PRINCIPLES FOR BEST SLM PRACTICES

For all major land use systems in Sub-Saharan Africa (SSA) including cropland, grazing land, forest and mixed land, the focus of SLM is on increased land productivity and improved livelihoods and ecosystems.

Table 1: Land use in SSA (2000)

Land use	Percentage cover
Permanent pasture	35
Arable and permanent cropland	8
Forested	27
All other land	30
Total	100

(Source: WRI, 2005 and FAO, 2004)

Increased land productivity

African cereal yields, particularly in the Sudano-Sahelian region, are the world's lowest. For SSA, increasing agricultural productivity for food, fodder, fibre and fuel remains a priority given the fast growing demand, widespread hunger, poverty, and malnutrition.

The primary target of SLM for SSA is thus to increase land productivity, improve food security and also provide for other goods and services. There are three ways to achieve this: (1) expansion, (2) intensification and (3) diversification of land use.

Expansion: Since 1960, agricultural production in Sub-Saharan Africa has been increased mainly by expanding the area of land under farming (Figure 2). Limited access and affordability of fertilizers and other inputs (e.g. improved planting material) has forced African farmers to cultivate less fertile soils on more marginal lands; these in turn are generally more susceptible to degradation and have poor potential for production. There is very limited scope for further expansion in SSA without highly detrimental impacts on natural resources (e.g. deforestation).

Intensification: The last 50 years have witnessed major successes in global agriculture, largely as a result of the 'Green Revolution' which was based on improved crop varieties, synthetic fertilizers, pesticides, irrigation, and mechanisation. However, this has not been the case for SSA (Figure 2).

Diversification: This implies an enrichment of the production system related to species and varieties, land use types, and management practices. It includes an adjustment in farm enterprises in order to increase farm income or reduce income variability. This is achieved by exploiting new market opportunities and existing market niches, diversifying not only production, but also on-farm processing and other farm-based, income-generating activities (Dixon et al., 2001). Diversified farming systems (such as crop–livestock integration, agroforestry, intercropping, crop rotation etc.) enable farmers to broaden the base of agriculture, to reduce the risk of production failure, to attain a better balanced diet, to use labour more efficiently, to procure cash for purchasing farm inputs, and to add value to produce.

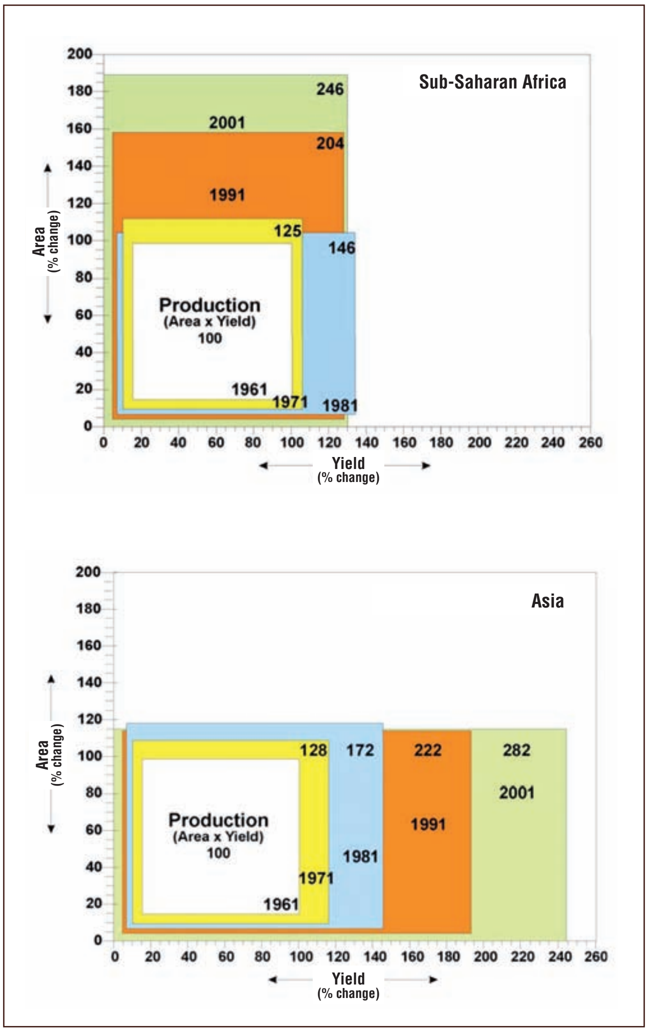

Figure 2: Comparison of changes in cereal production in SSA (above) due to changes in area and yield (1961=100) with those in Asia (below). (Source: Henao and Baanante, 2006)

Expansion, intensification and diversification to increase agricultural productivity imply:
– increasing water productivity (water use efficiency),
– enhancing soil organic matter and soil fertility (carbon and nutrient cycling),
– improving plant material (species and varieties), and
– producing more favourable micro-climates.

