Improving planting materials and plant management (Principles)

Improve planting material and minimising impact of weeds, pest and diseases, and post-harvest losses

Through supporting:

– selection and experimentation with local germplasm and exchange of seed materials;
– nutrient and water management of improved plant species and varieties based on locally available inputs (such as manure, compost and micro-dosed application of fertilizers);
– optimising planting dates, planting geometry etc.;
– mixed plant systems to benefit from synergies between different plants (intercropping, relay planting, rotations etc);
– weed management;
– IPM (Integrated Pest Management);
– post harvest management.

Micro-climate

Micro-climate conditions can be substantially influenced by land management, particularly by practices reducing wind and improving shade. Ground cover, be it vegetative or through mulching, is the key factor in determining the micro-climate. Improved micro-climates have the following positive impacts:

1. Improve soil moisture and air humidity: Higher productivity per unit of water is achievable under humid rather than under dry air condition (Tanner and Sinclair, 1983). Evaporation (unproductive water loss from the soil surface) can be minimised by protecting the soil either with crops or mulch material. Practices including mulching, cover cropping, intercropping, agroforestry, shelterbelts, as well as no or minimum tillage protect the soil from excessive heating, exposure to wind and moisture loss, favour moist conditions around plants and improve performance and productivity.

2. Protect from mechanical damage: To protect plants from mechanical impact of heavy rain, storms and wind, dust and sand storms a 'protective' micro-climate can be created through the improvement of cover, for example establishing trees as shelterbelts and windbreaks.

3. Balancing temperature extremes and radiation: Excessive soil and air temperatures and radiation during hot seasons or spells can be reduced to favour plant (and animal) production through increased cover and shade. This is preferably achieved through increased vegetative cover as the evapotranspiration has a cooling effect, creating a favourable micro-climate. In highlands and mountains in SSA the constraint is high fluctuations with low minimum temperatures. This is particularly an issue in the highlands of Ethiopia, and in eastern and southern Africa where crops are grown over 3,000 m altitude. In southern Africa cold is an issue in winter. In these environments trees and cover can protect again cold winds - but the shading may slow down the warming up of the soil.

Creation of a favourable micro-climate (Principles)

In dry and warm areas:

– reduce strong winds and storms (avoid drying out and mechanical damage);
– protect against high temperature and radiation;
– keep conditions as moist as possible;

In humid areas:

– protect against storms (mechanical impact and soil degradation).

All of these improvements can be achieved through windbreaks, shelterbelts, agroforestry, multistorey cropping and good soil cover through vegetation or mulch.

In cold highlands and southern Africa with winter seasons land management may need to protect crops against cold winds or frost.

Improved livelihoods

There would be little importance attached to SLM - and its uptake - if the livelihoods of millions were not at stake. Increased and sustained agricultural production, the provision and securing of clean water and maintaining a healthy environment are essential for improved livelihoods in SSA. Despite the constraints and problems land users have, they are willing to adopt SLM practices that provide them with higher net returns, lower risks or a combination of both.

Costs and benefits

For improved livelihoods and for adoption and spreading of SLM, costs and benefits play a central role. Given the urgent needs in SSA, investments in SLM should aim at both short-term (rapid) and long-term (sustained) paybacks. Thus inputs for both initial establishment and continued maintenance afterwards need to be compared with benefits. Figure 8 illustrates the different positive paybacks from SLM interventions:

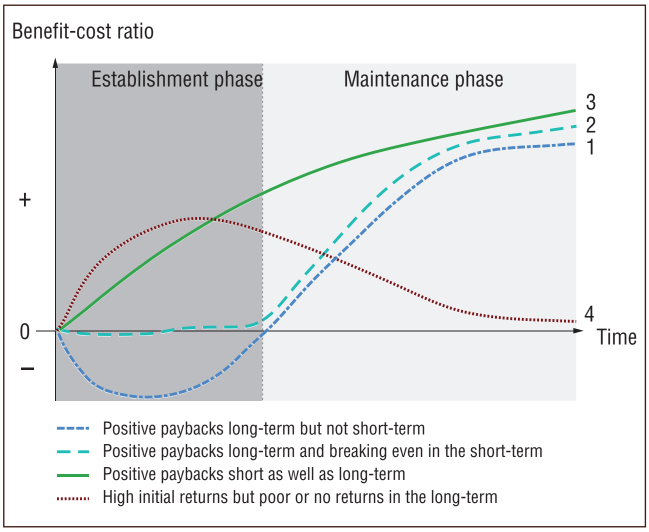


Figure 8: Benefits and costs of SLM over time, short-term establishment phase and long-term maintenance phase.

