SOLAW TR12

Coping with degradation through SLWM

SOLAW Background Thematic Report - TR12

Centre for Development and Environment

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Abbreviations and acronyms

UNDP	United Nations Development Programme
REDD	United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
FAO	Food and Agriculture Organization of the United Nations
UNEP	United Nations Environment Programme
PES	Payments for environmental services
FSC	Forest Stewardship Council
ES	Ecosystem services
SLM	Sustainable Land Management
ICPDR	International Commission for the Protection of the Danube River
IWM	Integrated watershed management
LDFA	Land degradation focal area
SFM	Sustainable Forest Management
CAP	Common Agricultural Policy (Europe)
M&E	Monitoring and Evaluation
PTD	Participatory Technology Development
NGO	Non governmental organizations
CSO	Civil society organizations
WISP	World Initiative for Sustainable Pastoralism

Executive summary

Sustainable Land and Water Management (SLWM) is defined as the use of land and water resources, including soils, water, plants and animals, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions.

Multiple benefits

Sustainable Land and Water Management (SLWM) is needed to ensure food security worldwide, and to improve the livelihoods of the 2.6 billion people who depend on the land. SLWM is vital to preventing further degradation and restoring productive, resilient, and well-functioning biodiverse ecosystems. Improved management of natural resources – soil, water and vegetation – includes social, economic and ecological dimensions at all scales. SLWM demands greater attention and the setting of priorities to respond to increasing pressures and demands, including growing population, increasing poverty, water scarcity, urbanization, industrialization, increasing competition for land and climate change. Broad adoption of appropriate technologies and approaches will provide multiple benefits, which is a major argument for further promotion of Sustainable Water and Land Management (SLWM).

Main principles of SLWM

The objective of SLWM is to increase land productivity for food, fodder, fibre and fuel on all land-use types, namely cropland, grazing land, forest and mixed land. An increase in land productivity should be based on the principles of improved water, soil fertility, plant management and micro-climate. The human dimensions of access to resources, security of tenure and an enabling environment are outlined in AGTER, 2010. An increase in overall production can be achieved through: (i) expansion of agricultural land; (ii) intensification of production; and (iii) diversification of the production system.

In most regions of the world, further expansion of agricultural land is restricted, therefore the focus should be placed on further intensification and diversification of production. Intensification has been achieved in several regions and has led to increased food production; often with negative trade-offs because of detrimental impacts on the ecosystem. Yet, in sub-Saharan Africa, intensification has not significantly addressed the intertwined problems of low productivity, degradation and poverty. Diversification of the production system has arguably the greatest potential, through more efficient and flexible use of natural resources and the potential for continuous local adaptation. Intensification, coupled with diversification, can generate a broader range of products and services to meet societal demands, while maintaining resilient and risk-reducing production systems.

SLWM technologies and approaches

A wide variety of SLWM technologies and implementation approaches – traditional or innovative – are applied around the world; but they are not widespread and there are no blue print solutions. Success will depend on technologies and approaches that are flexible and adapted to local ecological and socio-economic conditions such as climate, soils, tenure or market orientation. They should address immediate soil and water threats as well as specific and broader development goals. Land users are diverse, having different resource endowments, needs and aspirations; from those without land, to smallholders and large commercial enterprises. They require a basket of options from which to choose and combine. Moreover, the successful upscaling of technologies depends on securing tenure, markets and access to land and water resources.

Principles and examples of successful SLWM technologies for various land uses

Cropland

- intensification through integrated soil fertility management and improved efficiency of water use;
- increasing efforts to improve efficiency of water use in rainfed agriculture as well as on irrigated land: there is limited scope to increase the area under irrigation;
- crop diversity for food security, enhancing resilience and reducing the risk of crop failure;
- enhancing crop productivity of small-scale land users and maintaining optimal productivity of large-scale systems; and
- improving tenure security (ownership and user rights) and access to support services.

Grazing land

- making economic use of marginal grassland by supporting extensive grazing and by facilitating the mobility of livestock to avoid overgrazing;

SLWM TECHNOLOGIES FOR CROPLANDS

Photo: HP. Liniger

Photo: Francis Turkelboom

Conservation agriculture (CA) combines minimum soil disturbance (no-till), permanent soil cover, and crop rotation, and is suited to small- as well as large-scale farming.

Integrated soil fertility management benefits from positive interaction and complementarities of the combined use of organic and inorganic plant nutrients in crop production.

Rainwater harvesting is the collection and concentration of rainfall to ensure water is available for agricultural or domestic uses in dry areas where moisture deficit is the primary limiting factor.

Sustainable irrigation aims to achieve higher water use efficiency through improved water collection and abstraction, water storage, distribution and water application. It reduces salinization, waterlogging and waste water problems.

Vegetative strips are often used along contours helping to hold back excessive runoff, but can also act as wind breaks.

Structural barriers are interventions on sloping lands in the form of earth or soil bunds, stone lines, etc. to reduce runoff velocity and thus soil erosion.

Organic agriculture avoids the use of synthetic fertilizer, pesticides and genetically modified organisms; it optimizes organic matter management, conserves soil and water, and supports crop diversity and integrated pest management.

- improving grazing land management by bringing livestock numbers and grazing periods into balance with climatic variability, and the size and capacity of the pasture to recover from grazing and trampling (i.e. rotational grazing and frequent movement);
- restoring and maintaining vegetative cover to improve soil fertility and water management;
- strengthening local and traditional institutions to allow effective livestock and grazing management: establishing and observing grazing and stocking rules, negotiating livestock movements and herd mobility, supporting markets for animal products; and
- securing access to land and water, especially under common property regimes.

Forest land and woodland

- halting deforestation;
- ensuring balance of trees, understory and litter to enhance and maintain ground cover and re-growth;
- conservation of natural forest and associated biodiversity does not exclude measure that do not use these resources sustainably;
- community-based management, especially in areas where forests are the basis of livelihoods;
- improving land ownership and user rights;
- establishing integrated forest management plans to reduce pressure on natural forests, including zones for planted forests and clear delineation and buffer zones between forest and cropland;
- considering market and non-market approaches including forest certification (with clear regulations) for sustainable forest management; and
- ensuring effective wildfire protection.

SLWM TECHNOLOGIES FOR GRAZING LAND

Photo: HP. Liniger

Grassland improvement includes the 'improvement' of extensive natural grassland by propagating high value local grasses and legume species and varieties or introducing adapted, non invasive exotic species.

Stocking rate regulation involves management of the spatial and temporal distribution and composition of livestock on extensive grazing lands. Extensive grazing is managed at the landscape rather than at the local scale. Well-distributed water points and seasonal availability of water (as from small dams) help facilitate movement of livestock.

Mixed/integrated systems

- making full use of synergies by integrating various land uses: combining crop, tree and fodder production (agroforestry); combining productive with recreational services, combining productive and protective purposes;
- optimizing biomass, nutrient, carbon and water cycles;
- diversifying production and enhancing biodiversity;
- reducing the risk of production failure; and
- increasing resilience of the production system to cope with variability (climate, market, demography).

SLWM as a response to threats and vulnerabilities

Land-use systems should be designed to deal with environmental threats such as floods, heavy rains, dust storms or droughts, which may be further exacerbated by climate change. If all SLWM principles are observed – improved water, soil fertility and plant management, and micro-climate – the result will be improved protection against natural disasters and increased resilience to climate variability and change. SLWM technologies are all the more important as they generate both climate change adaptation and mitigation benefits.

Variety of SLWM approaches

Effective *technologies* alone are not a guarantee for successful upscaling of SLWM; appropriate SLWM *approaches* are required. An SLWM approach defines the ways and means used to promote and implement an SLWM technology, be it project or programme initiated, an indigenous system or a local initiative or innovation. The approach may include different levels of intervention, from promoting individual innovators, through the strengthening of community level arrangements or institutions, and the establishment of effective extension or advisory systems at regional or national levels.

SLWM TECHNOLOGIES FOR MIXED OR INTEGRATED SYSTEMS

Agroforestry (AF) integrates the use of woody perennials with agricultural crops and/or animals for a variety of benefits and services, including improved use of soil and water resources, multiple fuel, fodder and food products, and provision of a habitat for associated species. AF embraces a wide range of practices: contour farming, multi-storey cropping, (relay) intercropping, multiple cropping, bush and tree fallows, parkland and homegardens.

Integrated crop-livestock systems optimize the uses of crop and livestock resources through interaction and the creation of synergies. The waste products of one component serve as a resource for the other: manure from livestock is used to enhance crop production (improving soil fertility), while crop residues and by-products (weeds and processing waste) are supplementary feed for the animals.

SLWM APPROACHES

Photo: Sally Bunning

Photo: Cindy Shen

Farmer field schools comprise a group learning approach which builds knowledge and capacity among land users to enable them to diagnose their problems, identify solutions and develop and implement plans including self financing and networking.

Landcare is a community-based approach focused on building social capital to voluntarily resolve local problems affecting the community, while conserving land resources and productive landscapes.

Integrated watershed management (IWM) combines a range of technological and institutional interventions that improve interaction and co-benefits between land managers upstream and land and water users downstream. Improved private and communal livelihood benefits are generated by managing the watershed as the key landscape unit.

Participatory land-use planning allows the creation of synergies between local land users or community goals and national sectoral development goals. It generates combined efforts and investments in addressing land degradation and conflicts over resources by land owners on private and common property lands.

Extension and advisory services in SLWM support the capacity of land users and other stakeholders to improve productivity and generate socio-economic and environmental benefits and adapt to change. The key is to stimulate innovation and adaptive management through farmer-to-farmer exchange, promoting farmer innovation and research, training of 'local promoters' who then become facilitators and encourage participatory technology development.

Payment for ecosystem services (PES) or payment of ecosystems (or environmental) services are terms used for financial and non-financial mechanisms that reward land users for the generation of specific ecosystem services. These include carbon trading mechanisms, payments for downstream water supply and biodiversity conservation. They can stimulate improved land and water management.

Targeting SLMW interventions and investments

Given the multiple benefits of SLWM, and costs of not addressing degradation, best SLWM practices should be promoted and implemented locally to protect land and water resources worldwide. Today's need to increase production, to respond to population growth and increasing demands as well as natural threats and climate variability as well as many other challenges, justifies increased investment for spreading SLWM. Successfully targeting interventions requires identification of the most appropriate SLWM for a particular location.

Demonstration of local-scale cost-benefit SLWM measures plays a central role in the adoption and spreading of SLWM, which should generate positive paybacks for land users. This requires assessment of shortand long-term costs and benefits of SLWM interventions both in monetary and non-monetary terms. While establishment costs can be partly funded by external sources, maintenance costs need to be covered by local sources, and direct payback ensured to avoid dependency and stimulate self-initiative. However, SLWM often remains beyond the means, responsibility and decision-making power of individual land users.

The cost-benefit calculation should focus both on the local land user and on society and economy as a whole. At the larger scale, for example the watershed, landscape or regional scale, the range of social, economic and environmental impacts should be taken into account and the trade-offs between different options weighed when planning and implementing SLWM.

Often funds are mobilized when degradation has become severe. However, prevention and mitigation of degradation before it becomes serious is more effective and less costly; although less visible and spectacular than rehabilitation of already severely degraded areas. Usually the costs of rehabilitation can only be justified when people and (public) infrastructure are at immediate risk.

SLWM interventions need to break out of the typical three to four year project cycle and commit to a phased and cumulative investment over a minimum of ten or more years. SLWM interventions require long-term commitment and a clear strategy to sustain results beyond the project lifetime.

Each region and country has its own specific challenges and opportunities to be addressed by SLWM. At the regional-scale, limited financial resources require prioritizing SLWM investments to define where interventions are most appropriate and effective, i.e. in view of cost effectiveness, best returns on investment, priority to address poverty alleviation and food security, and environmental protection, in line with the Millennium Development Goals and pressing global threats. Investment priorities need to be set for local and regional interactions such as highland-lowland (including transboundary or large river basins), marginal-high potential areas and rural-(peri) urban areas. More consideration should be given to the off-site impacts of SLWM be it on neighbouring or downstream areas.

Rural-urban linkages – Major flows of goods from rural areas to urban markets include food, raw materials and sources of fuel. Enormous quantities of nutrients, water and carbon are transported in the process, and are thus removed from rural areas and cause immense pollution problems in urban zones. Efforts are needed to replenish the losses and counterbalance the negative effects.

Highland-lowland and terrestrial-aquatic interactions – One-third of the global population in lowland areas survives thanks to water flowing from distant highland areas. They depend on the inhabitants of highland areas to use available land and water resources sustainably and to maintain ecosystem services to protect the hydrological regime. Thus land and water management in these hilly or mountainous regions is not a purely local issue, but a wider landscape management issue, and often an international one, as in the case of transboundary rivers and lake basins.

International or global collaboration – International collaboration has increased owing to increased awareness and commitment to address urgent global issues. Well-known examples include the global plan of action for food security of the Food and Agriculture Organization of the United Nations (FAO), the three inter-related United Nations Conventions on Desertification (UNCCD), on biological diversity (UNCBD), and climate change (UNFCCC) as well as the Ramsar Convention on wetlands.

Different land-use systems require different investment priorities. Substantial achievements have been made on individual cropland all over the world. Yet there are still areas, especially in sub-Saharan Africa and marginal (dry or mountainous) regions, where further efforts are needed. Grazing land, which covers more than twice the area of cropland globally, has been neglected and therefore degraded in many regions. Although well protected in some regions and countries, forests and woodlands have been seriously degraded, as well as reduced in area through land conversion.

Regarding the global concerns of climate change, biodiversity and water scarcity, more importance is being attached to forests, woodland and grazing land for global investment and new payment or compensation mechanisms. Recent examples are the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD) mechanisms for carbon trading, and Green Water Credits provided by water suppliers for improved land management upstream. Yet, high transaction costs are a problem for smallholders.