Agricultural production and food security in SSA today and in the future

– Population growth is 2.1% per annum: doubling of the population expected within 30-40 years.
– In 1997-99, 35% of the population had insufficient food to lead healthy and productive lives.
– Average cereal yields: of 1 tonne per hectare.
– Cereal availability per capita decreased from 136 kg/year in 1990 to 118 kg/year in 2000.
– 73% of the rural poor live on marginal land with low productivity.
– Approximately 66% of Africa is classified as desert or drylands; 45% of the population lives in drylands.
– In 2000, US$ 18.7 billion were spent in Africa for food imports and 2.8 million tonnes of food aid: this represents over a quarter of the world's total.
– 83% of people live in extreme poverty; the number of people and thus their demands on food, water and other resources are increasing.
– Energy needs and the demand for firewood and biofuel are growing even faster than food needs. This increases deforestation and pressure on vegetation, crop residues and on manure (which is often used as fuel). In many countries 70% of energy comes from fuelwood and charcoal.
– Climate change, with increased variability and extremes, puts an extra constraint on food security.
– Land is the source of employment for 70% of the population.
– Agriculture will remain the main engine of growth at least for the next few decades.
– Land degradation is severe and ongoing.
– Land productivity, food security, poverty reduction / human development and wellbeing are strongly linked

(Sources: Henao and Baanante, 2006; Castillo et al, 2007; FAO, 2007; IAASTD, 2009b TerrAfrica, 2009; WB, 2010)

Water use efficiency

Water use efficiency is defined as the yield produced per unit of water. Optimal water use efficiency is attained through minimising losses due to evaporation, runoff or drainage. In irrigation schemes, conveyance and distribution efficiency addresses water losses from source to point of application in the field. Often the term water productivity is used: this means growing more food or gaining more benefits with less water. Commonly it is reduced to the economic value produced per amount of water consumed.

In the drylands of the world, water is – by definition - the most usual limiting factor to food production due to a mixture of scarcity, and extreme variability, long dry seasons, recurrent dry spells and droughts, and occasional floods. Water scarcity and insecure access to water for consumption and productive uses is a major constraint to enhancing livelihoods in rural areas of SSA (Castillo et al., 2007; FAO, 2008b). Hence, improving water use efficiency to minimise water losses is of top-most importance.

Under the principle of the water cycle, all water remains within the system. However, at local and regional level, water can follow very different pathways and losses may be high, depending on land (and water) management. In relation to agriculture, water is often referred to as being 'blue' or 'green'. Blue water is the proportion of rainfall that enters into streams and recharges groundwater – and is the conventional focus of water resource management. Green water is the proportion of rainfall that evaporates from the soil surface or is used productively for plant growth and transpiration (Falkenmark and Rockstöm, 2006; ISRIC, 2010).

Figure 3 illustrates three major sources of water loss in agricultural production, namely surface runoff, deep percolation and evaporation from the soil surface. Surface runoff can, however, sometimes qualify as a gain when it feeds rainwater harvesting systems. Similarly, deep percolation of water can be a gain for the recharge of groundwater or surface water. However, the main useful part ('productive green water') is the soil water taken up by plants and transpired back to the atmosphere.

Many land users in developing countries could raise water productivity and water use efficiency by adopting proven agronomic and water management practices. There is considerable potential especially under low yield conditions where a small increment in water translates into a significant increase in yield (Figure 4).

Expansion to steep slopes, intensification and diversification all combined in the Uluguru Mountains of Tanzania (Hanspeter Liniger).

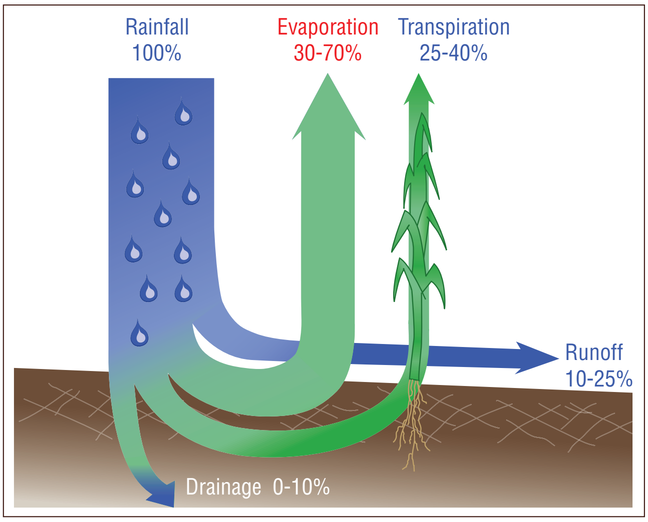

Figure 3: Productive water (transpiration) and water losses (evaporation and runoff) without water conserving measures in dry lands.

