale irrigation in the Sahel: Providing high-quality food and recharging groundwater. Photo: Ernst Gabathuler

Rangelands: production of meat, milk and dung. Photo: Hanspeter Liniger

Multi-functional land use: Food, water and energy are necessary to meet basic human needs. Multi-functional land use makes it possible to meet these needs. By contrast with mono-functional land use, which focuses on maximising profits, SLM pursues several goals simultaneously through multi-functional land use. It creates **synergies** that generate added economic and ecological value.

Integration of crop production and livestock production is the core of multi-functional land use. This makes it possible to optimise on-farm and local nutrient and biomass cycles. Fallow land and harvest residue can be used as fodder, and animal dung can be applied as high-quality fertiliser.

Multi-functional land use in different land use systems

Cropland: Production of food and cash crops is a priority. Risks related to climate, pests, and market forces are reduced by diversification of cultural land. Crop rotation, intercropping and agroforestry are promising practices. Thanks to agroforestry and the combination of annual crops, trees and shrubs associated with it, a significant portion of on-farm energy needs can be covered.

Irrigated land: Dryland areas with high potential for groundwater and surface water are used to cultivate crops, fruits and vegetables. In order to recharge groundwater reserves, for instance, ponds are established to collect runoff, from which water infiltrates into the ground. Bushes and trees grow between crops and protect the soil with light shade; they also produce fuel, fodder and biomass that can be used to manufacture organic fertiliser.

Rangeland: Livestock production is the priority. Livestock management reduces risks, while rotation of grazing land ensures that vegetation cover is preserved. Here, too, care is taken to ensure that rainfall infiltrates into the ground and is stored there as long as possible to recharge groundwater rather than being lost as surface runoff. In addition to livestock production, multi-functional rangeland provides wood for construction, fuelwood, wild fruit, and medicinal plants, and also serves as bee pasture.

Homestead enclosure, Argentina

In the region of Mendoza, Argentina, animal dung is accumulated in fenced places where animals are kept during the night for reasons of safety. The animal dung is collected and sold to farmers who produce cash crops on irrigated land. This way, nutrients and 'fertility' are collected on extensive grazing lands and accumulated on intensively used cropland. High crop production can thus be sustained without recourse to expensive mineral fertilisers. However, overuse of the grazing land must be avoided.

Cistern, Tunisia

In the area of Medenine, Tunisia, cisterns are used as reservoirs for storing rainfall and runoff water. A cistern is a hole dug in the ground and lined with a gypsum or concrete coating, in order to avoid vertical and lateral infiltration. Each unit consists of three main parts: the impluvium, the sediment settlement basin, and the storage reservoir. The impluvium is a sloping piece of land delimited by a diversion channel. A small basin in front of the entrance to the cistern allows sedimentation of runoff loads, improving the quality of the stored water and reducing maintenance costs. The runoff water is collected and stored in underground cisterns of various sizes. It is estimated that a tank with a capacity of 35 m^3 can meet the annual water needs of a family and its livestock. The water is used for multiple purposes such as drinking, animal watering and supplemental irrigation.

Grevillea Agroforestry System, Kenya

In the Kiawanja catchment in Kenya, the *Grevillea robusta* tree is used in an agroforestry system. Originally introduced from India to East Africa as a shade tree for tea and coffee estates, *Grevillea robusta* is now more commonly associated with small-scale farming areas. Grevillea is primarily used in combination with annual (maize/beans) and perennial crops (coffee). It is easily propagated and established and is relatively free of pests and diseases. Competition with crops (which is minimal in any case) is reduced, and pruned branches rapidly regrow. Grevillea is a multipurpose tree that meets various needs: it provides fuelwood and timber, serves to form boundaries, and carries ornamental functions. Its leaves provide fodder during severe drought. Simultaneously, it can control raindrop splash, increase organic matter, provide mulching materials to improve ground cover on the farm, reduce wind speed, and encourage nutrient recycling due to its deep rooting. The agroforestry system leads to an increase in wood and fodder production, crop yields, and farm income.