Impact assessment and monitoring

Impact assessment is required to justify investment in SLWM. To be able to compare and share results, monitoring and assessment methods requires a standardized and comprehensive framework, integrating ecological, economic and socio-cultural aspects as well as short- / long-term and on- / off-site benefits and disadvantages. Stakeholder participation and integration of multiple spatial and institutional levels are key principles of this framework, which is currently being developed under the UNCCD convention on desertification by various global and regional initiatives such as World Overview of Conservation Approaches and Technologies (WOCAT), Land Degradation Assessment in Drylands (LADA), DESIRE (a research project funded by the European Union) and the Global Environment Facility (GEF) Knowledge management (KM):Land-project.

Besides assessing the impacts and successes of SLWM, systematic documentation and mapping of the adoption and spread allows for the identification of innovations and achievements at all spatial levels. A major challenge is to obtain figures on specific and overall investments and benefits, and a global assessment of the real costs and impacts of SLWM is not yet possible. In addition, there is not much known about the impacts of policies or incentives on implementation of SLWM; for example if the CAP in Europe or other similar policies or strategic investment programmes such as TerrAfrica has produced or are producing the intended impacts on the ground.

Current spread of SLWM

Although substantial efforts have been made in the last few years to document and share knowledge about SLWM technologies and approaches, their actual extent and areal coverage are poorly known. From the scarce and scattered data available it must be assumed that SLWM is not widespread, which again emphasizes the need to intensify the promotion and upscaling of SLWM. Mapping the spatial extent, including causes and impact of land degradation and conservation, is required to provide key information for decision-making on where investments can best be made, which SLWM practices have the potential to spread and the support required. To-date almost no surveys exist on the spatial spread of SLWM, neither at the global nor at the regional, national and subnational levels. The LADA–WOCAT–DESIRE partnership has jointly developed a mapping methodology that elicits local knowledge of status, drivers, causes and impacts of degradation as well as SLWM.

There is a vital need for a global assessment showing not just extent, but quantifying the benefits and impacts of SLWM on issues such as food security, water availability, and climate change mitigation. The challenge of defining the state of the world with respect to SLWM remains.

Upscaling of SLWM

Although good SLWM can be found in many places, often present as enduring traditions, the uptake of technologies by the majority of land users will remain a wish rather than reality unless substantial and coherent investments are made. Excellent approaches on how to motivate land users to implement SLWM technologies are available, but these have not yet been adopted sufficiently widely to enhance food security and reduce poverty. There is a need to broaden the scope of interventions through nested approaches from the farm or household level upwards. Many reasons have been suggested for the limited spread of SLWM; ranging from lack of incentives and financial support, to markets and prices, services and infrastructure, legislation and regulations, education and promotion and documentation and knowledge management.

Ideally, resources should be mobilized to streamline engagement in all these spheres in an integrated manner. This would require informed and engaged land users, and decision-makers, planners and politicians who can provide the enabling conditions, while considering the potential drawbacks and threats, such as off-site disadvantages, water-use restrictions and social inequalities. Compensation payments or rewards for ecosystem services (PES) are modern means for providing incentives for SLWM interventions at the wider watershed or landscape scale. Partnerships involving governmental institutions, civil society organizations (CSO), private sector and individual land users, need to be simultaneously established to foster mutual respect and negotiation among these diverse stakeholder groups for a common sustainable future. Global programmes and collaboration through international conventions (especially the UNCCD) and investment mechanisms (such as GEF, Global Mechanism, World Bank and regional development banks) can deliver the desired large-scale funding and the framework for true global engagement.

Framework for action, knowledge management and decision support

Decision-makers need easily accessible and digestible information based on sound knowledge and experience. Standardized methods of information presentation ease the sharing of knowledge gained through monitoring and assessment methods as mentioned above, but the successful integration of this knowledge into decision-making processes also requires attention. This involves multi-level, multi-stakeholder and multi-sectoral approaches to ensure coherent land planning, management strategies and actions.

The key to success lies in effective collaboration between stakeholders at all levels, bringing together local experience and innovation by land users over generations with up-to-date ‘scientific’ ecological and technical knowledge or expertise ensuring that decisions weigh the different options and balance short-term economic and long-term societal and environmental goals. Providing such a coherent socio-economic, legal and institutional framework will stimulate long-term partnerships and concerted efforts between governmental institutions, researchers, civil society organizations and land users.

Main messages

Sustainable Land and Water Management (SLWM) is needed to improve rural livelihoods and ensure food security worldwide, to prevent further degradation and restore productive, resilient and well-functioning ecosystems. *SLWM deserves greater attention, priority setting and investment* to respond to the increasing pressures and demands of growing populations, poverty, urbanization, industrialization, increasing land competition and climate change. SLWM has *multiple ecological, economic and social benefits* as it has the potential to reduce land degradation and desertification andaddress simultaneously global concerns of food security, poverty alleviation, water scarcity, land-use conflicts, climate change and biodiversity conservation at local, national, regional and global level.

SLWM principles of *improving water, soil fertility, plant management and the micro-climate* can lead to increased land productivity for food, fodder, fibre and fuel on all land-use types. Promising SLWM technologies for cropland include conservation agriculture, integrated soil fertility management, rainwater harvesting, sustainable irrigation, vegetative strips, structural barriers and organic agriculture. Grazing land technologies, such as grassland improvement or agreed management regulations on communal lands, can make economic use of marginal areas. Sustainable plantations and integrated community-based forest management help reduce pressures on natural forests. Mixed systems, such as agroforestry or integrated crop-livestock systems optimize biomass, nutrient and water cycles, diversify production and enhance biodiversity.

Diversification of the production system has arguably the greatest potential, through more efficient and flexible use of natural resources and the potential for continued local adaptation. All SLWM technologies improve protection against natural disasters and increase *resilience to environmental threats and vulnerabilities*, including climate change. There is a wide variety of SLWM technologies, traditional and innovative, but there are no blueprint solutions. Upscaling depends on securing tenure, markets and access to land and water.

For successful promotion of SLWM, besides effective SLWM technologies that are adapted to the socio-economic and environmental context, an appropriate *SLWM approach* is required to determine the ways and means used to promote and implement the various technologies. Successful SLWM approaches include strengthened extension and advisory services, farmer field schools, participatory land-use planning, integrated watershed management or payment for ecosystem services. Investments need to support not only capacity building in technologies and approaches but also address *enabling conditions* such as incentives and financial support, markets and prices, services and infrastructure, legislation and regulations, knowledge management and advocacy.

SLWM often remains beyond the means, responsibility and decision-making power of individual land users. A *cost-benefit* analysis is needed to focus on the local land user and simultaneously on society and the economy, to take into account the range of social, economic and environmental impacts at local, watershed, landscape or regional scale and balance the trade-offs of various options for different stakeholders and goals. Prevention and mitigation of degradation is more effective and less costly than rehabilitation of already severely degraded areas. SLWM interventions require *long-term commitment* to generate benefits and overcome bottlenecks. Investments need to address local and *regional interactions* and off-site impacts such as highland-lowland (including transboundary or large river basins), marginal-high potential areas and rural-(peri) urban areas.

Standardized methods have been developed by LADA/WOCAT/DESIRE to *assess, document and map* at subnational and local levels the status and spatial extent of land degradation and conservation, and their drivers, causes and impacts. As no overview exists of the spatial spread of SLWM, the challenge remains to define the state of the world of SLWM. Subsequent monitoring and assessment of the impacts of policies or incentives on SLWM adoption will allow the identification and upscaling of innovations and achievements at all levels.

Successful sharing and integration of this knowledge into a *decision-making processes* requires multilevel, multi-stakeholder and multi-sectoral approaches that ensure coherent land planning and management strategies and actions. Effective *collaboration and partnerships* among stakeholders at all levels, will bring together local experience and land users' innovation over generations with up-to-date ecological and technical knowledge or expertise. This ensures that decisions weigh the different options and balance short-term economic and long-term societal and environmental goals.

Introduction – what to address

Sustainable land and water management (SLWM) is needed to ensure food security worldwide, and to improve the livelihoods of the 2.6 billion people depending directly on the land. SLWM is also vital to prevent further degradation and restore productive, resilient and well functioning, biodiverse ecosystems.

It is more cost effective to prevent degradation rather than cure it, but 52 percent of the land used for agriculture worldwide is moderately or severely affected by soil degradation, and nearly 2 billion ha of land – an area twice the size of China – are seriously degraded, some irreversibly (Nachtergaele *et al.,* 2010; Fischer *et al*., 2010; Mateo-Sagasta and Burke, 2010). Although efforts have been made over the last decades to promote SLWM in many regions and contexts, degradation and depletion of land and water resources continue and *threaten food security and livelihoods*.

Land degradation reduces productivity and food security, disrupts vital ecosystem functions, negatively affects biodiversity and water resources, and increases vulnerability to climate change. Increasing pressures and demands, including growing population, escalating poverty, water scarcity, urbanization, industrialization, intensified land competition and climate change will further exacerbate land degradation and decrease the water and land available for agricultural production.

SLWM deserves greater attention and priority setting to respond to these accumulating pressures and demands. While significant opportunities exist for increasing, or preserving, land productivity, thereby sustaining rural livelihoods and food security, in many areas worldwide the enormous challenge will be to produce more food and other goods while sustaining the natural resource base and maintaining healthy ecosystems. SLWM is the key to simultaneously addressing the predominant global issues of poverty and food insecurity (by improving production), desertification (halting aridification), biodiversity loss (enhancing diversity of flora and fauna, above and below ground) and climate change (by increasing carbon sequestration). These joint local and global benefits should trigger a new generation of projects that promote SLWM as the vehicle to a future with prevention of land degradation, conservation of biodiversity, improved ecosystem function, climate change adaptation and mitigation, with the simultaneously achievement of better livelihoods.

Sustainable land and water management (SLWM) is defined as the use of land and water resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions. SLWM has evolved out of the earlier concepts of 'soil conservation', 'soil and water conservation', 'land husbandry' and 'sustainable land management'.

SLWM includes the sustainability of land use as well as land management. The suitable use of land for cropping, pasture, forestry, or for non-agricultural uses such as protected areas, settlement or mining, should take into account the area's natural potential as well as the socio-economic context. Applied management practices should maintain the natural resource base, sustain productivity and food security. This requires that the quality and quantity of soil, water and biological resources, their biodiversity and vital ecosystem functions are all maintained, as well as resilience to climate change. SLWM is crucial to minimizing land and water degradation, rehabilitating degraded areas and ensuring the optimal use of land and water resources, and for enhancing productivity to benefit present and future generations to ensure long-term food security.

There are no blanket approaches or blueprint solutions to SLWM. To identify appropriate land uses and management practices costs and benefits need to be balanced with different land users and communities, on the level of society as a whole and for specific ecosystems, while analysing the trade-offs across systems and levels. This includes paying attention to the drivers of degradation especially unfavourable policies, lifestyle, consumption patterns and population dynamics.

This report *focuses on SLWM as a response* to the degradation and depletion of land and water resources. Challenges are discussed faced by certain regions and ecosystems, land uses and socio-economic settings, and the multiple benefits of SLWM for human livelihoods and ecosystem functions or services are explored. After discussing the main principles and examples of successful SLWM technologies for various land-use types, including their resilience towards threats and vulnerabilities, a variety of SLWM approaches are presented for their implementation. This is followed by a discussion of how to target and prioritize SLWM interventions and investments and how to monitor and assess progress, including area coverage. Finally, some leading methods are presented to aid in upscaling, decision-support and knowledge management.

1. Multiple benefits of SLWM

SLWM can improve management of natural resources – soil, water and vegetation – thereby reducing land degradation and desertification while simultaneously, addressing global concerns of food security, poverty alleviation, water scarcity, land use conflicts, climate change, biodiversity conservation and ecosystem function and services – on local and global scales. SLWM includes social, economic and ecological dimensions. These multiple benefits are a major argument for further promoting SLWM.

Today's agriculture faces various challenges and problems depending on the land-use type, production system, level of mechanization, impact of climate variability or change, etc. (see Box 1). In some areas, productive potential of land and water resources has been reached because of intensification and optimal use of land and water resources. Under certain land use and management practices, productivity is declining because of over-exploitation and loss of various vital ecosystem functions. In other areas, productivity remains extremely low because of low production potential and inappropriate practices.

SLWM needs to be targeted to address specific opportunities and challenges in different human and environmental contexts and regions. Furthermore, generally there is increasing pressure and demand on limited land and water resources resulting in shortages and competition for cropland between, for example, food and bio-energy production, encroachment of croplands into fragile land previously used for livestock and forestry (including steep lands and wetlands), expansion of settlements leading to loss of productive lands and shortage of water for agriculture. These pressures and impacts are compounded by the noticeable effects of climate change and variability (snow/glacier melt, incidence of flood, drought and storm events).

Land degradation, and the loss of productive land, incurs immense *costs to global society*. This results from loss of productive agricultural land and hence lost income and products; damage to infrastructure and services such as roads and water storage and increased costs of water treatment, flood prevention, and reduced resilience to shocks and climate change. All these issues make further spread and prioritizing of SLWM urgent.

BOX 1: **CHALLENGES FACED IN CERTAIN REGIONS AND ECOSYSTEMS**

Degraded pastureland in Morocco (G. Schwilch)

Today's agriculture faces many different challenges and problems depending on the land use type, the level of mechanization, the production system, and the impact of climate variability and change.

Threatened agropastoralism in North Africa, the Near East and the Mediterranean

Escalating human and livestock populations, combined with loss of traditional grazing rights have led to serious overstocking and degradation of pastures. Much semi-arid land has been ploughed for annual cropping, which is unsustainable under current practices. Livestock production systems are changing through intensification, the gradual control of animal diseases and commercialization of livestock products, particularly in peri-urban areas. Drought and desertification processes are being exacerbated by climate change.