1 Long-term but not short-term: many land users in SSA might be constrained to make these long-term investments, thus might need a kick-start, where the establishment costs are partly funded by aid and external sources. The maintenance costs however would need to be covered by local sources and direct paybacks.

2 Long-term and breaking even in the short-term: thus increased benefits but also higher inputs. Depending on the wealth of the land users, the initial investments are not possible without external assistance (see scenario 1).

3 Short as well as long-term: This is the ideal case, where land users receive rewards right from the beginning. The question remains whether they need some initial support for investments (micro-credit, loans, access to inputs and markets etc). However, due to the rapid and continuous returns, land users have the possibility of paying back loans and credits quickly.

4 High initial returns but poor or no returns in the long-term: These options are tempting for land users but will lose attractiveness in the long-run as the returns are not sustained. This has occurred where high yielding varieties and inorganic fertilizers were applied but yield responses fell away after a few years (see box 'Green Revolution' page 30).

While establishment costs can be partly funded by aid and external sources, maintenance costs must be covered locally by land users to avoid the 'dependency syndrome' of continuous aid and to ensure self-initiative and ownership.

Experiences with implementation of SLM, show the need for accurate assessment of benefits and costs (in monetary and non-monetary terms) and short- and long-term gains. However, this is seldom done and data are few. Assessments of benefits and costs are very site specific and therefore pose a great challenge for the spread of SLM in SSA. Without proper assessments, land users and development agencies cannot make informed decisions about which technologies and approaches are the most viable options for a particular natural and human environment - and where incentives for land users are needed.

Inputs challenges for land users

Land users may require additional inputs to take up SLM practices. These are related to materials (machinery, seeds, fertilizers, equipment, etc.), labour, markets, and knowledge. Some of the SLM practices require few extra or different inputs and little change compared to current practices; others mean a complete change in machinery, inputs and management. Some considerations are:

- Small-scale land users in subsistence agriculture have fewer options and resources to invest than commercial or large-scale farmers with a high level of mechanisation.
- A clear distinction between initial investment for the establishment and the maintenance of SLM practices is essential. Initial investment constraints need to be overcome and may require external assistance especially when benefits mainly accrue in the long-term. Thus any material and financial support should build on currently available resources. Special attention needs to be given to poor and marginalised land users.

High labour costs for ridging and low returns (left) compared to less demanding mulching with high benefits (right). (Hanspeter Liniger)

- Labour availability is a major concern and depends on the health of people and competition with other income generating activities. Malaria, HIV-AIDS and water-borne diseases significantly affect labour productivity. Conflicts with off-farm work, including the seasonal migration of labour force (often men) can be a major constraint for SLM. Single (often female) headed rural households need practices with reduced labour inputs.

- Access to inputs and equipment such as machinery, seeds / seedlings, fertilizers, etc. is essential. Introduction of SLM is only possible if markets for inputs and products are secured.

- Access to knowledge related to SLM practices and their introduction is a prerequisite for all land users. Practices that are easy to learn, and build on existing experiences and knowledge, have the best chance of being taken up.

Apart from the costs, benefits, access to inputs, markets and knowledge, there are other elements related to improved livelihoods such as the need for practices to be:

- socially and culturally acceptable: aesthetics (a non-linear contour may be visually unacceptable for example) and beliefs (some areas are 'untouchable' because of spirits) norms and values;
- flexible enough to allow (and even encourage) local adaptation and innovation;
- clearly seen to add value to the land and to the quality of life.

Improving livelihoods (Principles)

– provision of short (rapid) and long-term (sustained) benefits
– assistance for establishment might be needed for small-scale subsistence land users if costs are beyond land users' means
– assistance for establishment if short-term benefits are not guaranteed
– maintenance costs need to be covered by the land users to ensure self-initiative

Changes towards SLM should build on – and be sensitive to - values and norms, allow flexibility, adaptation and innovation to improve the livelihoods of the land users.

Improved ecosystems: being environmentally friendly

The principles of increased production presented above, to be truly sustainable should also aim at improving ecosystem functions and services. Best practices must be environmentally friendly, reduce current land degradation, improve biodiversity and increase resilience to climate variation and change.