Fencing of livestock at night allows accumulation of nutrients, which are sold as fertiliser for intensive crop production. Photo: Hanspeter Liniger

Water collected in a cistern: the water is used for household and livestock production. Photo: Ouessar M., Tunisia

Agroforestry systems in Eastern and Southern Africa provide a multitude of products on small parcels of land: food, fiber, fodder and fuel. Photo: Christoph Studer

Soil and vegetation cover – for water, carbon and biodiversity

Covering the soil surface with mulch and other materials plays a crucial role in reducing water loss from runoff and evaporation in the semi-arid tropics.

Watering trees during the establishment phase: mulching protects the water and makes it available to trees. Photo: CAMP

Rangelands and heavy grazing pressure show the importance of tree cover in increasing fodder production.

Dryland areas react with particular sensitivity to disturbances in the water and biomass cycles. Regulating and supportive functions are seriously affected by inappropriate management of the soil and the vegetation cover.

Biomass cycle: Soil organic matter has an influence on multiple soil functions such as soil biodiversity, soil fertility, carbon storage, regulation of surface water flows and improved water quality. With good soil cover, production of biomass and organic material as well as the soil organic matter content can be increased. The carbon sequestration capacity of the soil has been significantly impaired by expansion of cultivation, intensification of agriculture, overexploitation and degradation of vegetation cover, and fire. C sequestration in soils can make a significant contribution to CO_2 reduction in the atmosphere.

Water cycle: Reduction of soil cover (plants, litter and mulch) and of soil organic matter must be recognised as the starting point in a vicious degradation spiral due to a drastic disturbance of the water cycle. As the soil is no longer protected against erratic and often intense rainfall, water cannot infiltrate into the soil. This leads to increased surface runoff and floods as well as erosion during wet periods, but also reduced water storage in the soil and reduced recharge of the groundwater. Together with high evaporation loss on uncovered soil, the consequences during the dry seasons are less soil water available to plants, lower groundwater tables, and reduced river flows.

SLM practices for better soil cover management are essential to improve both the biomass and the water cycles, which are a key to improving soil fertility and water availability.

Cropland and irrigated land: Deep tillage and poor vegetation cover rapidly reduce soil organic matter. Intensive use of mineral rather than organic fertilisers accelerates depletion of organic matter in soils and impairs its regulatory functions. Moreover, the rate of evaporation increases, leading to deterioration of the water cycle. Methane and laughing gas emissions from rice paddies are another source of GHG. There exists a variety of SLM practices for improving soil cover, such as conservation agriculture, agroforestry systems or intercropping.

Rangeland: The global growth in livestock population is increasing the pressure on well-developed grazing areas. The consequences are reduced vegetation cover and loss of valuable fodder species, resulting in reduced biodiversity, as only species unattractive to animals survive. Reduced cover also leads to accelerated decomposition of soil organic matter and increased aridification. Reduced and controlled grazing and restoration of degraded soils through afforestation are SLM practices that positively affect biomass and the water cycle.

No-tillage with controlled traffic, Australia

Large-scale no-till grain production with permanent wheel tracks is practiced on a 1900 ha farm in semi-arid Queensland, Australia. The main technical objective of this measure is to eliminate soil compaction. The three principles of conservation agriculture, namely minimal/no tillage, crop rotation, and soil cover, are applied as far as possible. Over the first three years the soil improved, becoming soft, friable and moist between plant lines. In the five years since implementation, sorghum yields rose from 3 to 7 tons per hectare. Compared to the previously applied conventional tillage method, labour costs are 4 times lower with no-tillage than before. The average annual diesel consumption is even 8 times less with no-tillage, which also has a significant effect on costs. The farmer's income increased significantly due to this SLM practice.

Controlled traffic, minimum soil disturbance, and leaving some crop residue are the key to protecting soil and water in semi-arid areas such as Australia.