Traditionally-cultivated, unfertilised millet field with its characteristic high-spatial variability in plant growth in Niger. (A. Buerkert)

Nutrient depletion in small-scale cropping systems in sub-Saharan Africa

Only 7 percent of sub-Saharan Africa is under cropland and the potential for further expansion of agricultural land is limited. Crop productivity is very low. Soil fertility depletion is critical especially under small-scale land use. Nutrient depletion results from a negative nutrient balance, with at least four times more nutrients removed in harvested products compared with nutrients returned as manure and mineral fertilizer.

(continued)

BOX 1: *(continued)*

TIncreasing resistance to herbicides in large-scale cropping in South America

Massive land use changes such as deforestation owing to soybean cropping have exacerbated land degradation in Argentina, Bolivia, Brazil and Paraguay. This land use change alters both the water cycle and the regional climate, enhancing aridity and desertification in many of the already water-stressed regions in South America. Expanding large-scale mono-crop agriculture is not only a driver of deforestation, but a major threat to soil health and quality through the impact of fertilizers and pesticides. Worrying is the increase in herbicide-resistant weeds, pushing farmers onto a new pesticide treadmill.

Grazing in Central Asia. (HP. Liniger)

Susceptible mountain pasture ecosystems in Central Asia

Mountain ecosystems are highly vulnerable and sensitive to human-induced pressures as demonstrated by an increasing occurrence of natural disasters (mudflows, landslides, floods), rapid biodiversity losses, reduced water resources and soil degradation. After the breakdown of the Soviet system, large agrofood complexes were dismantled and cooperative farms privatized. The reforms led to a massive shift from collective to household herds, where stock numbers are too few to warrant independent herding, and communal or family herding has not yet developed. This often leads to overgrazing on pastures near homesteads, while distant pastures remain unused.

Traditional irrigated paddy rice terraces in Bali, Indonesia. (HP. Liniger)

Paddy rice in Asia: pressure to increase productivity while reducing methane emissions

In many countries of the Pacific, East and South Asia, irrigation has a long history, closely linked to rice cultivation. Rice is the most important staple food in the world and is under pressure to increase productivity to feed future

(continued)

BOX 1: *(continued)*

demands. Rapid population growth, limited arable land and continuous increase in demand for food in the past 50 years have driven an unprecedented expansion of the area under irrigation; although this has slowed recently. An additional threat is that paddy rice fields make a significant contribution to atmospheric methane, one of the most potent greenhouse gases.

Depopulation in Portugal (University of Aveiro & Escola Superior Agrária de Coimbra)

Increasing land abandonment in European rural areas

Out-migration from European rural areas to cities, specifically from mountainous areas, causes a number of problems, including ageing of the population, abandonment of traditional agro-silvo-pastoral practices, accumulation of inflammable material and therefore risk of forest fires. Another threat is the increasing lack of supervision, control and protection of the mountains, for which local communities traditionally took responsibility. Forest fires can become a major driver of land degradation processes.

Acquaculture in the Philippines. (W. Critchley)

Aquaculture and coastal ecosystems in Southeast Asia

Aquaculture can be more environmentally damaging than exploiting wild fisheries. There are concerns regarding waste handling, side-effects of antibiotics, competition between farmed and wild animals, and accumulation of fish-waste. Also, aquaculture is becoming a significant threat to coastal ecosystems. About 20 percent of mangrove forests have been destroyed since 1980, often the result of the increase in shrimp farming. The use of wild juveniles and 'trash fish' for feed production can have major food security implications for the local population. Aquaculture may compete with other land uses as well as with tourism and recreational activities, especially in coastal areas.

(continued)

BOX 1: *(continued)*

Logs that have been felled to open new fields with traditional slash and burn technique in Santa Cruz Bolivia. (FAO, Photo-Database)

Loss of natural forests in Latin America and the Caribbean

The Amazon Basin contains the world's most extensive tropical rainforest encompassing unique biodiversity. However, the rate of deforestation is one of highest in the world. Between 1990 to 2005 the region lost almost 64 million ha, or 7 percent, of its forest area. Commercial farmers have cleared large areas for soybean exports in Brazil, Bolivia and Paraguay, for coffee in Brazil, and for bananas in Central America, Colombia, Ecuador and the Caribbean. Small-scale farmers also cause deforestation by employing slash-and-burn practices to extend their agricultural land into forests. With the increasing global demand for food, fuel and fibre, forest-rich countries in South America will continue to lose forests to large-scale industrial agriculture and cattle ranching. For many land users in the world it is currently more economically beneficial to clear forests than to keep them. On a global basis rainforests are of more value to the international community than to the local population – thus there is a conflict of interest that must be resolved.

It cannot be ignored that a number of *successful SLWM technologies and approaches* have already been developed worldwide, building on generations of local and farmer experiences and modern scientific knowledge that sustains and increases productivity, enhances food security to meet the increasing demands (for food, fodder, fibre, energy, and construction materials). While the direct benefits of SLWM for livestock and forest production, rural livelihoods and GDP are reasonably well known, there is inadequate knowledge and recognition of the *multiple direct and indirect social, economic and environmental benefits of SLWM* at local, national and global levels.

As combating degradation may not provide sufficient motivation for land users and planners to invest in SLWM, it is important to demonstrate the multitude of benefits to stimulate governments, planners, technicians and land users to mobilize resources and prioritize their interventions. These benefits have been classified by the Millennium Ecosystem Assessment as the "socio-cultural, productive, regulating and supporting" services provided by ecosystems. Box 2 illustrates the multiple benefits of SLWM by providing various examples from around the world.

Social-cultural benefits – SLWM safeguards and allows continued evolution of cultural and natural landscapes and their livelihood systems, preserves cultural heritage and provides ecotourism opportunities, supports social learning and interaction, builds community spirit, stems out-migration, builds and valorises indigenous knowledge and innovations.

Economic benefits (productive services) – SLWM safeguards agricultural production (food, fibre, fodder), provides energy and water, reduces off-site damage and disaster risk, provides income-generating opportunities, thereby increasing food security while reducing poverty.

Ecological benefits (regulating and supporting services) – SLWM optimizes water, biomass and nutrient cycling, builds healthy soils, replenishes ground and surface water and mitigates and assists adaptation to climate change (carbon sequestration; resilience).

SLWM positive impacts on different scales – from local to watershed, landscape up to the global level.

BOX 2: THE MULTIPLE BENEFITS OF SLWM

Socio-cultural benefits

Cultural site on the Loess Plateau, China. (HP. Liniger)

Cultural site on the Loess Plateau of China. Cultural landscapes embody traditional values, knowledge and experience gained over centuries. Cultural and natural landscapes provide cultural identity. SLWM helps keep alive cultural and natural landscapes and protect cultural heritage, valorise indigenous knowledge and production methods, and enhance ecotourism.

Abandoned terraces resulting from migration in Lanzarote, Canary Islands. (W. Critchley)

SLWM (in combination with improved marketing opportunities) can contribute to the maintenance of cultural landscapes and social structure and therefore reduce outmigration, particularly of young men from rural areas to areas of economic opportunity (cities, foreign countries, etc). Terraced landscapes, for example, would not fall into disrepair because sufficient labour would be available to maintain them.

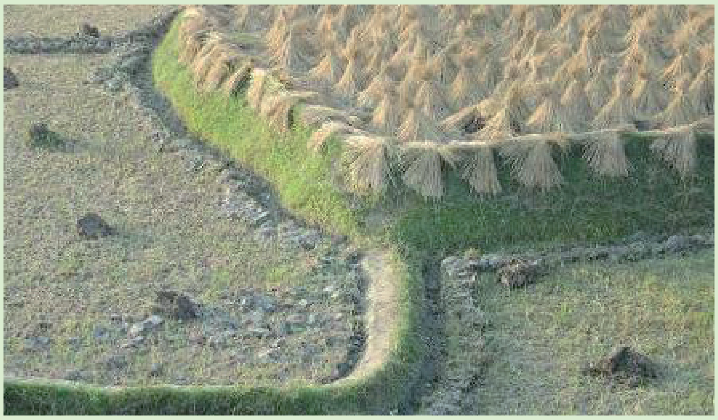
(continued)

BOX 2: *(continued)*

Economic benefits

Rice harvest in Nepal (HP. Liniger)

Optimized biomass and nutrients as well as water and carbon cycles are prerequisites for long-term productivity. SLWM helps increase food security, primarily for smallholder farmers; provides local energy and provides local fresh and clean water.



Soil erosion on cropland, Switzerland. (HP. Liniger)

SLWM can reduce disaster and off-site impacts on people and their livelihoods close-by or thousands of kilometres away (such as the costs caused by downstream floods or dust storms). Improved land management – soil and water conservation – can minimize downstream flooding and improve water resources for downstream users.

(continued)

BOX 2: *(continued)*

Ecological benefits

Torrential flooding of a river in Tajikistan. (HP. Liniger)

Water regulation – SLWM helps preserve soil moisture (for plant production) and increase primary production. It also regulates river, lake and groundwater levels; regulates water discharge from highland to lowland areas, and through these reduces floods and increases baseflows.

Agroforestry sequesters carbon over many years, Kenya. (K. Mutunga)

Soil carbon sequestration – SLWM helps reconstitute carbon pools in soil and vegetation cover; decreases atmospheric CO_2 and global warming. The potential of SLWM for C-sequestration depends on the practices implemented. The plantation of trees in an agroforestry system or afforestation can sequester carbon between 1-2 tonnes/ha/year over 50 years depending on the tree species and the natural environment.

(continued)

BOX 2: *(continued)*

Ecological benefits

A wide variety of land management practices conserving soil, vegetation, biodiversity and water. (Kenya, HP. Liniger)

Conservation of soil, vegetation, biodiversity and water – SLWM helps mitigate soil degradation and enhances soil development; increases soil moisture, enabling soil development and functions; enhances primary production and nutrient cycling; preserves above- and below ground biodiversity.

TABLE 1: POSSIBLE EFFECTS OF RAINWATER HARVESTING ON ECOSYSTEM SERVICES

Ecosystem services	Possible benefits of rainwater harvesting...
Supporting	Enhancing the primary productivity of the land, increasing green water flow
Provisioning	Enhancing crop productivity, food supply and income Increasing water and fodder for livestock Increasing rainfall infiltration, thus recharging shallow groundwater sources and baseflow in rivers Regenerating landscapes increasing biomass, food, fodder, fibre and wood for human consumption
Regulating	Enhancing infiltration, evaporation, recharge and baseflows in rivers Reducing flood incidence Reducing soil erosion and sedimentation Habitat for soil biota, beneficial predators and pollinators and their functions Bridging water supply in droughts and dry spells
Cultural	Supporting spiritual, religious and aesthetic values Creating green oasis or mosaic landscapes that have aesthetic value

Source: Table adapted from UNEP, 2009

An example of SLWM's potential, Table 1 shows the possible effects of rainwater harvesting on ecosystem services.

2. Principles and examples of successful SLWM

An increase in land productivity must be based on the principles of SLWM, which are improved water, soil fertility, plant management and micro-climate. These require appropriate SLWM technologies and implementation approaches that are based on these principles. If followed SLWM increases the resilience to natural disasters and climate variability and change.

Considering the fact that the number of hungry people has reached 1.02 billion, 75 percent of whom are found in rural areas, where the primary sources of livelihood are the agricultural, forestry and fisheries sectors, the main global challenge of current and future agricultural production systems should be to increase food availability. By 2030 food availability should be increased by 50 percent and doubled by 2050. Increasing food availability does not simply mean increasing food production. It means simultaneously ensuring that food currently produced reaches the consumer. Better distribution of food can increase the current world's food availability by about 30–45 percent, without any additional water, land or energy. The best potential lies in reducing pre- and post-harvest losses in developing countries, and food wastage in developed countries. Nevertheless, food production must increase, and therefore land and water productivity must be enhanced.

SLWM aims to increase land productivity for food, fodder, fibre and fuel in all land-use types, namely crop, grazing, forest and mixed land, while providing socio-cultural, economic and ecological benefits at various scales. Efforts to increase land productivity should be based on an integrated approach that combines the principles of improved moisture and water-use efficiency and maintains water quality and supply, soil health and fertility. This includes soil life and biological activity and plant, livestock and biodiversity management as well as improved micro-climate.

There are three options for increasing overall production: expansion of agricultural area, intensification of the production, and diversification of production systems.

Expansion of the productive area implies conversion from one to another land use, notably expansion of cropland into grazing and forest land and wetlands. This may provide substantial short-term benefits but leads to eventual degradation of fragile lands, and increased human and environmental risk and vulnerability.

Intensification of agricultural production is an important strategy for enhancing overall land productivity. It is often associated with increasing specialisation and use of external inputs such as irrigation technologies, fertilizers, agrochemicals and mechanization. As demonstrated by the 'Green Revolution' of the 1970s in Asia, where the introduction of high-yielding crop varieties was successful for several years, especially for the more wealthy land users. However, it was detrimental to the poor and to the environment and was accompanied by loss of valuable ecosystem services (biocontrol, soil life and function, water quality and recharge). Intensification of agricultural production systems should be based on the principles of SLWM.

Diversification of production systems implies enrichment of the production system related to species and varieties, land-use types and management practices. An important strategy is to make optimal use of a given land area. However, this requires substantial learning and adaptation to avoid competition and to optimize production and land use both spatially (multiple habitats, associations of plant species, varieties, livestock breeds and multi-storey systems) and over time (rotations, improve pastures, tree crops). It includes an adjustment in farm enterprises to increase farm income and reduce income variability. This can be achieved by exploiting new market opportunities and existing market niches, diversifying production and on-farm processing and other farm-based, income-generating activities.