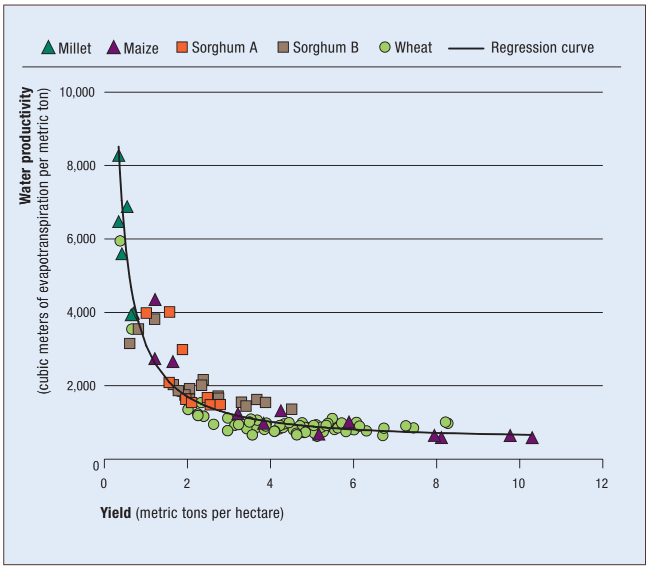

Figure 4: Water productivity and cereal yield under various management and climatic conditions: for cereal yields of less than 1 t/ha four to eight times more water is used per tonne compared to yields above 3 t/ha as the proportion used for grain (cf vegetative production is much less). (Source: Rockström et al., 2007)

Local practice combining deep tillage and ridging stops runoff but increases evaporation from the bare soil surface; under the plants the protected soil remains moist (Hanspeter Liniger).

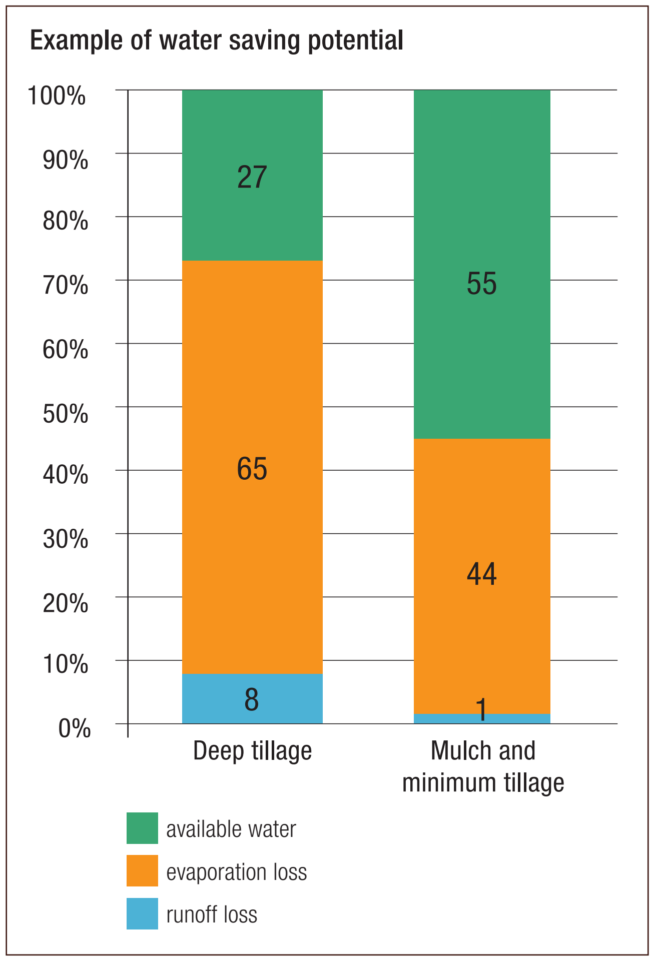

Figure 5: Water use efficiency in a semi-arid to subhumid environment comparing a local practice (deep tillage) with conservation agriculture comprising minimum tillage for weed control, mulching and intercropping of maize and beans. Under the local practice, total water loss was over 70%, with evaporation being the main contributor to this. Under mulch, the loss was reduced to 45%.The productive use of the water was doubled, and yields in some seasons even tripled (Gitonga, 2005).

Wastage of scare and precious water – the disturbed water cycle

- Depending on land management practices, between 30 and 70% of the rainfall on agricultural land in semi-arid areas is lost as non-productive evaporation from the soil surface or from intercepted rainfall.
- An additional 10-25% of that rainfall is lost as direct runoff without being harvested.
- As a result of these losses, only 15% to 30% of rainfall is used for plant growth.
- This low water use efficiency is closely linked to low or degraded soil cover, leaving soils exposed to solar radiation, wind and heavy rain storms and subsequent aridification and land degradation. Soil organic matter has major effects on water infiltration and nutrient availability.