Furrow-enhanced runoff harvesting, Syria

The Khanasser Valley in north-west Syria is a marginal agricultural area. Traditionally this area is used for extensive grazing or barley cultivation. Yet several farmers have developed olive orchards in this area. They prefer to till their orchards by tractor in order to keep them weed-free. As this tillage operation is usually practised up and down the slope, the resulting furrows stimulate runoff and erosion. However, when this is combined with V-shaped and/or fish-bone-shaped microcatchments around individual trees, the furrows created can be used to harvest runoff water for improved production. This technology saves irrigation water during the dry season, enhances soil moisture storage, and stimulates olive tree growth. Furthermore, fine particles of eroded soil and nutrients are captured in the microcatchments.

Rainwater harvesting with up and down tillage and v-shaped structures for olive production in the Mediterranean region: a possibility to grow trees where water is too scarce.
Photo: Francis Turkelboom

Rotational Grazing, Tajikistan

During the Soviet era the steep mountain slopes in the Faizabad District were intensely cultivated, which led to severe soil degradation. Rotational grazing is an option for sustainable land use in these areas. A farmer near the Karsang and Tshinoro mountains applied a rotational scheme of 10 days to two weeks. One day of grazing is divided into a grazing period of 4 hours in the early morning and a later period in the afternoon. The dung left by the animals enhances soil fertility. Favours palatable species and compensates for the fertilisers that used to be applied in the Soviet era. The applied rotational scheme also has the advantage of causing much less trampling paths than on the overgrazed village pastures. The prices for the animals this farmer sells from his herd are higher than what his neighbours get.

Rotational grazing applied on mountain slopes in Tajikistan.
Photo: Christian Wirz

Benefits for culture and society

Cultural site on the Loess Plateau of China. This site coexists with crop production on the plateau and fruit tree production on slopes. Photo: Hanspeter Liniger

'Irrigation cultures', which require close collaboration between users, have developed all over the world. Photo: Hanspeter Liniger

Herding and nomadism have long traditions and unique values. Photo: CAMP

Cultural and natural landscapes: Intact natural and cultural landscapes and endemic crops contribute significantly to cultural identity. They embody experience gained over centuries by particular societies and are an expression of their historical and cultural characteristics and values. Cultural and natural landscapes can be preserved as long as the type of cultivation associated with them is profitable for the land user, i.e. so long as he can hope for yields that correspond to his effort. When this is no longer the case, land users focus on more profitable alternatives that are often linked with greater environmental risks and loss of cultural values.

Cultural and natural landscapes frequently nurture great biodiversity. They form gene pools in which endemic crops are preserved and from which these crops are disseminated.

In addition to agricultural use, cultural and natural landscapes have great value as recreational space for humans. Many UNESCO Cultural and Natural World Heritage Sites are in dryland areas. The tourism and ecotourism that these sites attract offers the population new economic opportunities, including new opportunities for income that can be used to make investments in the preservation of the natural resource base.

Increasing migration, particularly of young men migrating from rural areas in dryland regions to areas of economic opportunity (cities, foreign countries), is contributing to the decline of cultural landscapes and social structures. Terraced landscapes, for example, are falling into disrepair because sufficient labour is no longer available to maintain them.

Policy: Governments or local communities have put issues relevant to SLM on their agenda and approved corresponding ordinances, laws, and rules of use. Control mechanisms and sanctions have been introduced. These include protection of forests, regulation of grazing and water use, management of bush and savannah fires, and passage of herds through settled areas. Taken together, measures such as these establish important conditions for facilitating SLM and, when formulated in cooperation with concerned stakeholder groups, contribute to preservation and strengthening of ecosystem services.

Rehabilitation of ancient terraces, Peru

Terracing systems on hillsides often date back to the beginning of agriculture. The level bench terrace system in the Colca Valley of Peru dates back to 600 years AD. Since then the terraces have been continuously used for crop production, but due to lack of maintenance they have deteriorated, and the population has lost its traditional knowledge of repair. Rehabilitation of the terraces recreates their original structural design. The complementary irrigation and drainage systems are simultaneously reconstructed. The rehabilitated terraces efficiently conserve soil and water on steep slopes, creating a favourable microclimate for crops, reducing loss of stored heat at night, and mitigating dry conditions through moisture conservation. Terrace rehabilitation in the Colca Valley was project-based; the high establishment costs were mainly covered from project funds, while maintenance is the responsibility of the local community. The main economic benefits are from increased yields and crop diversification.