Diversified farming systems (such as crop–livestock integration, agroforestry, intercropping, crop rotation) enable farmers to broaden their agricultural base, reduce the risk of production failure, attain a better balanced diet, use labour more efficiently, procure cash for buying farm inputs and to add value to their produce. Recently the value of biodiversity has been recognized for crop, grazing, forest and aquatic systems, efforts to enhance agrobiodiversity at habitat, species and genetic levels. Attention is focussed on optimizing the beneficial interactions and functions that ensure system resilience and contribute to food and livelihood security.

In most regions of the world, further expansion of agricultural land is restricted, therefore intensification and diversification of production should be focused upon. Intensification has been achieved in several regions leading to increased food production; although with various trade-offs or detrimental effects on the ecosystem. Yet, in sub-Saharan Africa, intensification has not significantly addressed the intertwined problems of low productivity, degradation and poverty. Arguably, diversification of the production system has the greatest potential, through more efficient and flexible use of natural resources and potential for continuous local adaptation.

The economic orientation and the sociocultural characteristics of the land user determine which SLWM interventions make the most sense. In a given area and land use, the appropriate intervention measure will differ between a land user with a small area of land producing for subsistence and a large-scale semi-industrial company producing for the export market. Nonetheless, the biophysical principles behind sustainable use of land and water resources are the same. This section presents the SLWM principles and technologies for various land-use types as well as the main challenges and threats such as climate change.

SLWM technologies and approaches

Successful SLWM requires appropriate technologies and implementation approaches that are based on the main principles of sustainable land and water management – improved water, soil fertility and plant management and micro-climate.

SLWM technologies can be differentiated into four types of conservation measures: agronomic, vegetative, structural and management. Usually, agronomic and vegetative measures require lower investment and are more easily established and should be given priority over more demanding structural measures such as terraces. Structural measures should be promoted primarily where other measures are insufficient on their own. Furthermore, SLWM technologies are ideally combined with vegetative or agronomic measures for protection and to improve soil fertility and water management. Management measures are especially important on grazing land and in forest and woodlands. Frequently conservation measures are implemented together, combining different functions and creating synergies. Effective SLWM technologies are insufficient for the successful promotion of SLWM; they require an appropriate *SLWM approach* as discussed in the last part of this section.

Worldwide there are many varied and *successful SLWM technologies and approaches* both traditional or innovative. They are not widespread, and there are no blue print solutions, although a number of principles for 'sustainability' emerge as elaborated in the following paragraphs. Success will depend on flexible technologies and approaches that can be adapted to local ecological and socio-economic conditions such as climate, tenure or market orientation. They should address immediate soil and water threats and specific and broader development goals. Land users are varied having different resource endowments, needs and aspirations: from those without land, to smallholders and large commercial enterprises. They require a basket of options from which to choose and combine. However, the successful upscaling of technologies depends on securing tenure, markets and access to land and water resources.

In the following section the best-known and most promising technologies are described for different land-use types and an overview given of the different approaches. However, the list does not claim to be comprehensive.

Principles and examples of successful SLWM technologies for various land-use types

Rainfed and irrigated cropland

The global area of cropland is estimated to be over 1.5 billion ha of the world's surface and is increasing through expansion into forests, wetlands and grazing lands. To ensure global food security it is crucial that the productivity of cropland increases, especially in small-scale, often subsistence production systems. Large-scale production systems aim to produce at maximum yield levels. Efforts must be made to sustain those levels, since large-scale crop production, as maintained in North America, South America and parts of Asia and Europe, is crucial for overall global food production.

To ensure food security the *soil fertility* of the cropland must be increased or maintained. The lowest average productivity of cropland is found in sub-Saharan Africa, in small-scale systems, because of low inherent soil fertility of the land, compounded by severe nutrient depletion; average cereal crop yields are often below 1 tonne/ha. Replenishing soil organic matter is the key to improved soil fertility management and has multiple benefits related to soil structure, nutrient uptake, and water-holding capacity. Soil fertility and soil organic matter can be increased by manuring, composting, cover improvement, crop rotation and fertilization.

Relatively low applications of inorganic fertilizer can address nutrient deficiencies (N, P, K, or trace elements) and/or organic fertilizer such as compost, manure, or nitrogen fixing crops combined with better water management or irrigation can immensely impact crop yields. Selected crop rotations, and use of crop residues and mulch, are essential to maintaining protective soil cover for as long as possible to reduce evaporation from hot, bare soils, and to optimize rainwater infiltration and groundwater recharge. These practices positively impact upon soil fertility and hence crop yields and the efficiency of water use and reduction of drought risk.

Crop diversity is an important means to enhance crop productivity. Monoculture agriculture is often susceptible to minor changes in rainfall or temperature or to extremes (hail, frost, heavy rains, strong winds). Heavy use of agrochemicals is a risk to soil health, water resources and human health. Crop variety or selection can enhance the resilience to pest and diseases and climate variability, and hence reduce the risk of crop failure. Furthermore, agricultural diversity underpins diet diversity and can lead to an improved and more balanced nutrition, especially for poor people. Crop rotations, intercropping and agroforestry, often found in traditional systems, follow the principles of diversification. Various systems have evolved under subsistence and mixed farming systems in the less developed countries, mainly to reduce the risk of crop failure. In contrast, in the highly commercial system of the developed countries, diversification has suffered and is only now being re-emphasized and restored.

Genetic modification (GM) organisms are one source of new crop varieties. GM crops have great potential, but they also bring along complications. The use of GM crops thus needs full understanding of all factors involved. In particular, the impact of GM crops on food security, poverty, biosafety and the sustainability of agriculture needs further assessment. GM crops should not be seen as a technical panacea isolated from these factors.

Water-use efficiency – the greatest potential for yield increases is in rainfed areas, where many of the world's poorest rural people live, and where enhancing soil and rainwater management is key and a priority. Decision-makers view irrigation as the panacea to low yields, degraded soils and perceived drought (i.e. failure to capture and use rainwater). Moreover, restoration of soil health and effective use of rainwater may be a more economical and sustainable option than irrigation, which can be very costly to install and maintain. Furthermore, irrigation consumes large amounts of water and competes with household and livestock, industrial and municipal needs, and can lead to water conflicts and thus governance issues.

Water scarcity is already a problem worldwide and will be further exacerbated by climate change. Water deficits resulting from inadequate and erratic rainfall can be addressed by introducing rainwater harvesting, supplementary irrigation or by improved irrigation. The key principle is to avoid water loss through runoff, evaporation from the soil or excessive and inefficient irrigation practices. Water-use efficiency must be increased in rainfed and in irrigated production systems:

1. Rainfed agriculture can be upgraded by improving soil moisture conservation by improving soil cover management (*in situ* conservation) and rainwater harvesting systems. Where feasible, supplementary irrigation can be used to optimize water productivity.

2. The total global area of cropland under irrigation is about 17 percent. However the scope of further increasing the area under irrigation is limited owing to water scarcity. The potential is restricted to smallholder irrigation schemes and to areas where irrigation is not yet widely spread, such as in sub-Saharan Africa. Increasing the water-use efficiency of existing irrigation schemes has great potential for agricultural productivity, since existing schemes are often inefficient. Large amounts of valuable water are wasted, and serious degradation such as salinity and sodicity result. Under optimistic assumptions about water productivity gains, three-quarters of the world's additional food demand can be met by improving water productivity on existing irrigated lands.

Smallholder irrigation systems are valid options in almost all types of agro-ecologic zones. They are most relevant in areas where water is a significant constraint to crop production, and where water resources are limited or overused, as in semi-arid to subhumid zones. Priority should be given to supplementary irrigation with the objective of complementing rainfed agriculture, where a small amount of irrigation water can lead to a significant increase in yield or prevention of crop failure.

Summary of SLWM principles for cropland

- Intensification of cropping through integrated soil fertility management and improved water use efficiency

- Increasing efforts to improve water-use efficiency in rainfed agriculture as well as on irrigated land: there is limited scope to increase the area under irrigation

- Crop diversity for food security, enhancing resilience and reducing the risk of crop failure

- Enhancing crop productivity of small-scale land users and

- Maintaining high (maximum) yield level and optimal productivity of large-scale systems, and

- Improving tenure security (ownership and user rights) and access to support services.

SLWM TECHNOLOGIES FOR CROPLAND

Conservation agriculture in Australia. (HP. Liniger)

Conservation agriculture – combines three principles: minimum soil disturbance (no-till), permanent soil cover and crop rotation. Each of the principles can serve as an entry point to the technology. Only the simultaneous application of all principles results in the full benefits of the concept. CA is suited to small- as well as large-scale farming. Its adoption is perhaps most urgently required by small-scale land users, especially those facing acute labour shortages.

Farm Yard Manure, Nepal. (K.M. Sthapit)

Integrated soil fertility management – is a strategy incorporating both organic and inorganic plant nutrients to attain higher crop productivity, preventing soil degradation and reducing the loss of nutrients. It relies on nutrient application through organic inputs such as compost, manure, inorganic fertilizer or the integration of nutrient-fixing crops. The integrated use of organic and mineral inputs in crop production is the best method, owing to positive interactions and complementarities.

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Furrow-enhanced rainwater (runoff) harvesting, Syria. (F. Turkelboom)

Rainwater harvesting (RWH) – refers to technologies under which rainwater runoff is collected to make it available for agricultural production or domestic purposes. RWH aims to minimize the effects of variations in water availability and to enhance the reliability of agricultural production. The basic components of a RWH system are (i) a catchment area; (ii) a concentration or storage area; and (iii) a cultivated area. When runoff is stored in the soil profile, (ii) and (iii) are synonymous. RWH covers a broad spectrum of different technologies from simple measures such as V-shaped structures with a planting pit to more complex structures such as dams; therefore the investment costs can vary considerably.

Drip irrigation system. (W. Critchley)

Sustainable irrigation – the main principle for sustainable irrigation is 'more crop per drop'. This can be achieved by more efficient (1) water collection and abstraction; (2) water storage; (3) distribution; and (4) water application in the field. Micro-irrigation schemes are water-efficient systems that apply small volumes of water at frequent intervals to the spot where roots are concentrated, e.g. in a drip irrigation system. In drip irrigation system, water flows through a filter into special drip pipes and water is discharged directly onto the soil near the plants.

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Natural vegetative strip, Philippines. (A. Mercado, JR)

Vegetative strips – may be composed of grass, shrubs and trees or a combination. Vegetative strips are often used along contours helping to hold back excessive runoff, but may also be perpendicular to wind to control wind erosion. Vegetative strips along the contour often lead to the formation of bunds and terraces resulting from 'tillage erosion', which is the downslope movement of soil during cultivation. Compared to terraces and bunds strips are easier and cheaper to establish. Vegetative strips can also be employed on flat land as shelter-belts, windbreaks or as barriers surrounding fields.

Establishment of small bench terraces, Thailand (S. Sombatpanit)

Structural barriers on sloping land are in the form of earth or soil bunds, stone lines and reduce runoff velocity and soil erosion. This is achieved by reducing the steepness and or length of the slope. Structural barriers are well-known and are common as traditional soil and water-conservation measures. Structural barriers are often combined with soil fertility improvement such as soil cover, manure or fertilizer application.

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There are 3.4 billion ha of grazing land globally, over double the extent of cropland. Compared to cropland, grazing zones are commonly located in marginal areas in terms of climate, soils, topography, fertility and accessibility. They include *natural grassland, pastures and rangelands.* Large areas of high-quality grassland are being converted to cropland, mixed farming or fodder pastures. Grazing land is being increasingly fragmented and encroached upon by crops for biofuels and for urbanization. Extensive grazing is one way of making economic use of less productive or fragile land that is not suited to more intensive agricultural enterprises.

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Organic fertilization through intercropping canavalia (a legume) with pineapples in Uganda. (W. Critchley)

Organic agriculture is a holistic production management system that avoids the use of synthetic fertilizer, pesticides and genetically modified organisms, conserves soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people. Organic agriculture includes measures such as crop rotations and enhanced crop diversity; different combinations of livestock and plants; symbiotic nitrogen fixation with legumes; application of organic manure; and biological pest control, such as 'push-pull'. All these strategies seek to make the best use of local resources.

Sustainable management of grazing land, particularly extensive grazing areas based on community property regimes, need clear land-use rights regulations. Clarification of grazing rights, and an appropriate legal framework, should take into account existing perceived rights, and allocation of some form of long-term security, which is necessary before herders can begin to invest in medium- to long-term modifications to their existing systems. Technical grassland interventions can only be useful once the land tenure situation is clarified.

SLWM for grazing land is mainly a question of management, bringing the *livestock density* into balance with climatic variability, the size of the pasture and its capacity to recover from grazing and trampling. The overall management of extensive grazing land should be carried out within a holistic framework on a landscape scale to deal with the entire range of pastoral resources and products. This includes taking into account migration territories and corridors of transhumant groups, as well as conservation of wildlife and catchment areas.

Grazing land and livestock are often mixed with other land uses. For example in sub-Saharan Africa and elsewhere, *livestock are an integral component* of strategies for food security and poverty alleviation through the provision of food (milk, meat, eggs) and services (investment for cash in times of need, security against crop failure, manure for soil amendment, draft for tillage and transport, skins and feathers for fibre and cultural functions).

Water is a major determining factor for stock management on extensive grazing land. *Improvement of water supply*, by creating water points or improving those already existing is crucial.

Pasture degradation can be reversed; although the methods are a question of debate and negotiation. Management measures are far more important in this context than structural or vegetative remedies.