Prevent, mitigate and rehabilitate land degradation

Assessments in SSA show the severity of land degradation and the urgency to improve natural resources and their use through SLM (see box page 35).

Depending on what stage of land degradation has been reached, SLM interventions can be differentiated into prevention and mitigation of land degradation or rehabilitation of already degraded land (Figure 9) (WOCAT, 2007).

Prevention implies employment of SLM measures that maintain natural resources and their environmental and productive function on land that may be prone to degradation. The implication is that good land management practice is already in place: it is effectively the antithesis of human induced land degradation.

Mitigation is intervention intended to reduce ongoing degradation. This comes in at a stage when degradation has already begun. The main aim here is to halt further degradation and to start improving resources and their ecosys-

Land Degradation in Africa:
- 67% of Africa's land is already affected by land degradation. 4 - 7 % of SSA is severely degraded – the highest proportion of any region in the world.
- The cumulative loss of productivity is: 25% of cropland, 6.6% of pasture land.
- Soil degradation in Africa is attributable to: overgrazing (50%); poor agricultural management practices (24%); vegetation removal (14%); and overexploitation (13%).

Soil erosion by water and wind: mainly loss of topsoil / surface erosion, gully erosion and offsite degradation effects.
- Annual yield losses due to soil erosion estimated as averaging 6.2 %.
- Erosion by water: 46% of land area.
- Erosion by wind 38% of land area mainly in drylands.

Chemical soil degradation: mainly fertility decline and reduced organic matter content, salinisation.
- Four times the amount of nutrients removed in cropland compared to the amount returned with manure and fertilizer. Africa loses an equivalent of 4 billion USD per year due to soil nutrient mining.
- 30% of irrigated land lost due to salinisation: Kenya (30%), Namibia (17%), Nigeria (34%), Sudan (27%) and Tanzania (27%).
- Losses of irrigated land due to waterlogging: DR Congo (20%), Mauritania (50%) and Gambia (10%).

Physical soil degradation: compaction, sealing and crusting, waterlogging.

Biological degradation: reduction of vegetation cover, loss of habitats, quantity / biomass decline, detrimental effects of fires, quality and species composition / diversity decline, loss of soil life, increase of pests / diseases, loss of predators.
- Although the continent hosts only 17% of the world's forests, Africa accounted for over half of global deforestation during 1990-2000.
- In most parts of Africa, deforestation rates exceed planting rates by a factor of 30:1. The rate of 0.6 per year for the last 15 years is among the highest globally (largely in humid and sub-humid West Africa).
- 89% of deforestation is attributed to clearing for agriculture. Of these, 54% are attributed to subsistence agriculture and the other 35% to intensive agriculture.
- In South Africa and Lesotho, alien plants cover about 10 million ha (more than 8 percent of total land area), and are spreading at 5% per year

Water degradation: aridification, change in quantity of surface water, change in groundwater / aquifer level, decline of surface water quality, decline of groundwater quality, reduction of the buffering capacity of wetland areas.
- 70% of Africa's soils suffer from periodic moisture stress.
- Some 86% of African soils are under soil moisture stress.
- Water tables have dropped in many regions and many wells have dried up.
- More fluctuations in river, stream and spring flows, with more frequent flooding in the rainy season and longer periods of water shortage in the dry season.

Sources: Oldeman 1994 and 1998; Versveld et al, 1998; Reich et al. 2001; FAOSTAT, 2004; FAO, 2007; SARD, 2007; WOCAT, 2008a; WB, 2010)

Figure 9: Prevention, mitigation and rehabilitation of land degradation less than half a kilometre apart. (Hanspeter Liniger)

tem functions. Mitigation impacts tend to be noticeable in the short to medium term: this then provides a strong incentive for further efforts.

Rehabilitation is required when the land is already degraded to such an extent that the original use is no longer possible, and land has become practically unproductive and the ecosystem seriously disturbed. Rehabilitation usually implies high investment costs with medium- to long-term benefits.