Rehabilitation of ancient terraces in Peru: even though this is a costly investment, it is a component of cultural identity. Photo: DESCO

Biodiversity conservation of ancient church/ monastery yards, Ethiopia

In Ethiopia less than 3% of natural forest remains, while the forest is still decreasing at a rate of 7.5% per annum. Islands of natural forests survived on the sacred land around Ethiopian churches and monasteries, providing unique natural biodiversity. However, due to increasing population pressure and the need for fuelwood and timber, these areas are also threatened. Debre Libanos monastery is located 104 km from Addis Ababa in the North Shewa Zone of Oromia State. The forest at Debre Libanos Monastery is one of the few remaining dry mountain forests providing a rich habitat for birds and wild animals.

Forests around Debre Libanos monastery are well protected, whereas the surrounding land is under heavy pressure. Photo: Frédéric Leviez

Pastoral nomadism, Mongolia

Approximately one-third of the population of Mongolia are nomadic pastoralists. The minimum number of animals required for a pastoral family to survive has increased in recent years from 150 to 250 sheep or goats. The composition of herds has shifted heavily in recent years in favour of goats (cashmere wool). Up to 5 ha are required to graze a sheep or a goat. Grazing areas with minimal productivity must therefore be used extensively. Pastoralists distinguish between spring, summer, autumn and winter pastures, moving between them with the rhythm of the seasons. Grazing grounds are frequently separated by distances of up to 100 km. Mobility, flexibility, and thorough knowledge of local conditions (watering sources, pasture quality, local and seasonal climate conditions) are prerequisites for successful livestock production. Horses and camels play an important role as a means of transportation. Nomadic pastoralism has contributed to the development of a culture with specific characteristics (social structure, living units, epic, music, horsemanship, etc.). The freedom of movement of nomadic populations is being increasingly limited by social change.

Long traditions of herders and Khans in Mongolia. Photo: Hanspeter Liniger

EXTENT OF SLM AND OFF-SITE IMPACTS

Mapping degradation and conservation (SLM practices) is a key to proper planning and decision-making about where to invest to combat desertification. Photo: Hanspeter Liniger

Off-site impacts of unsustainable land use: wind storms and dust bowls are well known effects and cause heavy damage. Photo: Gudrun Schwilch

An intensive storm in an overgrazed valley in Central Asia caused a flash flood and a landslide that covered a main road. Photo: Hanspeter Liniger

Lorry transporting hay from a rural area of Mongolia to the capital: an opportunity for income but with a potential risk of overuse of rural areas. Photo: Hanspeter Liniger

Mapping of SLM practices

Whereas substantial efforts have been made in the last few years to document good, available SLM practices, their extent and areal coverage are practically unknown. Both degraded and well conserved areas with land degradation and good SLM practices need to be identified and the impacts on ecosystem services need to be assessed. Thus mapping of degradation and conservation provides key information for decision making, about where investments can best be made, and about which SLM practices have the best potential to spread.

On-site and off-site interactions

Desertification and SLM have not only local but also regional and even global impacts. Dust storms originating on degraded land threaten people and their livelihoods close by but also hundreds to thousands of kilometers away. Similarly, floods in the lowlands may be aggravated or even caused by inappropriate land use upstream. In arid areas transport of soil material causes major economic and ecological damage and impairs the health of millions of people. Too little consideration has been given to proper assessment of on-site and off-site land use interactions that lead to regional and global damage or benefits.

Highland-lowland interactions

Most of the populations in arid areas are heavily dependent on ecosystem services provided by highland areas. Mountains and highlands are water towers that provide water to the surrounding lowlands. 1/3 of the global population in lowland areas survives thanks only to water flowing from frequently far-off highland areas. They depend on the inhabitants of highland areas to use available water resources sustainably and to preserve ecosystem services. People in highlands and mountains provide or withhold services to the lowlands. Thus land management in these regions is not a purely local issue.