Summary of SLWM principles for grazing land

- Making economic use of marginal grassland through support to extensive grazing and facilitating the mobility of livestock to avoid overuse

- Improving grazing land management by bringing livestock numbers and grazing periods into balance with climatic variability and the size and capacity of the pasture to recover from grazing and trampling (i.e. rotational grazing and strategic movement)

- Strengthening local and traditional institutions to allow effective livestock and grazing management by establishing and observing grazing and stocking rules, negotiating livestock movements and herd mobility, supporting markets for animal products, and

- Securing access to land and water, especially under common property regimes

Forest land and woodlands

Forests play a vital role in providing global ecological services. They shelter the greatest biological diversity of vegetation and wildlife, and play a crucial role in the global climate and in regional, specifically micro-climate, regulation. Therefore, the first priority must be to *reduce further deforestation* worldwide. It should be recognized that forests and woodlands are essential for meeting the basic needs for wood, fuel, medicine, fruits and other foods of people living in or near forests around the world. Forests and woodlands provide fodder for livestock and ensure water supplies. Forests are important for livelihoods, as they generate employment and contribute to economic growth, as well as having a role in providing ecological services. Forests and woodlands represent one important means of achieving food security, but there is a fine line between forest exploitation and sustainability.

This realization has stimulated national and regional and global communities to begin to take responsibility for protecting the world's forests. There is a new willingness to pay or compensate local people who depend on forest use to 'put aside the axe'. The UN-REDD, a collaborative partnership between FAO, UNDP and UNEP, supports countries in developing capacity to Reduce Emissions from Deforestation and Forest Degradation (REDD) and is a first step in taking these responsibilities.

Further new trends and *market-related instruments* that provide incentives and motivation for sustainable management of forest (and other natural) resources need further promotion and exploration. Payments for ecosystem services (PES) provide a promising solution that integrates conservation and economic aspects. Forest certification, regulations on forest use and abuse are clearly stated, such as by the Forest Stewardship Council (FSC), is another market instrument that can provide incentives for sustainable production.

Natural forests that are maintained in good condition confer excellent soil and water protection as a result of their canopies and 'floor' (ground cover). Efforts need to be applied to the maintenance of sufficient *forest cover* using technical measures.These include enrichment planting, selective felling, controlled logging and fire management, to sustain the ecological benefits of hydrology and biodiversity of a healthy forest system.

Sustainable management of forests is primarily a question of management. *Community-based management* is especially required in developing countries, where forests are the basis of livelihoods. Clear land and tenure rights are important prerequisites. Forest management should be a part of comprehensive and sustainable

Spread of Themeda grass with high fodder value after fire and protection against overgrazing in East Africa (HP. Liniger)

Grassland improvement includes the 'improvement' of extensive natural grassland by propagating high value local grasses and legume species and varieties or introducing adapted, non invasive exotic species. Grassland improvement is carried out along with sown pasture, common in commercial mixed farming and more intensively managed grassland. Techniques involve temporary suppression of existing vegetation (by fire, hard grazing, herbicides or mechanically, alone or in combination) and varying degrees of disturbance of the soil surface; fertilizer is often used.

Moving herds of mixed livestock with different grazing preferences, Kenya. (HP. Liniger)

Stocking rate regulation and management of the spatial and temporal distribution and composition of livestock are the basis for grazing management. The amount and composition of livestock a particular area can carry is not dependent on its botanical composition alone, since the management objectives of the livestock owners should be taken into account as well as the availability of other resources and seasonal fluctuations of water. Well-distributed water points and seasonal availability of water (from small dams) facilitates the movement of livestock. Stocking must be seen in the context of the entire available area and management decisions made based on local knowledge. Extensive grazing is managed at the landscape rather than at the local scale.

land-use planning and management at the national and regional level. All relevant sectors should participate in improving and designing appropriate policies and mechanisms. Clear delimitation of the forest area is a prerequisite.

Planted forests and smallholder plantations provide an important asset especially for fuelwood and commercial timber production. As long as they are not perceived to be a direct substitute or alternative for forest, they can be encouraged and will reduce the pressure on the natural forests.

Summary of SLWM principles for forest land and woodlands

- Halting of further deforestation
- Ensuring balance of trees, understory and litter to guarantee good ground cover and re-growth
- Conservation of natural forest and associated biodiversity does not exclude the sustainable use of these resources
- Community-based management, especially in areas where forests are the basis of livelihoods
- Improving land ownership and user rights of land users and communities living around the forests.
- Establishing integrated forest management plans to reduce pressure on natural forests, including zones for planted forests and clear delineation and buffer zones between forest and cropland
- Considering market and non-market approaches including forest certification (with clear regulations) for sustainable forest management and

Large-scale afforestation with hillside terraces in Eritrea. (Mats Gurtner)

Afforestation and sustainable plantations are mainly commercial or for environmental and protective use, or for rehabilitation of degraded areas. The sustainability and value of new planted forests depends on what they replace; the replacement of a natural forest with a plantation will hardly be an improvement on land use. The following technical aspects need to be considered:

- sustaining soil fertility by confining harvesting of forest products to stem wood; soil conservation measures; and application of fertilizer, etc.;
- proper harvesting planning, that is careful citing of extraction routes and felling methods;
- selection of species focusing on diversity of trees to enhance their resilience;
- creating natural corridors to enhance biodiversity especially in industrial plantations; and
- forming fire breaks to limit the extent of fires, these are often combined with access roads.

Students observing the sustainable use and ecology of rattan, Democratic Republic of Congo. (Robert Nasi)

Sustainable forest management ensures that goods and services derived from the forest meet present-day needs. At the same time their continued availability should be secured as well as their contribution to long-term development. This will involve administrative, legal, technical, economic, social and environmental aspects of the conservation and use of forests. The main techniques used for sustainable management are spatial zoning for various users; restricted interventions; protective measures; best practices in the harvesting of non-wood forest products; planning of grazing management; improving governance, etc.

- Effective wildfire protection by way of preventive forestry (managing fuel load, firebreaks and prescribed fire).

Mixed and integrated systems

As noted, different land-use types can be combined in mixed and or integrated farming systems (such as integrated crop–livestock system, agroforestry, intercropping, and crop rotation). Mixed and integrated systems optimize the use of the biomass and nutrient cycles within a production system. The components within the system interact to create synergies, thus allowing the best use of resources. The waste products of one component serve as a resource for the other. For example, manure from livestock is used to enhance crop production (improve soil fertility), while crop residues and by-products (grass weeds and processing waste) are supplementary feed for animals. Furthermore, a mixed or integrated system diversifies production, enabling farmers to broaden the base of their agriculture, to attain a better balanced diet, to use labour more efficiently, to produce cash to buy farm inputs and to add value to products. They are best suited to cope with climate and or market variability and to reduce the risk of production failure.

Summary of SLWM principles for mixed or integrated systems

- Making full use of synergies by integrating various land uses: combining crop, tree and fodder production (agroforestry); combining productive with recreational services, combining productive and protective purposes

- Optimizing biomass and nutrients as well as, carbon and water cycles

- Diversifying production

- Increasing resilience of the production system to cope with variability (climate, market, demography) and

- Reducing the risk of production failure

Multi-story cropping system with coconut, papaya, banana, coffee and pineapple in the Philippines. (J.D. Rondal)

Agroforestry (AF) describes a land-use system where woody perennials are integrated with agricultural crops or animals for a variety of benefits and services, including better use of soil and water resources, multiple fuel, fodder and food products, and provision of a habitat for associated species. Usually there are both ecological and economic interactions between the components of the system. AF embraces a wide range of practices such as contour farming; multi-storey cropping; (relay) intercropping; multiple cropping; bush and tree fallows; parkland; home gardens. Many of these practices are traditional land-use systems.

Stall feeding of dairy cows, Uganda (W. Critchley).

Integrated crop-livestock systems optimize the use of crop and livestock resources through interaction and creation of synergies. The waste products of one component serve as a resource for the other. Manure from livestock is used to enhance crop production (improving soil fertility), while crop residues and by-products (grass weeds and processing waste) are supplementary feed for the animals. Other forms of integrated systems exist apart from crop-livestock systems, for example aquaculture.

SLWM technologies as a response to environmental threats and vulnerabilities

Land management systems should be designed to deal with environmental threats such as floods, heavy rains, dust storms or droughts that may be further exacerbated by climate change. Thus more than ensuring land productivity, SLWM technologies increase resilience to climate variability and change and contribute to disaster prevention.

The impacts of current environmental threats, triggered – or made worse by – *climate change*, are different in each region. Drought and water scarcity may be exacerbated in many areas, while the frequency of floods or landslides, resulting from high rainfall events, may increase in humid areas. Climate change and variability are already, or are likely to, negatively affect the basic resources of food production, namely soil, water and biodiversity. On the other hand, some regions may benefit from more favourable conditions, such as form new cropping options at higher altitudes, or more rainfall in areas previously facing drought. However, increased variability is already, and is likely to be, a major challenge worldwide.

To adapt to climate change agricultural systems need to be resilient to both excess water (owing to high intensity rainfall) and lack of water (as a result of extended drought). Soil cover creates favourable microclimates to buffer extremes. Soil organic matter is the key element behind responses to both threats, as it improves both water-holding capacity and soil stability at the field level. Diversified systems over space and time such as crop rotations; agroforestry; crop-livestock integrated systems; landscape structures (vegetative and structural barriers) enhance the environment's ability to cope with risks of drought, heavy rain or winds.

Besides the positive impacts of SLWM on average agricultural production, many SLWM practices reduce the annual production variability (for example, organic practices improve soil–moisture holding capacity, or integrated pest management practices that reduce vulnerability to pests). Other SLWM practices can diversify agricultural income, for example, non-timber tree products, agrotourism, supplementary off-farm employment.

All these factors decrease vulnerability and increase the resilience of changing environmental conditions. They hence help people adapt to climate change and other environmental risks.

Many SLWM practices can simultaneously be part of an *adaptation* strategy to climate change and contribute to *mitigation*, especially those that increase soil organic matter and improve water management. This fact should therefore be used to effectively promote SLWM, and to encourage investment. The response to natural disasters and the potential increase in environmental risks and hazards may mobilize additional funds and engagement needed to promote wider adoption of SLWM. The principles of SLWM, as described in the section above, are the basis for increased resilience to environmental threats and vulnerabilities.

Knowledge gaps remain as to how resilient SLWM practices are, and how best to design and promote adaptation and mitigation processes. Nevertheless, immediate action is needed to manage existing and future risks. The principles of land management resilience, that have evolved over the last 50 years, are still relevant to modern environmental threats and vulnerabilities.

Principles of SLWM that address and cope with environmental threats and vulnerabilities:

- Water management through better soil cover, improved soil structure and water storage capacity of the soil, reduced water losses, improved water harvesting, etc.
- Soil cover enhanced by surface mulch or plant cover to protect the soil from wind, excess temperatures and evaporation loss, and thereby reduce crop water requirements and enhance soil organic matter content restoration
- Soil organic matter management to enhance soil life, increase soil fertility, improve soil structure and water infiltration and retention, and thereby enhance productivity and biomass
- Integrated soil fertility management to optimize use of organic and inorganic fertilizers enhance plant growth and reduce the risk of crop failure
- Micro-climate improvement by planting trees and shrubs (e.g. agroforestry) and better soil cover to help regulate the climate and reduce the impact of extreme events by reducing the impact of strong winds in humid and dry areas, protecting against high temperatures and radiation and moisture loss in dry and warm areas
- Species variety and diversity, resulting from the use of resilient crop varieties, tree species or animal breeds such as drought-tolerant and early-maturing cereals, and high-yielding seeds; plant and animal diversity to cope better with changing pests and diseases, and
- Income diversification: practices diversifying income and reducing risks of production failure e.g. non-timber tree products, agrotourism, and supplementary off-farm employment.

BOX 3: EXAMPLES OF SLWM TECHNOLOGIES THAT FOCUS ON ENHANCING THE PRODUCTION SYSTEM'S RESILIENCE TO CLIMATE CHANGE

Community reforestation, Brazil – response to floods and landslides

Many people from Brazil's interior have moved to Rio de Janeiro, and now live in slums 'favelas' with poorly constructed houses on steep hillsides. The rapid growth of the favelas has led to deforestation, soil erosion and landslides, which in turn has caused sedimentation, flooding and wet areas with mosquitoes. The city created the Community Reforestation Project in 1986 to control erosion and reduce the associated landslide and flood risks by the reforestation of erosion-prone areas of the city. The project employs residents and reintroduces native tree species, best suited for erosion control.

(continued)

BOX 3: *(continued)*

Photo by W. Critchley

Dry seedbed, Bangladesh – managing the risks of early season dry spells

Dry seed bed for transplanted wet (aman) season rice (known as T. aman rice) is one of the preferred adaptation options for managing the risk of delayed onset of monsoon rains and early season dry spells. Dry seedbed practice with minimal supplemental irrigation helps farmers keep seedlings ready for transplanting immediately after the onset of monsoon rains, even if the rains are delayed. This farmer innovation was improved by local research institutions to ensure robust seedlings and suitability for heavy, textured soils.

Photo by Yang Zihui.

Vegetative sand barriers against wind erosion in Gansu Province, China

North China is suffering from severe land desertification, which is bringing immense economic losses to dryland agriculture and is damaging the railway line. The railway department raised funds to construct tall living barriers. The vegetative barriers are bushes and trees of an appropriate height and penetrability, suitable for dry and sandy conditions. These sand barriers are an effective sand fixation technology to protect fields and infrastructure from drifting sand.

Successful SLWM approaches

Effective SLWM technologies alone are unable to promote SLWM successfully, there also needs to be an appropriate SLWM approach that defines methods involved in promoting and implementing an SLWM technology. This approach may be initiated by a project or programme, an indigenous system, a local initiative or innovation to support the achievement of sustainable land and water management. It may include different levels of intervention, from the individual farm, through the community level and the extension or advisory system at regional or national levels. The SLWM approach may be set in an international framework. Analysis of approaches should answer questions on how land users learn about improvements or 'new' technologies, how do they obtain skills to apply them? And how do they gain access to required inputs, equipment and financial resources?