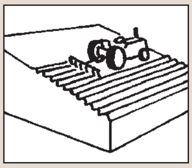
Major efforts and investments have been made in the implementation of structural measures. They are conspicuous in showing efforts made towards SLM. However they are input intensive and often could be substituted by less demanding agronomic, vegetative and management measures. As a rule of thumb priority should be given first to agronomic and / or vegetative measures with as little outside input as possible and only then apply structural measure if the 'cheaper' options are not adequate. In addition, structural measures should be combined as much as possible with vegetative or agronomic measures to protect the structures and make them directly productive (e.g. fodder grass on earth bunds). Frequently, measures can be implemented together, combining different functions and creating synergies. Combinations of measures that lead to integrated soil and water, crop-livestock, fertility and pest managements are promising as they increase both ecosystem - and livelihood - resilience.

Improve biodiversity

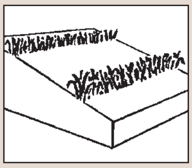
A key concern in sustainable land management and protecting ecosystem functions in SSA is conserving biodiversity. Sub-Saharan Africa has both remarkable richness and abundance of biological diversity. The world's second largest area of rainforest after South America's Amazon Basin is found in Central Africa. It shelters some of the greatest biological diversity of Africa in terms of vegetation and wildlife and plays a vital role in worldwide ecological services

Categories of SLM Measures

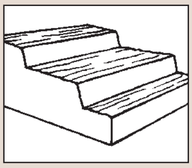
The measures for prevention, mitigation and rehabilitation of land degradation and restoration of ecosystems services can be classified into four categories (WOCAT, 2007):

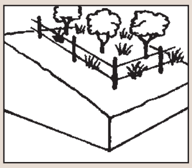
Agronomic measures: measures that improve soil cover (e.g. green cover, mulch); measures that enhance organic matter / soil fertility (e.g. manuring); soil surface treatment (e.g. conservation tillage); subsurface treatment (e.g. deep ripping).

Vegetative measures: plantation / reseeding of tree and shrub species (e.g. live fences; tree crows), grasses and perennial herbaceous plants (e.g. grass strips).

Structural measures: terraces (bench, forward / backward sloping); bunds banks / level, graded); dams, pans; ditches (level, graded); walls, barriers, palisades.

Management measures: change of land use type (e.g. area enclosure); change of management / intensity level (e.g. from grazing to cut-and-carry); major change in timing of activities; control / change of species composition.

Any **combinations** of the above measures are possible, e.g.: Terrace (structural) with grass strips and trees (vegetative) and contour ridges (agronomic).

(Owen, 2004). Furthermore, dryland biodiversity has distinguishable features that are often overlooked. These include heterogeneity, diversity of micro-organisms, presence of wild relatives of globally important domesticated species, and traditionally adapted land use systems (pastoralism, parklands, mixed farming, mixed seed cropping, etc.) (Bonkoungou, 2001; Mortimer, 2009). Sustainable management of natural forests, woodlands, wetlands, grasslands, savannas and deserts results in the protection of biodiversity and environmental quality and at the same time offers opportunities for food security and poverty alleviation. SSA has of the world's most attractive and rich national parks and reserves, which apart from their intrinsic value, offer employment and revenue from tourism.

Women are guardians of West Africa's crop diversity

Women play a dominant role in every part of West Africa's food systems. Often they are responsible for managing small parcels of land on the family farm or for growing food in small gardens around the home. At a time when diets are becoming increasingly simple, and nutritious traditional foods are being replaced by refined carbohydrates and fat, the role of women in promoting diversified diets rich in traditional crops is of vital importance (Smith, 2008).

Plant and animal biodiversity are central to human well-being, most notably in food production but also as a source of fibre for clothing, wood for implements, shelter, and fuel, and for natural medicines, as well as having strong cultural and spiritual significance. Agricultural biodiversity encompasses domesticated crop plants, livestock and fish (etc.), wild crop relatives, wild food sources, and 'associated' biodiversity that supports agricultural production through nutrient recycling, pest control and pollination. Agro-biodiversity is the result of the careful selection and inventive development of land users whose livelihood depends on the sustained management of this biodiversity. Land users value having agricultural biodiversity in their farming systems and small-scale farming is far less of a threat to biodiversity than large-scale mechanised systems (Mortimer, 2009). Promotion of crop genetic diversity is part of their coping strategies for mitigating weather unpredictability; it also spreads availability of food products over time (Bonkoungou, 2001).