Watershed management (and SLM planning)

SLM is often beyond the means, responsibility and decision-making power of individual land users. Proper planning includes both elements of local participation by the stakeholders and regional overall planning where on-site and off-site interactions are considered and regulated. This is most important with regard to watersheds, where it can involve very distant communities and affect their local land use planning. Regulating mechanisms are often required for protection and compensation of affected land users.

Regional interactions and rural-urban linkages

The proportion of the urban population in dryland areas has already reached 30% and is rising rapidly. Major flows of goods to urban markets from rural areas include food, raw materials and fuel sources. Enormous quantities of nutrients, water and carbon are transported in the process, and are thus removed from local cycles. Efforts are needed to counterbalance the negative effects on soil fertility and productivity.

Check dam for land reclamation, Shaanxi Province, China

A check dam is built in a watershed valley to retard runoff and increase sedimentation. This leads to fertile soils of good quality within the check dam area after the dam is filled up. This area is then used for intensive crop production while a new check-dam is built nearby to collect water and sediment. The costs of establishment are very high; investment by government and local organisations is needed. The labour costs are met by land users working free of charge during the establishment phase. Further maintenance costs are much lower.

A check dam in the Loess Plateau of China provides and traps sediment until it is filled up. It is then used for crop production. Photo: Hanspeter Liniger

Gully control and catchment protection, Bolivia

In the Cochabamba District a degraded catchment led to loss of cropland as well as serious downstream damage to the city of Cochabamba. The integrated gully treatment consisted of several simple practices, including stone and wooden check dams, cut-off drains, and reforestation in sediment traps (biotrampas). Through reforestation, better vegetation cover stabilised the land. Furthermore, the applied measures led to safe discharge of runoff from the surrounding area through the main gullies down to the valley. The rather high establishment and maintenance costs were paid for by a project during the intervention period of 6 years.

Catchment gully control in Bolivia with a variety of different SLM technologies. Photo: Georg Heim

Poplar trees for bio-drainage, Kyrgyzstan

Poplar planting has been applied on a degraded plain in Kyrgyzstan under semi-arid conditions to deal with rising water tables and increasing soil salinity in irrigated areas. Poplar trees, well known for their tolerance to waterlogging and salinity, provide ‘bio-drainage’. Excess water is rapidly taken up by the root system and transpired through the dense foliage. Within the plantation, the humidity level of the lower layers of air is increased, thus reducing the influence of the dry, hot winds. A more favourable microclimate for plant growth is thus created. Simultaneously, the original purpose of planting – to obtain cheap timber and firewood – is achieved. The cost/benefit ratio of this measure was negative in the short term; in the long term, however, the effect was very positive, leading to a remarkable increase in income.

Poplar trees act as a natural drainage system in water-logged areas with salinity problems. Photo: Hanspeter Liniger

Area closure for rehabilitation, Ethiopia

30% of the land in the Bilate River Catchment is degraded, resulting in low crop yields and poor livestock production. Therefore, area closure of degraded land for land rehabilitation was conducted. The natural regeneration of the vegetation cover was supported by water harvesting structures and planting of nitrogen-fixing/multi-purpose shrubs and trees as well as local grass species. The area to be closed is demarcated and protected with fencing. Rehabilitation usually takes about 7-10 years. After one year, cut-and-carry grass for stall feeding can be partially supplied, providing a small benefit to the farmers. Good participation by and involvement of land users are fundamental for fruitful implementation of area closure, since land use rights in this area are mainly open access rather than individual.

Area closure with additional conservation measures in Ethiopia, allowing rehabilitation and re-growth of the vegetation and making land productive after several years of rest. Photo: Hanspeter Liniger

The way forward

Degradation of ecosystem services is evident in disturbances of natural cycles (water, biomass and nutrients). These disturbances are responsible for accelerated breakdown of soil organic matter, reduced levels of carbon stored in soils, diminished soil fertility, reduced biomass production, and lower levels of surface water and groundwater. In the medium and long term, these effects lead to lower agricultural productivity and thus to noticeable harvest loss as well as global environmental degradation (climate change, loss of living space).