SLWM APPROACHES

Priority ranking of problems for growing olives by local farmers, a community facilitator, researchers and development workers, Syria. (F. Turkelboom)

Extension and advisory services support the capacity of land users and other stakeholders to improve productivity and generate socio-economic and environmental benefits and adapt to change. The key is investment in training and extension to support the capacity of land users and other local and national stakeholders to adapt to changing environmental, social and economic conditions and stimulate local innovation. Methods used are farmer-to-farmer exchange, promoting farmer innovation and research, training 'local promoters' who become facilitators, encourage participatory technology development and so forth.

Farmers field school (S. Bunning)

Farmer field schools (FFS) for SLM comprise a group learning approach that builds knowledge and capacity among land users to enable them to diagnose their problems, identify solutions and develop plans and implement them with or without support from outside. The school brings together land users who live in similar ecological settings, socio-economic and political situations. FFS provides opportunities for learning-by-doing. Extension workers, SLM specialists or trained land users facilitate the learning process.

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Farmer sharing experiences about the implementation of vegetative strips with his fellow land users, Philippines. (A. Mercado Jr)

Landcare is a community-based approach focused on building social capital to voluntarily resolve local problems affecting the community while conserving land resources. The unique aspect of Landcare is its effective partnership with government and the broader society, including the business sector as a provider of financial and technical advice. In this way technical knowledge from scientific sources can be integrated into indigenous knowledge and skills of local people.

Village development plan for a comprehensive watershed development, India. (W. Critchley)

Integrated watershed management (IWM) combines a range of technological and institutional interventions that improve interaction and cobenefits between land managers upstream, and land and water users downstream. Improved private and communal livelihood benefits are generated by managing the watershed as the key landscape unit. The concept of IWM includes institutional arrangements for collective action and market-related innovations that support and diversify livelihoods.

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A community assembles to discuss the formation of a village development plan, India. (D.Gandhi)

Participatory land-use planning allows for the creation of synergies between local land users or community goals and national sectoral development goals. Combined efforts and investments are generated to address land degradation and land users' conflicts over resources on private and common property. Rather than regulating communal land with national policy, it can be regulated with stakeholder negotiation and communally binding rules for SLWM based on planning units, such as social units (e.g. village) or geographical units (e.g. watershed).

Demonstration of conservation agriculture through a farmer self help group for further promotion of the technology, Kenya. (F. Kihara)

Farmer associations and self-help groups or water user associations (WUA) share common resources or common interests. The group usually elects leaders, organizes joint events and activities, handles disputes internally and collects fees. WUA attempt to achieve sustainable use of river water and to mitigate conflicts related to the use of this resource. WUAs are recognized as grassroots institutions for community mobilization and may be considered as planning mediators, as their thematic focus and their catchment approach is a better basis than administrative boundaries. A minimal financial resource base, good governance and quality leadership are prerequisites for their successfully functioning.

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Farmers excavating Fanya juu terraces to improve crop production and to reduce runoff within the 'Equitable payments for watershed services' – Project in Tanzania. (E. Massoro)

Payments for ecosystem services (PES) or payment of ecosystems (or environmental) services are terms used for financial and non-financial mechanisms that reward land users for the generation of specific ecosystem services. PES cover positive externalities; measures taken in one place can positively impact upon another location and people benefit without having to pay, which can be perceived as a market failure. PES includes a voluntary transaction for well-defined ecosystem services (ES) between an ES buyer and an ES provider and can include carbon trading mechanisms, payments for downstream water supply. These transactions stimulate improved land and water management and biodiversity conservation. Many constraints exist to implementing PES – such as lack of clearly defined property rights, the assessment and establishment of the price for ES. Often, there is limited institutional capacity to set up payment systems.

A successful approach is characterized by being people-centred; responsive and participatory; practical; multilevel and multi-stakeholder; part of a partnership; sustainable (in its socio-economic, institutional and ecological dimensions) and dynamic. Good and promising approaches are not 'quick fix', they are based on an integrated system that take into account ecological processes and socio-economic conditions.

The need to promote adapted technologies and approaches is recognized as well as the need to address land users' *constraints and barriers to the adoption of SLWM*. A favourable enabling environment (including land-use rights, access to markets and inputs, supporting policies, etc.) is crucial for any successful SLWM adoption (AGTER 2010). An example here is the TerrAfrica strategic investment programme for SLM in sub-Saharan Africa, which is helping countries conduct stocktaking in multiple sectors with many actors, and is developing national SLM strategic investment frameworks. This then leads to the question of how to target SLWM interventions.

3. Targeting SLWM interventions

Targeting SLWM interventions requires the identification of the need for action (where and what type) as well as advantages and disadvantages of the various land uses at different scales.

Given the multiple benefits of SLWM, and cost of not addressing degradation, best SLWM practices should be promoted and implemented locally to protect land and water resources worldwide. Farmers, herders and fishers have been engaged in natural resource stewardship for generations using traditional SLWM practices. Today there is the need to increase production, to respond to population growth and increasing demands as well as natural threats and climate variability along with many other challenges. This justifies larger investments to promote the broader uptake of SLWM and to combat the use of degrading practices. Successfully targeting interventions requires the evaluation of cost-benefits for land users at the local level, as well as for a larger regional upscaling to international investments and partnerships.

Cost–benefit at the local scale

From an economic viewpoint, the cost-benefit ratio plays the central role in the adoption and spreading of SLWM; thus the objective of investments in SLWM should be to achieve positive paybacks. This requires assessment of costs and benefits (in monetary and non-monetary terms) and short- and long-term benefits of SLWM interventions. Without accurate assessment of costs and benefits, land users and planners cannot

TABLE 2: APPROXIMATE BENEFIT-COST RATIOS OF VARIOUS SLWM TECHNOLOGIES

	Benefit-cost ratio		
Technology	Short-term	Long-term	Comments
Conservation agriculture	+	++	The establishment of CA is usually only related to new machinery or hand tools and seed for new crops and cover crops. However, the availability and the affordability of these tools and seeds can be a major obstacle, especially for small-scale land users.
Integrated soil fertility management	++	+++	Even a small extra input as organic or inorganic fertilizer can have an immediate impact on crop production. However, profitability is closely linked to the price.
Agroforestry	+	+++	The establishment of seedling nurseries and distribution of plants at community or catchment levels need to be taken into account as well as the community or individual cost of protecting planted trees from livestock and fire.
Vegetative strips	+	++	Vegetative strips can be used as cost-effective contour farming measures for the reduction of runoff or as wind barriers. They have similar effects as structural barriers (see below) but can be established at much lower cost.
Structural barriers	+/-	+++	The establishment of structural measures such as terraces, stone lines, etc. requires high initial investments in material and labour. They may be effective on steep land and in dry conditions but their construction often needs financial and or material support.

Key: effect on benefit-cost ratio = negative -, neutral +/-, slightly positive +, positive ++, very positive +++

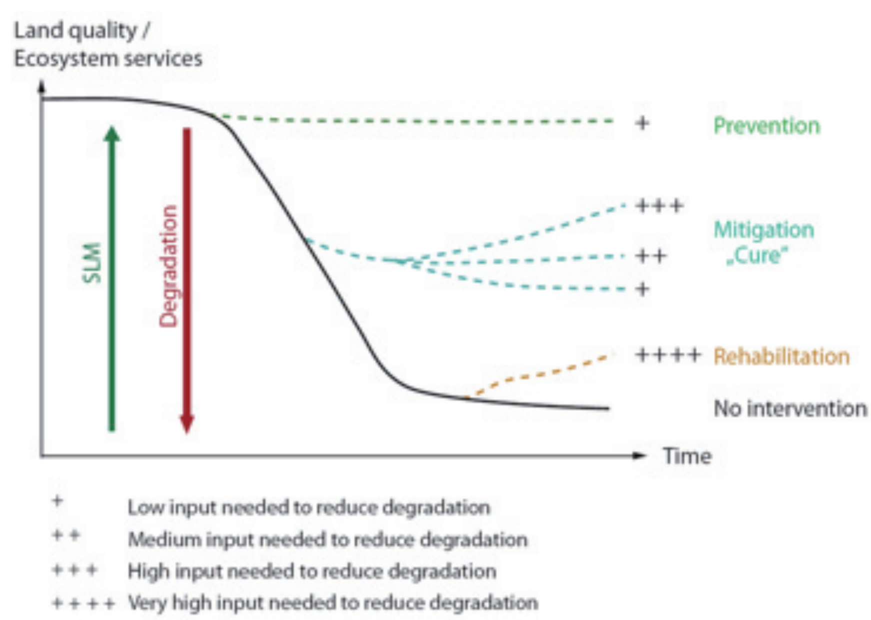
make informed decisions on the technologies and approaches that are the most viable options for a particular context (environmental and societal). While establishment costs can be partly funded by external sources, maintenance costs need to be covered locally, and direct payback ensured to avoid dependency and to stimulate self-initiative.

The cost–benefit calculation should, however, focus both on the local land user and on the wider landscape and economy. In Tunisia, for example, a study has shown that although the on-site impact of water-harvesting technologies does not justify the investments made, the government should seriously consider the off-site benefits as well. Water-harvesting technologies play an important role in flood control, reduce erosion, improve groundwater recharge and the quality of life in relatively disadvantaged rural areas. They may even halt out-migration.

Market-driven approaches, using labels or certification, can profit from significant investments made worldwide in commodity and market-based food and seed systems. These govern land management through consumer preferences and production demand. A label for organic production, or for ecological wood production (FSC), serves as an incentive to implement a technology and allows the land user to gain a higher price for certain products.

The appropriate *stage of intervention* needs to be considered. This takes into account the current level of land degradation in the area. Inputs and achievements of interventions depend very much on the stage of degradation at which SLWM interventions are made. Do the worst and highly degraded hotspots require immediate attention, or are investments needed more urgently in areas where degradation is starting? Whether considering a situation or an area a hotspot is context-specific, that is it depends on the region and ecosystem. From an economic viewpoint, experience shows that prevention and mitigation of degradation is more effective than rehabilitation of already completely degraded areas, as they require lower inputs (Figure 1).

FIGURE 1: SLWM INTERVENTION CONCERNING STAGES OF DEGRADATION AND RELATED OBJECTIVES



Stages of intervention and objective:

Prevention: to maintain natural resources and their environmental and productive function on land that may be prone to degradation.

Mitigation: to reduce the impact of already ongoing degradation, halt further degradation and start restoring resources and their functions.

Rehabilitation: to restore the productive potential of severely degraded land and bring it back into production.

Graph: Hanspeter Liniger, WOCAT

Ironically, the least spectacular, yet most cost-effective category, preventing degradation, is not perceived as a necessity, and typically it is only when degradation becomes severe that funds are mobilized. Therefore, prevention of the not-yet-degraded land should be focussed upon, especially in the highly susceptible regions of these areas. Usually the cost of rehabilitation can only be justified when people and (public) infrastructure are at immediate risk.

Investments and efforts have tended to be funded by short-duration projects. Projects or programme interventions need to break out of the typical three-year project cycle and commit to a minimum of five, or better ten or more years. SLWM interventions require *long-term commitment* and a clear strategy is needed to sustain results beyond the lifetime of the project, taking into account impacts of interventions that may only become apparent in the long term, and the benefits that accrue to future generations.

SLWM investments on the wider regional scale

Cost–benefit considerations at the regional scale focus on areas having the highest potential gains, such as those with low yields (e.g. sub-Saharan Africa and South Asia). As these are areas of extreme poverty, targeting these areas can mitigate the depletion of land and water resources and simultaneously help reduce poverty. Investments for water, in areas currently producing little water (having a potential yield increase from 1 to 2 tonnes/ha) are globally more effective than investing in areas that already exhibit high physical water productivity, with limited scope for improvement. Optimistic estimations of the scope for saving irrigation water, as an important strategy to increase the availability of water for cities and the environment, are commonly overstated. This is because the scope for water savings at the river basin scale is often limited owing to water reuse. Moreover, water-saving measures may benefit one user, while representing a loss for another.

Apart from increasing productivity from low levels of water use, there is the need to maintain highly productive systems and to prevent possible degradation or mismanagement. These areas have been, and will remain, the foundation of food security.

Bottom-up and topdown planning should find a common route to integrating local and broader perspectives and arguments. Further considerations on this aspect can be found in section 5.

There is a need to prioritize investment in limited resources and decide which practices to promote. All actors, from policy-makers to private sector investors, to land users, are interested in ensuring cost effectiveness and the best returns on investments (labour, funds, inputs, etc.). Governments and international donors and organizations are committed to giving high priority to poverty alleviation, food security and environmental protection in line with the Millennium Development Goals and, with the increased recognition of the threats of climate change, disaster-prevention is likely to be accorded greater attention.

Each country or region has its own specific challenges (and opportunities), as described in Box 1, which SLWM can help to address. Different foci are required when defining investment priorities, depending on the local and regional context. Priority-setting builds the basis for developing locally adapted SLWM strategies and action plans, as well as locally adapted implementation processes to allocate limited resources most efficiently.