Giraffes in the Amboseli Nationalpark, Kenya. (Hanspeter Liniger)

Sub-Saharan Africa is the cradle of vitally important international agro-biodiversity. It is the centre of origin of, for example sorghum (*Sorghum vulgare*) and both bulrush millet (*Pennesetum typhoides*) and finger millet (*Eleusine coracana*), as well as the cowpea (*Vigna unguiculata*) various yams, and coffee (Harrison et al., 1969,1985). There are important endemic species also, such as *rooibos* tea, which is restricted to South Africa. Because African farming depends, still, very largely on local landraces of a wide variety of crops, the wealth of its agro-biodiversity must not be underestimated. In the protection of agro-biodiversity the precautionary principle needs to be applied: maintain as many varieties of plants and domestic animals as possible for their future potential.

Climate change: a fresh challenge – a new opportunity?

Climate change is a major concern for SSA, bringing with it various new challenges. Without doubt, there is huge potential and opportunity for SLM in climate change mitigation and adaptation. Climate change science shows how important the land is, in terms of a carbon source and a carbon sink. SLM practices not only contribute to building up carbon in the land but can also give protection against climate variability. There is evidence of current

Afforestation around Mt. Kenya. (Hanspeter Liniger)

adaptations and innovation in SLM technologies and approaches, demonstrating response to climate change: this experience needs to be acknowledged, investigated and tapped (Woodfine, 2009).

The concept of dealing with environmental (including climate) change is not new to land users. Traditional SLM practices can serve as an entry point for efforts to enhance system resilience, but will not be enough on their own, in the medium to long-term, for coping with climate change (FAO, 2009b). Strong transdisciplinary research efforts are needed, and additional emphasis should be given to monitoring and assessment (M&A) of off-site impacts of land degradation and SLM. Increased occurrence of extreme climatic events leading to disasters such as floods, land slides, mud flows and droughts also have national, and global, impacts. The role of SLM to prevent and / or reduce disasters must be acknowledged and investigated.

Mitigation and adaptation are discussed in the following section. Mitigation in the context of climate change means reducing greenhouse gases and thus their impacts, while adaptation means amending practices to cope with the impacts of changing climate (FAO, 2009b). SLM is concerned with both. With respect to mitigation, SLM practices can help sequester carbon in the vegetation as well as in the soil; in terms of adaptation suitably versatile and 'climate proof' SLM technologies and approaches are key to maintaining productive land and ecosystem function. SLM is good for farmers: it is helpful in the challenges posed by climate change also. Climate change acts as a spur to encourage better SLM – and it provides new funding windows for the reasons set out above.

Mitigation of climate change: Land users in Sub-Saharan Africa can contribute to global efforts to mitigate climate change by adopting SLM technologies that sequester carbon both above and below ground and avoid emissions of greenhouse gases. Various SLM technologies presented in this document can make major contributions, and need to be acknowledged as such. While mitigation of climate change is not a priority for poor farmers, the same SLM practices that benefit them directly, can help sequester carbon and reduce emissions.

Sequestering carbon above and below ground can be achieved through:
- afforestation, reforestation and improved forest management practices;
- agroforestry and silvopastoral systems, integrated crop-livestock systems which combine crops, grazing lands and trees;
- improved management of pastures and grazing practices on natural grasslands, including optimising stock numbers and utilising rotational grazing to maintain ground cover and plant biodiversity;
- improved tillage practices – such as conservation agriculture – to increase soil organic carbon (SOC) content through permanent soil cover with crops and mulch, minimum soil disturbance, fallows, green manures, and crop rotations; and
- micro-dosing with fertilizer to increase biomass production, yields and SOC.

Reducing emissions of carbon dioxide through:
- reduced land degradation and deforestation, loss of biomass and OM;
- reduced use of fire in rangeland and forest management;
- reduced machine hours for agriculture by adoption of conservation tillage practices / conservation agriculture systems; and
- practices requiring lower doses of agrochemicals.

Climate change in Africa

Africa's climate ranges from humid equatorial regimes, through seasonally-arid tropical and hyper-arid regimes, to sub-tropical Mediterranean-type climates. All these climates demonstrate various degrees of variability, particularly with regard to precipitation. Africa is especially vulnerable to climate change because of its geographic exposure, low incomes, and greater reliance on climate sensitive sectors such as agriculture.