Sustainable agricultural practices have the potential to reverse this trend. They can help to improve local livelihoods, reduce hunger, and restore natural ecosystems. Sustainable land management practices can contribute significantly to climate change adaptation and mitigation.

Recommendations to policy- and decision-makers

Policy

Investment in rural areas and sustainable land management is a local concern, a national interest and a global obligation. Thus it must be given priority (1) at the local level to increase income, to improve food security and to contribute to poverty reduction; and (2) at the national and global level, to help alleviate hunger and malnutrition, to reduce poverty, to protect the world's climate, to safeguard natural resources and ecosystem services, and in many cases to preserve cultural heritage.

Profitability: Sustainable agricultural practices need to be stimulated by further emphasising improved production and reduced costs. Production benefits are the primary interest of land users, and have direct consequences for livelihoods in small-scale subsistence farming.

Multi-functional use: Multi-functional use helps considerably to reduce risk through diversification, to promote synergies that produce added economic, ecological or social value, and to preserve and strengthen important ecosystem services.

Small-scale farming: A major portion of the land used for agriculture, particularly in ecologically fragile areas, is cultivated by smallholder farmers who perform significant ecological services in the process. But for economic reasons, and also owing to lack of knowledge, their use of available resources in many cases is characterised by inappropriate technologies and methods. These smallholder farmers must be given much more effective support.

Enabling environment: An enabling environment should be nurtured for sustainable land management to thrive best. Indirect measures such as infrastructure, access to credit and inputs, favourable prices for agricultural products, and legislation indirectly contribute to sustainable use of natural resources. Security of land use rights is a major component affecting conservation: policies that improve the rights of individual land users are a prerequisite for sustainable land management.

Com**pensation for ecosystem services:** Farmers are key agents in maintaining the world's terrestrial ecosystems. Rural areas may need and deserve compensation for the environmental services they provide from more affluent, economically advanced regions. This could consist, for instance, of innovative systems to compensate upstream land users in watersheds, of global mechanisms to finance carbon sequestration in soils, or of in-situ preservation of agrobiodiversity.

Knowledge & Training

Knowledge Management: There is a need for investment in documenting and evaluating SLM practices and in assessing their impact on ecosystem services. Scattered knowledge about SLM needs to be identified, documented and assessed in a thorough and interactive review process that involves the joint effort of land users, technical specialists, and researchers. Documented knowledge about SLM practices must be made broadly available for land users, decision-makers, etc. to provide a basket of options for decision-making at different levels.

Research: Many SLM practices have been documented. Their sustainable effect and practical implementation have also been confirmed in many cases at the local level. But there is a great need to clarify their impact in different contexts and to adapt and optimise them under different conditions. Additional new technologies need to be developed. Among other things, the role of soils in climate change mitigation and adapation is an issue of urgent concern.

Awareness raising and capacity development: Many resource users, extensionists, researchers, policy-makers and decision-makers are insufficiently informed with respect to the causes, the context, and the impacts of inappropriate resource use. Major efforts in information and training will be necessary if SLM practices are to achieve a break-through.

Extension services: Topics unilaterally related to short-term increases in yield and productivity are frequently a current priority for extension services. On the other hand, extension advice concerned with sustainable resource use and with preservation and strengthening of ecosystem services is neglected. In future, extension services must provide more information on SLM practices.

Participation & Planning

Participation and community involvement: SLM practices can be implemented most efficiently if all actors involved (farmers, extensionists, researchers, and decision-makers) participate in decision-making processes (selection, development, adaptation, planning, and implementation). Successful implementation of SLM often requires close cooperation between neighbours or members of a village community. Providing information, imparting knowledge, and exchanging experience play a key role in each of these steps.

Planning for sustainable land management: Land management is not a purely local issue. It is often beyond the means, responsibility and decision-making power of single land users. Off-site impacts due to inappropriate land management can be severe and should be considered in planning and decision-making at the local level. Therefore, overall regional planning (e.g. in an entire watershed), taking account of on-site and off-site interactions, needs to be given sufficient attention.