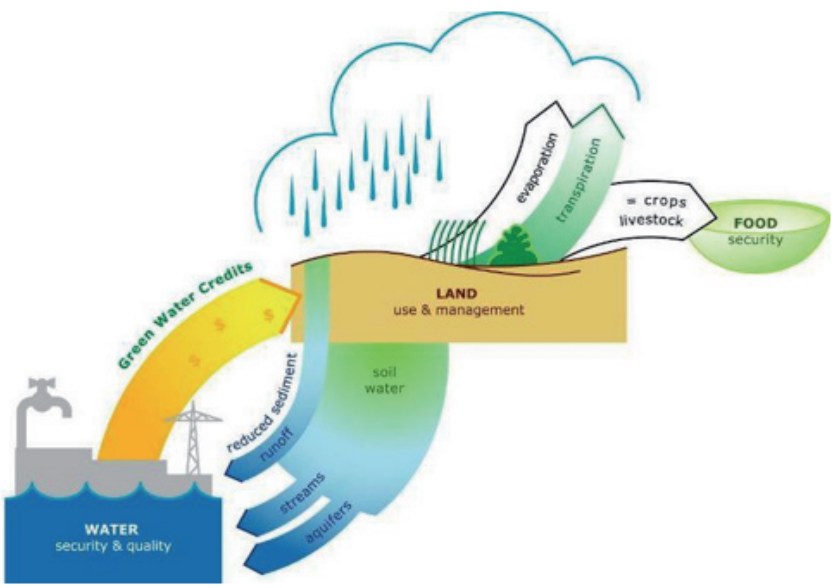
Before investing, consideration should be given to the types of degradation that are occurring and where. What are the direct causes and indirect drivers? What are the effects of past and ongoing investments in SLWM? This can help select the most appropriate interventions and where to intervene, for example: i) to address poverty degradation interactions and how to mobilize resources; ii) to promote the uptake of improved practices by relatively better-off land users and agrobusiness through regulations and incentive measures; and iii) to rehabilitate disaster-prone areas that are threatening life and infrastructure.

Investment priorities need to be set for local and regional interactions such as highland-lowland (including transboundary and large river basins), marginal-high potential areas and rural-(peri)urban areas. Some examples are presented below:

- **Rural-urban linkages** – Major flows of goods from rural areas to urban markets include food, raw materials and sources of fuel. Enormous quantities of nutrients, water and carbon are transported in the process, and are thus removed from rural areas and cause huge pollution problems in urban zones. Efforts are needed to replenish the losses and counterbalance the detrimental effects on the water and carbon balance, soil fertility and productivity.

- **Highland-lowland and terrestrial-aquatic interactions** – One-third of the global population in lowland areas survives thanks to water flowing from often distant highland areas. They depend on the inhabitants of highland areas to use available land and water resources sustainably and to maintain ecosystem services to protect hydrological regimes. Local SLWM interventions need to be combined to create synergies within a watershed including up- and downstream; on- and off-site effects. On the one hand this restricts the freedom of the local interventions (e.g. the abstraction of river water), on the other hand it offers opportunities for downstream users to support upstream SLM interventions with payments of ecosystem services that they obtain from upstream investments in SLWM.

- **Transboundary river basin management** – Where river and lake basins, watersheds and estuaries are transboundary, hilly or mountainous regions, land and water management is not purely a local or national issue but international. International river basins, covering almost half of the global land



Example: Green Water Credits

The Green Water Credits (GWC) project bridges the incentive gap between upstream and downstream water users. The project implements a regular compensation system by water users to water providers for specified water management services (ISRIC, 2010).

surface, require negotiation and joint strategies among riparian states. Such agreements are needed not only to allow a fair distribution of scarce water, or to prevent floods, but to sustainably manage land and water throughout the region. Further, transboudary river basin management could initiate collaboration beyond pure water management to broader sustainable development. Large river basin management is a continuous process that requires sustained engagement.

Example: International Commission for the Protection of the Danube River

All European waters have been managed using a river basin approach since 2000, when the European Union Water Framework Directive was adopted by the European Union, creating a new tool for the effective management of water resources. The International Commission for the Protection of the Danube River (ICPDR) is the coordinative body for the basin management plan, which involves experts from industry and agriculture, and representatives from environmental and consumer organizations as well as local and national authorities. The final plan focuses on the main transboundary problems of pollution and hydro-morphological alterations and was adopted in February 2010.

Transboundary management of mountains and highlands – Trans-boundary cooperation is useful for river basin management and generally for regional cooperation, for example in mountains. An example is the transboundary cooperation in the High Pamir and Pamir Alai mountains, which aims to promote SLWM practices that improve the livelihoods and economic well-being of the inhabitants. FAO is executing a number of projects that address transboundary land degradation issues, including the Integrated Management of the Fouta Djallon Highlands, Transboundary Agro-ecosystem Management Programme for the Kagera Basin. It also developed the UNDP led project on using farmer field school approaches to overcome land degradation in agropastoral areas of Eastern Kenya.

Example: Transboundary agro-ecosystem management programme for the Kagera River Basin

The Kagera TAMP project is funded by the GEF and partners and is executed by FAO (US$7 million over 4.5 years, 2009–2014) including the Governments of Burundi, Rwanda, Uganda and the United Republic of Tanzania, which share the river basin. The objective is to support adaptive management and the adoption of an integrated ecosystems approach for the management of land resources in the Kagera River Basin over the medium- to long-term. This will generate local, national and global benefits, notably improved agricultural production; restoration of degraded lands; carbon sequestration and climate change adaptation; agrobiodiversity conservation and sustainable use these also contributing to protection of international waters and improved agricultural production; food security and rural livelihoods. Expected project outcomes include:

- transboundary coordination, information sharing and M&E mechanisms operational and effective in promoting sustainable, productive agro-ecosystems and restoration of degraded lands;
- enabling policy, planning and legislative conditions;
- capacity and knowledge enhanced at all levels for promoting sustainable management of land and agro-ecosystems in the basin (practices and approaches); and

- improved land and agro-ecosystem management practices implemented and benefiting land users for the range of agro-ecosystems in the basin.

  - **International and global collaboration** – Beyond watershed, landscape, district or country focus, international collaboration has increased, in part as a result of increased awareness and commitment to addressing urgent global issues through the global plan of action for food security (FAO), desertification (UNCCD), biodiversity (UNCBD), climate change (UNFCCC) as well as the Ramsar Convention on wetlands. Noticeable, there is no international convention on international waters. An example of international SLWM promotion is the ‹Great Green Wall› initiative involving eleven countries in the Sahel to halt the southward advance of the Sahara with a 15 km wide and 7 000 km long tree line between Dakar and Djibouti. Broader objectives include the conservation of natural resources, strengthening of infrastructure and improving the living conditions of communities, and may assist in the prevention of ‹environmental refugees› to other areas (which is one more argument to raise global funds).

Example: World Bank

The World Bank is one of the implementing agencies of the Global Environment Facility (GEF), which is the world’s largest investor in sustainable land and water management through the land degradation focal area (LDFA) – the newest of the six focal areas. GEF has 88 projects and programmes that support sustainable land management, in particular to combat desertification and deforestation. Overall, US$332 million is invested; more than US$2.4 billion have been leveraged for co-financing that helps the global environment while simultaneously improving the livelihood base of millions of rural people who rely on the land to survive. GEF is also the largest investor in multi-country collaborations on shared water systems. Projects across multiple country boundaries have included 30 river and lake basins, five groundwater basins and 19 of the planet’s 64 large marine ecosystems. However, not enough has been invested in SLWM worldwide, especially when compared to other investments made.

Different land-use types require varying investment priorities. Much achievement has been made on individual cropland throughout the world. Yet there are still areas, especially in sub-Saharan Africa and marginal (dry or mountainous) regions where further efforts and investments are needed. Grazing land, covering more than twice the area of cropland globally, has been neglected and has deteriorated in many regions. Although well-protected in some regions and countries, forests and woodlands often have been seriously degraded as well as reduced in area as a result of land conversion. Regarding the global concerns of climate change, biodiversity and water scarcity, more importance is being attached to forests, woodland and grazing land for global investment and new payment or compensation mechanisms. Carbon trading arrangements through the Kyoto Protocol and voluntary arrangements provide a mechanism for promoting Sustainable Forest Management (SFM) practices that enhance carbon sequestration above and below ground (biomass and soil carbon). Recent examples are the REDD+ mechanisms for carbon trading, and Green Water Credits provided by water suppliers for improved land management upstream. Yet, high transaction costs are a problem for smallholders as described in Agter, 2010.

4. Assessing and monitoring SLMW

Impact assessment and monitoring

Impact assessment is required to justify investment in SLWM. There are well documented case studies concerning SLWM practices. Generally there is very limited knowledge of SLWM costs and benefits. This missing knowledge hampers investment in SLWM because of the lack of confidence in returns. It is a concern for all actors involved, from policy-makers to planners and technicians and to land users. The principle of combating land and water degradation may be accepted as valid, but without data showing its benefits, rarely provides sufficient motivation in itself for land users and planners to invest in SLWM. Thus assessment and documentation of SLWM technologies and approaches and their costs and benefits is needed to enable governments, planners, technicians and land users to mobilize resources and to make informed decisions on the most viable intervention options and to better prioritize their interventions.

Besides assessing the impacts and successes of SLWM, systematic documentation and mapping of the adoption and spread allows for identification of innovations and achievements at all spatial levels. The challenge is to obtain figures on specific and overall investments and benefits, and a global assessment of the real costs and impacts of SLWM is not yet possible. In addition, not much is known about the impacts of policies or incentives on implementation of SLWM; for example if the Common Agricultural Policy (CAP) in Europe (or other similar policies) has produced the intended impacts on the ground.

Developing a global standard for a comprehensive framework

To be able to compare and share results, monitoring and assessment methods require a standardised and comprehensive framework, integrating ecological, economic and socio-cultural aspects as well as short- and long-term and on-, off-site benefits and disadvantages. Stakeholder participation and integration of multiple spatial and institutional levels are key principles.

Before becoming more ‘participatory’ and ‘integrated’, a process that began in the 1980s onwards, monitoring & evaluation (M&E) focused on kilometres of bunds built, hectares terraced, or kilograms of yields increased. The main interest was to prove the achievements of a project using physical targets. The broader and more comprehensive monitoring and assessment (M&A) of today is focussed on provision of evidence to support decision-making, as well as being participatory and integrated (from farm and landscape to country and global level).

Researchers and practitioners have invested in developing methods for impact assessment and have recently joined forces to work towards a global standard to support the desertification convention; the UNCCD. The major global projects involved in this exercise are WOCAT, LADA, DESIRE and the GEF KM:Land. Key lessons from these and other projects include the need for a multi-scale approach that makes use of common indicators, and a variety of information sources, including scientific data and local knowledge. These global efforts and dialogues represent a first step towards a common conceptual and methodological framework. This needs to be further developed and promoted to reflect the complexity of interlinkages between human actions and biophysical processes over time and space.

A remaining key challenge is to ensure that the knowledge gained through M&A is available to those who need it most to initiate changes – including local land and water users, and decision-makers at various scales (see section 5).

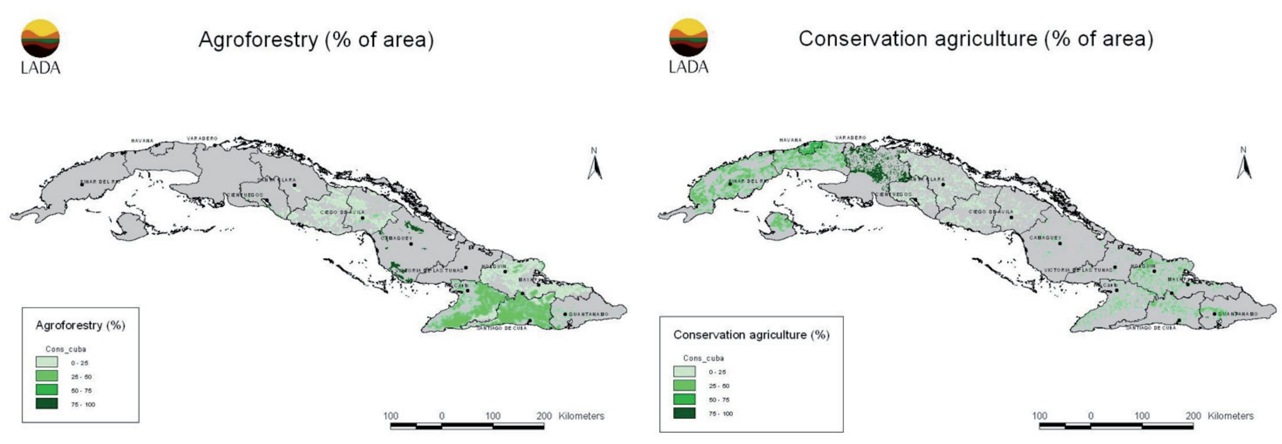
The current spread of SLWM

In view of the global extent and severity of degradation and its impact on natural resources, on the functioning of ecosystems and on livelihoods and societies, wider adoption of SLWM is urgently needed. A number of promising examples exist, as shown in the reports that form part of this series. Although substantial efforts have been made in the last few years to document available SLWM practices, their extent and coverage are poorly known. Mapping the spatial extent, including the causes and impact of land degradation and conservation, is required to provide key information for decision-making on where investments can best be made, and which SLWM practices can spread and what support is required. This must include how to overcome constraints to the widespread adoption of SLWM, and thus focus on the larger scale.

To-date, almost no overviews exist of the spatial spread of SLWM, either at the global or at the regional or national levels. There are only few compilations of the spread of selected technologies, such as conservation agriculture and organic agriculture (see Box 4). From the scarce and scattered data available it appears that, with specific exceptions, SLWM is not widespread. This emphasizes the need to promote and upscale SLWM considerably. Considering the benefits that can be gained locally, there is great potential if SLWM is expanded to all areas currently affected by, or prone to, land degradation. In view of the importance of investments in SLWM the mapping of both the distribution and effectiveness of the measures taken is imperative.