Climate change:

- Africa is considered at more risk from climate change than other regions.
- During the 20th century, most of Africa already experienced a warming of approximately 0.7°C and large portions of the Sahel experienced a rainfal decrease: East and Central Africa an increase in precipitation.
- Droughts and floods have increased in frequency and severity across Africa over the past 30 years, particularly in southern and eastern Africa (around the coast of the Indian Ocean e.g. Mozambique).
- Predictions regarding climate changes are uncertain but scenarios indicate additional temperature increase of 3-4°C and rise of sea level by 15-95 cm by 2100, and an increase in the frequency of extreme weather events – droughts, floods and storms. The length of growing period is likely to decrease in many parts of SSA.
- The general trend of currently marginal areas becoming more marginal is apparent. In aggregate, Africa will be left worse-off.

Climate change mitigation:

- Most African countries contribute little to the world's total greenhouse gas emissions.
- Land use change and deforestation in Africa account for 64% of its greenhouse gas emissions.
- 30-50% of savanna is burnt annually in Africa accelerating the release of GHG and the loss of organic matter. Carbon stocks in the soil are more than twice the carbon in living vegetation.
- Above ground carbon stock has been reduced through deforestation and replacement of land use systems with less permanent biomass. Afforestation and reduced deforestation in Africa have the potential to reduce global GHG emissions by about 6.5%.
- Soil organic carbon in most of SSA's drylands has been reduced in the topsoil - due to land degradation - to less than 1%, whereas SLM can increase SOC to a level of 2-3%.

Climate change adaptation:

- Adaptation to climate variability and extremes is not new to land users in SSA. Yet traditional coping strategies are not sufficient, additional and innovative efforts are required.
- Adaptation to high climate variability and more extreme events are a major concern in SSA especially on marginal agricultural prone to desertification.

Environmental impacts of climate change:

- physiological effects on crops, pasture, forests and livestock (quantity, quality)
- changes in land, soil and water resources (quantity, quality)
- changes in and shifts of vegetation
- increased weed and pest challenges
- sea level rise, changes to ocean salinity

Socio-economic impacts of climate change:

- decline in yields and production
- increased number of people at risk of hunger and food insecurity
- reduced marginal GDP from agriculture
- fluctuations in world market prices
- migration and civil unrest

(Sources: Desanker and Magadza, 2001; Desanker, 2002; Stern, 2007; FAO, 2009a; FAO, 2009b; Pender et al., 2009; Woodfine, 2009; WB, 2010)

Reducing emissions of methane and nitrous oxide through:

- improved nutrition for ruminant livestock;
- more efficient management of livestock waste (manure);
- more efficient management of irrigation water on rice paddies; and
- more efficient nitrogen management on cultivated fields, reducing volatile losses through better agronomic practices (rotations, fallows, manuring and micro-dosing).

To increase carbon stocks above ground, afforestation, reforestation and agroforestry systems are important, but additional attention must be given, and efforts made, to restore biomass and ground cover on grasslands (through improved grazing land management) as well as permanent cover on crop land (see SLM group on 'Conservation Agriculture'). Carbon markets for funding the spread need to be further explored and are emerging opportunities (refer to page 45) for land users to implement SLM.

Soil organic carbon (SOC) increase can be achieved by implementing SLM practices which add biomass to the soil, cause minimal soil disturbance, conserve soil and water, improve soil structure, enhance activity and species diversity of soil fauna – increasing 'biological tillage' and strengthen mechanisms of carbon and nutrient cycling (see SLM group on 'Integrated Soil Fertility Management') (FAO, 2009a).

Adaptation to climate change: Adaptation to climate change means dealing with its impacts and this can be achieved by adopting more versatile and climate change resilient technologies – but also through approaches which involve flexibility and responsiveness to change. In this latter context land users need to be aware of alternative SLM practices.

Implementing SLM practices which increase soil organic matter will be beneficial in adapting to climate change. These will increase 'the resilience of the land', and thus 'climate proofing' through enhanced fertility, soil structure, water infiltration and retention, soil life and biomass production (Scherr and Sthapit, 2009).

Surface mulch or plant cover established under several SLM practices generally protect soil from wind, excess temperatures and evaporation losses, reduce crop water requirements and extend the growing period. This could prove critical in many areas of SSA affected by climate change. All practices improving water management increase resilience to climate change. This can be achieved through reducing water losses and harvesting of rainwater to improve water storage in the soil but also in reservoirs.

Practices diversifying incomes and reducing risks of production failure, for example integrated crop-livestock systems and improved or more appropriate plant varieties provide additional opportunities for adaptation.