Mapping of degradation and conservation coverage is essential, in order to visualise the extent and effectiveness of achievements that support sustainable land management. It is also a prerequisite for proper planning of investments in SLM.

SLM concerns all of us and pays off in many more ways than recognised.

REFERENCES

Land use and ecosystem services

MA (Millennium Ecosystem Assessment). 2005. Ecosystem services and Human Well- Being, Desertification Synthesis, 2005. World Resources Institute, Washington, DC.

Population

Eswaran et al. 2001. Global Desertification Tension Zones. In: Stott et al, (eds). Sustaining the Global Farm.

Food, fibre fuelwood production

Nobel et al. 2006. Intensifying Agricultural Sustainability: An Analysis of Impacts and Drivers in the Development of 'Bright Spots'. Colombo, Sri Lanka: Comprehensive Assessment Research Report 13.

Soil degradation

Wood, S., K. Sebastian and S. Scherr. 2000. PAGE - Pilot Analysis of Global Agroecosystems. Washington, D.C.: World Resources Institute and International Food Policy Research Institute.

Dregne, H. and M. Kassas. 1991. A New Assessment of the World Status of Desertification. In: Desertification Control Bulletin, 20, 6-18. See also: Dregne, H.E. and N-T. Chou. 1992. Global desertification dimensions and costs.

Pimentel et al. 1995. Environmental and Economic Costs of Soil Erosion and Conservation Benefits. Science, New Series, Vol. 267, No. 5201.

Oldeman, L. R. 1998. Soil degradation: A threat to food security? Report 98/01. Wageningen, The Netherlands: International Soil Reference and Information Centre.

World Resources Institute (WRI). 2000. World Resources 2000-2001: People and Ecosystems: The Fraying Web of Life.

UNEP. 1997. World Atlas of Desertification. Second Edition. Data from GLASOD (Global Assessment of Soil Degradation) by ISRIC, UNEP, FAO (1990).

Stoorvogel et al. 1993. Calculating soil nutrient balances in Africa at different scales. In: Nutrient Cycling in Agroecosystems. Vol. 35, No. 3 / October 1993.

Carbon sequestration

Lal, R. et al. 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science, Vol. 304, No. 1623.

Water

WDR [World Development Report]. 2008. Agriculture for development. Washington, D.C. The International Bank for Reconstruction and Development, The World Bank.

Pretty et al. 2006. Resource-conserving Agriculture Increases Yields in Developing Countries. Environmental Science & Technology, Vol. 40, No. 4.

IWMI. 2007. Comprehensive Assessment of Water Management in Agriculture Expert knowledge CDE / WOCAT.

Cultural services

UNESCO World Heritage. 2009. http://whc.unesco.org/; accessed March 2009. Darwin Initiative for the Survival of Species. 2009. Final report.

Technologies and approaches

WOCAT. 2007. Where the land is greener: case studies and analysis of soil and water conservation initiatives worldwide. Editors: Hanspeter Liniger and William Critchley. Copublished by CTA, FAO and UNEP.

WOCAT. 2009. Database on SLM technologies and SLM approaches.

Publisher: WOCAT (World Overview of Conservation Approaches and Technologies)
CDE (Centre for Development and Environment), University of Berne
Photos: Hanspeter Liniger (unless acknowledged differently)
Authors: Ernst Gabathuler, Hanspeter Liniger, Christine Hauert, Markus Giger
Editing: Ted Wachs, Marlène Thibault
Layout: Simone Kummer
Printed by: Druckerei Varicolor AG, Bern
Financed by: Swiss Agency for Development and Cooperation

www.unccd.int
www.wocat.org
www.fao.org
www.isric.org
www.cde.unibe.ch

WOCAT
World Overview of Conservation Approaches and Technologies

UNCCD

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Agency for Development and Cooperation SDC

UNIVERSITÄT BERN

CDE
CENTRE FOR DEVELOPMENT AND ENVIRONMENT

FIAT PANIS

ISRIC
World Soil Information