The WOCAT-LADA-DESIRE projects have jointly developed a mapping methodology that elicits local knowledge on status, drivers, causes and impacts of degradation, as well as SLWM itself. Both biophysical and socio-economic information is gathered. This allows connections to be made between SLM impacts on ecosystem services as well as human well-being. The information is compiled from knowledge of experts, land users and from existing documents and studies. Information is collected based on questionnaires on the extent of SLWM technologies and approaches, the conservation group and specific measures applied (i.e. vegetative, agronomic, structural or management), the type of degradation addressed, effectiveness and the impact on ecosystem services. Some recently developed examples are presented below.

FIGURE 2: MAPS SHOWING THE SPREAD OF AGROFORESTRY AND CONSERVATION AGRICULTURE IN CUBA. THE MAPS ARE BASED ON THE WOCAT-LADA-DESIRE MAPPING TOOL.



BOX 4: EXAMPLES OF GLOBAL ASSESSMENTS OF THE SPREAD OF SLWM

Conservation agriculture (CA)

Global: In 1999 conservation agriculture was adopted on about 45 million ha worldwide, increasing to 72 million ha in 2003 and to 111 million ha in 2009. This corresponds to an average growth rate of 6 million ha per year.

The breakdown on a regional basis is as follows:

- South America: some countries use CA on about 70 percent of their cultivated area, two-thirds of this total is permanently under CA. The leading countries are (1) Brazil: 25.5 million ha which has 60 percent of the cultivated area under CA; (2) Argentina: 19.7 million ha which 60 percent of the cultivated area is under CA; and (3) Paraguay: 2.4 million ha, about 90 percent of the cultivated area is under CA;
- North America: United States: 26.4 million ha were under no-tillage in 2004 (about 25.5 percent of the total cropland); however, only 10-12 percent is under permanent no-tillage; Canada: 13.5 million ha (about 46 percent of the cropped area);
- Australia: 12 million ha;
- Africa: mainly in Southern and Eastern Africa, with an increasing trend but the number is still low in many countries. South Africa: 368 000 ha, Kenya and Tanzania: 20 000 ha;
- Europe: 16 million ha under conservation agriculture, mostly minimum tillage with plant cover (over 12 million ha) and direct drill (about 3 million ha) and tree crops (about 1 million ha, mainly olives and other fruit trees). The leading countries are: (1) Spain: 650 000 ha on annual crops. CA is applied on about 10 percent of arable land in Spain. (2) France: 200 000 ha; (3) Finland: 200 000 ha. In Europe the spread of CA is promoted by national regulations such as in Spain, Portugal and Switzerland.

Organic agriculture

- Global: 35 million ha of agricultural land are managed organically by almost 1.4 million producers;
- Regions with largest areas: Oceania: 12.1 million ha; Europe: 8.2 million ha; and Latin America: 8.1 million ha;
- Europe: 8.2 million ha are managed organically, which is 1.7 percent of the European agricultural area. The highest national proportions of organically managed agricultural land are in: Liechtenstein, Austria, Switzerland, Sweden;
- countries with the most certified producers are India (340 000 producers), Uganda (180 000) and Mexico (130 000). More than one-third of organic producers are in Africa. On a global level, the organic agricultural land area in 2010 increased in all regions by almost 3 million ha, or 9 percent, compared to data from 2007.
- 26 percent (or 1.65 million ha) more agricultural land under organic management was reported for Latin America, mainly owing to strong growth in Argentina;
- About one-third of the world's certified organically managed agricultural land – 12 million ha – is located in developing countries. Most of this land is in Latin America, with Asia and Africa in second and third place; and
- Almost two-thirds of the agricultural land under organic management is grassland (22 million ha). The cropped area (arable land and permanent crops) comprise 8.2 million ha, which represents a quarter of the total organic agricultural land.

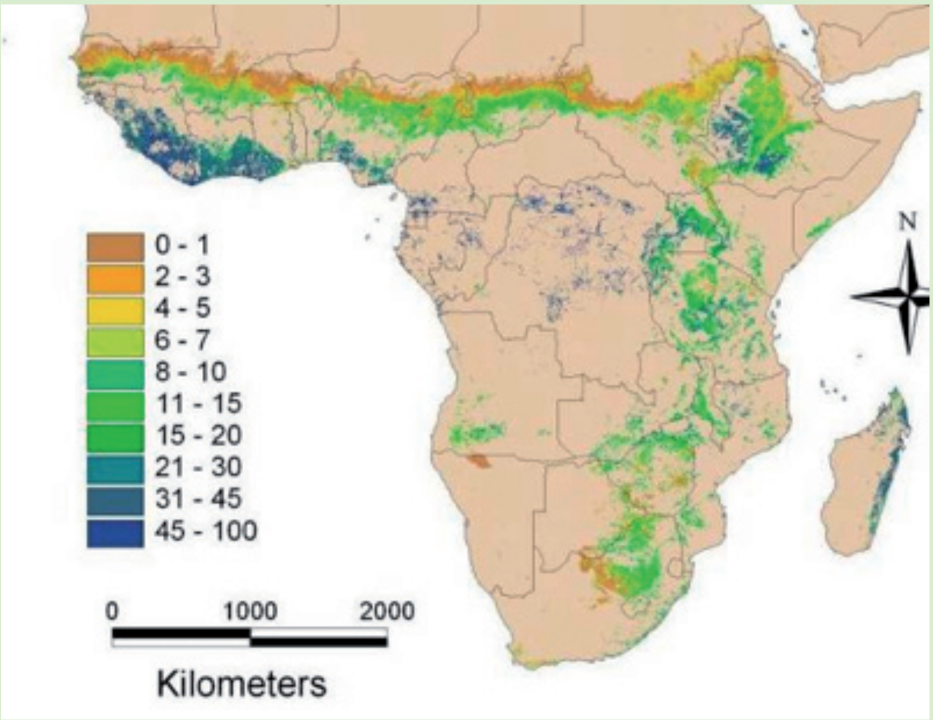
(continued)

These examples show that although some efforts have been made to collect data for specific types of SLWM, there is a vital need for a global assessment that both shows the extentand quantifies the benefits and impacts of SLWM on food security, water availability and climate change mitigation. The challenge of defining the state of the world concerning SLWM remains.

BOX 4: *(Continued)*

Agroforestry

An estimation made by Nair, *et al.* (2009) gives the current worldwide area under agroforestry as approximately 1 023 million ha.



Map showing trees in agricultural land in sub-Saharan Africa. (Zomer et al., 2009)

Sustainable forest management

In 2007 certified forests in the world totalled 306 million ha:

- Africa: 3 million ha (about 1 percent of global certified forest area) and most of it as planted forests.
- Latin America and the Caribbean: about 12 million ha (about 4 percent of global certified forest area), with an increase from 0.4 percent of the regions' forest area in 2002 to 1.2 percent of the forest area in 2007. In the Amazon about 5 percent of the timber volume is FSC certified.

Examples:

Brazil: Certification, under the principles of the Forest Stewardship Council (FSC), of 140 658 ha of native forest in the municipal district of Paragominas, in the state of Pará, will double the certified area of Amazonian forests in Brazil to 278 103 ha. At the country level, the total certified area amounts 870 511 ha, which makes Brazil the highest in Latin America, followed by Bolivia, for certified area of both native forests and plantations.

5. Knowledge management and decision support

Decision-makers need easily accessible and digestible information, based on sound knowledge and experience. Standardised methods of information presentation ease the sharing of knowledge gained by monitoring and assessment methods as described above. Successful integration of this information into decision-making processes should not be neglected.

'Stakeholders' in the context of land and water comprise all those using and managing these resources or having an interest in them in one form or another. Sustainable use of land and water is dependent on these stakeholders' attitudes, perceptions and actions. Processes of multi-stakeholder land and water-use planning, and promoting participatory approaches to SLWM, have become more important over the last few decades. Methods and frameworks have been developed by various organizations and projects.

To-date collaboration with stakeholders has focused on the planning and implementation stage, while little integration has been achieved for monitoring, evaluation or research. Moreover, monitoring and assessment have often looked selectively at the extent of degradation and depletion of land and water resources, rather than at the positive achievements of SLWM, such as improved vegetation cover, yield increase or replenished water resources.

Approaches and challenges to promote action and spread SLWM vary across scales. FAO has identified four common principles for SLWM:

1. Land-user-driven and participatory approaches

2. Integrated use of natural resources at ecosystem and farming systems levels

3. Multilevel and multistakeholder involvement, and

4. Targeted policy and institutional support, including development of incentive mechanisms for SLWM adoption and income generation at the local level.

The application of these principles requires collaboration and partnership at all levels – land users, technical experts and policy-makers – to ensure that the causes of the degradation and corrective measures are correctly identified, and that the policy and regulatory environment enables the adoption of the most appropriate SLWM measures. Expert networks and partnerships allow for the sharing of knowledge at the regional or global level. Principles either address SLWM in general, such as the WOCAT network, or focus on specific technologies such as agroforestry or conservation agriculture, or on implementation approaches such as Landcare. Most of these networks or partnerships hold regular international conferences for exchange of knowledge from local application and from scientific research.

There are a variety of excellent participatory approaches on how to motivate land users to implement and further refine SLWM technologies, for example Participatory Technology Development (PTD); but this is not sufficient on its own. To enhance food security and reduce poverty it is necessary to broaden the scope from the farm or household level to landscape or catchment, community, country or even global level.

Access to markets, better prices, the development of services and infrastructure, and knowledge networks are framework conditions necessary for the successful promotion of SLWM. Participatory and multi-stakeholder approaches are therefore required at various levels and across a multitude of institutions and sections. Partnerships involving governmental institutions, non governmental organizations (NGOs) civil society organizations (CSOs), private sector and individual land owners, and land users foster mutual respect and negotiation among these diverse stakeholder groups for a common sustainable future.

Local scale

At the local scale, land users (farmers, herders, foresters) are continuously challenged to find, select and implement the most suitable and effective ways to manage their precious land and water resources. Knowledge is partly available locally and passed from one generation to the next, but is also exchanged within the closer or wider region. Access to knowledge, from outside the local context, is not equally available to all. It depends on the support land users obtain from the government, through advisory services, professional training or technical and financial assistance. Partnerships, as described above (of governmental organization, non governmental organizations, civil society organizations, the private sector and individuals) are uncommon, but are promising. Box 5 shows an example of how stakeholders jointly identify, evaluate, select and implement potential SLWM strategies at the local scale.

The key to success lies in a concerted effort by all concerned stakeholders. It brings together local experience and innovation with scientific ecological and technical expertise, and considers socio-economic, legal and institutional framework conditions. This requires stakeholder collaboration at various levels, which may ideally evolve into long-term partnerships between governmental institutions, researchers, civil society organizations and land users. International networks may foster such partnerships. An example is the World Initiative for Sustainable Pastoralism (WISP), which aims to enhance knowledge management through being a catalyst for partnership-fostering between pastoralists, governments, NGOs, international organizations and the private sector.

Special attention needs to be paid to the process of selecting potential SLM interventions, but stakeholder involvement is crucial at all stages. The concept and examples of approaches on the ways and means to implement SLWM technologies have been presented in section 2.

(Sub-) national scale monitoring and support to decision-making

Just as local assessment of land degradation cannot simply be aggregated to a watershed or country level, SLM assessments cannot be extrapolated or upscaled easily. It is therefore important to use separate methods for local and national or global scales, but with the possibility of linking them through common indicators. Mapping allows the upscaling of local impacts of SLM and supports coarse assessments with local evidence. The spatial and temporal scale of (sub-) national and regional mapping depends on the envisaged level of planning and decision-making.

The interactive mapping methodology fostered by the WOCAT-LADA-DESIRE consortium (see section 4 above) allows joint learning of stakeholders and decision-makers involved at the planning level. Supplemented with appropriate map viewing and decision support tools, this approach can potentially be used to base SLM investment decisions on facts rather than predefined concepts or wishful thinking.

BOX 5: SELECTION OF DESERTIFICATION MITIGATION STRATEGIES IN DESIRE

Stakeholders scoring SLWM technologies against forest fires according multiple ecological, economic and socio-cultural criteria in Portugal (Photo: G. Schwilch)

The DESIRE project develops and tests alternative strategies for the use and protection of desertification-vulnerable areas. Scientists are working on 16 study sites, which serve as a 'global laboratory' for testing conservation techniques and remedial measures. The applied integrative participatory approach includes close collaboration of scientists with local stakeholder groups and ensures the acceptability and feasibility of conservation technologies, as well as a sound scientific basis for effectiveness at various scales. The methodology for a participatory process of appraising and selecting desertification mitigation strategies combines a collective learning and decision-making approach with the use of evaluated global best practices. It moves through a concise process:

1. Identifying land degradation and locally applied solutions in a stakeholder workshop with the help of a participatory learning approach.
2. Assessing existing local solutions with the standardised WOCAT evaluation tool.
3. Jointly selecting promising strategies for test implementation with the help of a decision-support tool.

The methodology has been applied on 16 study sites around the world and is preceded by field trials and monitoring, as well as regional simulation and scenario models. Information on proven and cost-effective SLM strategies that have been adopted and accepted by local stakeholders is funnelled into the policy arena and disseminated to other stakeholders.

Advanced decision-making support systems have been developed for various river basin systems (e.g. Elbe, Nile Basin, Mekong), but to a limited degree for land management systems. A bottleneck in developing such highly sophisticated tools is their data requirements, which exceed the capacity of many planning units or levels. What is needed is a flexible framework to support decision-making with the data that are easily available and manageable. Off-site issues, beyond watersheds or other units, equally need to be part of such a framework. Too little consideration has been given to proper assessment of on-site and off-site land use interactions leading to regional and global damage or benefits. Showing benefits of linking upstream (on-site) with downstream (off-site) needs more attention and will help in setting priorities for intervention and investments.

Recent modelling approaches, including agent-based modelling and scenario analyses offer opportunities for decision-makers at the planning level to assess the regional effects of applied and potential SLWM and evaluate possible changes (e.g. policies, subsidies, market prices, climate change, migration, etc.).

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