Thus avoiding or reversing any form of land degradation, thereby improving the ecosystem health as well as improving the micro-climate, increases resilience to climate variability and change, and results in improved agricultural production. There is no one silver bullet solution to solve the problems which land users face due to climate change. However, the following generalisation can be made: Virtually all of the SLM practices identified in these guidelines contribute (in varying degrees) both to climate change mitigation and adaptation strategies.

Synergies between adaptation and mitigation: Synergies between reduced land degradation, conserved biodiversity, food security, poverty reduction and climate change mitigation and adaptation through SLM generate multiple benefits. A multifocal approach to SLM that takes into account all ecosystem services and human wellbeing is more likely to succeed than one focused exclusively on climate change mitigation and adaptation. SLM is not limited to smallholder land users; many SLM practices can make medium to large-scale commercial land use more sustainable and resilient to climate variability and can contribute to climate change mitigation.

Yet, some mitigation responses may conflict with food security – and vice-versa. For instance, plant production for biofuels leads to competition for land and water resources. Adaptation and mitigation synergies or antagonisms in agriculture, forestry, and fisheries at the global, regional, and local levels are poorly documented. Therefore further research and efforts related to knowledge management are needed to identify locations and conditions where food security adaptation and mitigation benefits intersect in a cost-effective way (FAO, 2009a; FAO, 2009b).

Climate change mitigation and adaptation (Principles)

Mitigation:

- Increase carbon stock above and below ground: improve plant cover, increased biomass, mulch, organic and green manure, minimum soil disturbance, water and soil conservation – e.g. through forestation, agroforestry, conservation agriculture, residue management.
- Reduce emissions of greenhouse gases: reduce vegetation and soil degradation, reduce fire, reduce machine hours, improve livestock and irrigation management, more efficient use of fertilizers and manure

Adaptation:

Identify and promote versatile and resilient technologies

- improve soil cover and microclimatic conditions: through mulch, crops, grass, trees
- improve soil fertility: through soil organic carbon, soil structure, nutrient cycling
- improve water harvesting, storage (in soils, reservoirs etc), and distribution
- reduce water losses: evaporation, uncontrolled runoff, leakage in irrigation systems

Encourage adaptation approaches and strategies

- give land users SLM options
- encourage local innovation

Triple-win solutions

For food security and overall development in SSA, increased land productivity for food, fodder, fibre and fuel is the urgent priority. This can be achieved by:

- Intensification of agricultural production: which still has great potential, yet there remain challenges in finding sustainable practices to continued improvements.
- Diversification of agricultural production: which can help strengthening resilience to changes (be it induced by climate, markets or policies).
- Expansion of the agricultural area: though this has very limited potential. In most regions good and suitable land has already been used.

For intensification, diversification, and / or expansion, four land productivity principles guide the way towards SLM in SSA, namely (Figure 10):

1. improved water productivity and water use efficiency on rainfed and irrigated land;
2. improved soil fertility;
3. improved plant management: plant material and control of weeds, pest and diseases;
4. improved micro-climate.

This underlines the fact that good cover conditions, improved soil organic matter, water saving or harvesting, nutrient recycling, and improved management of plants, livestock and control of pests and diseases are key entry points for best SLM practices. SLM practices are related to maximum soil cover, minimum soil disturbance, enhancement of biological activity, integrated plant nutrition management, development of integrated crop / livestock / agroforestry systems, flexible management of traditional pastoral systems and reduced use of burning (Woodfine, 2009).

Best land management practices are win-win-win solutions. All SLM practices presented in Part 2 aim at tripple win: improving productivity, livelihood and ecosystems. Figure 11 summarizes the issues related to productivity, ecosystem concerns, livelihood and human well-being. Table 3 lists principles, strategies and practices to improve land productivity and yields.

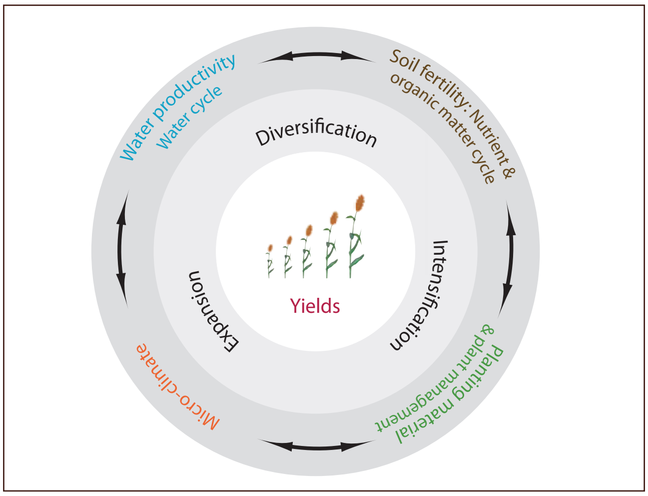


Figure 10: Key to improved land productivity and food security.

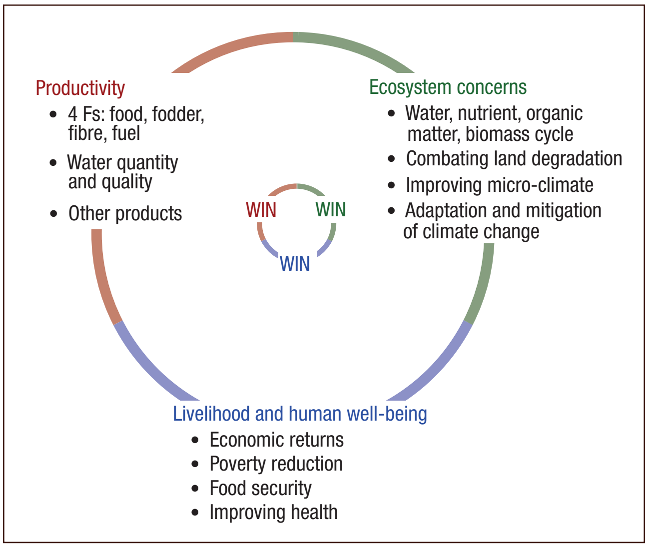


Figure 11: Win-win-win solutions for livelihood, ecosystem and productivity.

Table 3: Strategies and practices to improve land productivity and yields

Principles	Aim	Strategies	SLM practices (Case studies see Part 2)
Water use efficiency and productivity	**Increase plant water availability in rainfed agriculture**	minimise run-off; maximise rainfall infiltration and storage in the soil	soil cover, composting, contour cultivation, conservation agriculture, life barriers, soil / stone bunds, terracing, *fanya juu*, etc.
		reduce non-productive evaporation	good plant cover, intercropping, mulching, windbreaks, agroforestry, etc.
		harvest & concentrate rainfall through runoff to crop area or for other use	planting pits, semi-circular bunds, microbasins, contour bunds, stone lines, vegetative strips, trash lines, runoff and floodwater farming, small dams, etc.
	Increase plant water availability in irrigated agriculture	minimise water losses from irrigation system	lining of canals, deep and narrow instead of shallow and broad canals, good maintenance, pipes, etc.
		efficient and effective application of water	watering can irrigation, drip irrigation, micro sprinklers, low pressure irrigation system, improved furrow irrigation, supplemental irrigation, deficit irrigation, etc.
		recharge aquifer / groundwater; water collection to enable off-season irrigation	small dams, farm ponds, subsurface tanks, percolation dams and tanks, diversion and recharging structures, etc.
	Increase plant water uptake	increase productive transpiration	afforestation, agroforestry, optimum crop rotation, intercropping, improved crop varieties, planting date, etc.; vigorous plant and root development through soil fertility and organic matter management, disease and pest control, weed management, etc.
Soil fertility	**Improve nutrient availability and uptake**	reduce nutrient mining and losses	composting and manuring (e.g. corralling) integrated fertility management (organic combined with inorganic), microfertilization, green manuring, rotations including legumes, improved fallows with leguminous trees and bushes, enrichment planting of grazing land, rotational grazing, etc.
		improve soil nutrient holding capacity and plant nutrient uptake capacity	minimum to no till, improve soil biotic activity, increase soil organic matter, mulching, manage avoid burning (residue management), etc; adapted varieties, etc.
Plants & their management	**Maximise yields**	use best suited planting material and optimise management	choice of species, varieties, provenances, etc.; short season varieties, drought tolerant varieties, pest and disease resistant varieties, etc.; planting dates, plant geometry, fertility and water management, etc.
Micro-climate	**Create favourable growing conditions**	reduce evapotranspiration	windbreaks, agroforestry, hedges, living barriers, parklands, good soil cover, dense canopy, etc.
		optimise temperature and radiation	agroforestry, vegetative and non vegetative mulch, etc.
		reduce mechanical damage of plants	windbreaks, barriers, vegetative and non vegetative mulch, etc.