(Sources: Liniger, 1995; Rockström, 2003; Molden et al., 2007; Gitonga, 2005)

Water use efficiency in rainfed agriculture: In Sub-Saharan Africa, some 93% of farmed land is rainfed (Rockström et al., 2007). The water challenge in these areas is to enhance low yields by improving water availability for plant growth: that is to maximise rainfall infiltration and the water-holding capacity of soils - simultaneously reducing surface erosion and other land degradation. Full response to water investments is only achievable if other production factors, such as soil fertility, crop varieties, pest and disease control, and tillage and weeding practices are improved at the same time (Figure 5).

Given the large water wastage through inappropriate land use practices there are significant opportunities to raise yields under rainfed agriculture and improve degraded ecosystems through better water management. All best practices in this regard fall under the five strategies listed in the box below. Management of rainwater is a main entry point into SLM.

Each of the best practices presented in Part 2 of these guidelines include improved water management and water use efficiency; some of them are particularly focused on coping with water scarcity - such as water harvesting in drylands or protection against evaporation loss and runoff, through conservation agriculture, agroforestry or improved grazing land management.

Different strategies for improved rainwater management

Divert / drain runoff & runon

Where there is excess water in humid environments, or at the height of the wet seasons in subhumid conditions, the soil and ground water can become saturated, or the soil's infiltration capacity can be exceeded. Thus safe discharge of surplus water is necessary. This helps avoid leaching of nutrients, soil erosion, or landslides. It can be achieved through the use of graded terraces, cut-off drains and diversion ditches etc.

Impede runoff (slow down runoff)

Uncontrolled runoff causes erosion - and represents a net loss of moisture to plants where rainfall limits. The strategy here is to slow runoff, allowing more time for the water to infiltrate into the soil and reducing the damaging impact of runoff through soil erosion. It is applicable to all climates. This can be accomplished through the use of vegetative strips, earth and stone bunds, terraces etc.

Retain runoff (avoid runoff)

In situations where rainfall limits plant growth, the strategy is to avoid any movement of water on the land in order to encourage rainfall infiltration. Thus water storage is improved within the rooting depth of plants, and groundwater tables are recharged. This is crucial in subhumid to semi-arid areas. The technologies involved are cross-slope barriers, mulching, vegetative cover, minimum / no tillage etc.

Trap runoff (harvest runoff)

Harvesting runoff water is appropriate where rainfall is insufficient and runoff needs to be concentrated to improve plant performance. Planting pits, half moons etc. can be used. This can also be applied in environments with excess water during wet seasons, followed by water shortage: dams and ponds can further be used for irrigation, flood control or even hydropower generation.

Reduce soil evaporation loss

Water loss from the soil surface can be reduced through soil cover by mulch and vegetation, windbreaks, shade etc. This is mainly appropriate in drier conditions where evaporation losses can be more than half of the rainfall.

Water use efficiency in irrigated agriculture: Irrigated agriculture consumes much more water than withdrawals for industrial and domestic purpose. The demand for irrigation water by far exceeds water availability. Due to water scarcity in SSA, the potential demand for irrigation water is unlimited and causes competition and sometimes conflicts. This is not just a question of drinking water supplies for people, livestock and wildlife but also environmental water requirements – which keep ecosystems healthy. Currently, only 4% of the agricultural land in SSA is irrigated - producing 9% of the crops (IAASTD, 2009b). Many irrigation schemes suffer from water wastage, and salinisation is also a common problem.

Irrigated Agriculture in SSA

– The agricultural sector is by far the biggest user of water resources worldwide; around 70% of annual water withdrawals globally are for agricultural purposes.
– In SSA, 87% of the total annual water withdrawals in 2000 were for agriculture, 4% for industry and 9% for domestic use.
– In SSA less than 4% of agricultural land is irrigated, compared to 37% in Asia and 15% in Latin America.
– The irrigated area in SSA is concentrated in South Africa (1.5 million ha), and Madagascar (1.1 million ha). Ten other countries (Ethiopia, Kenya, Mali, Niger, Nigeria, Senegal, Somalia, Tanzania, Zambia and Zimbabwe) each have more than 100,000 irrigated hectares.
– About half of the irrigated area comprises small-scale systems. In terms of value, irrigation is responsible for an estimated 9% of the crops produced in SSA.
– Inappropriate irrigation can result in soil salinisation. Tanzania for example has an estimated 1.7–2.9 million hectares of saline soils and 300,000–700,000 hectares of sodic soils, some of it now abandoned. This has not only detrimental effects on agriculture but also on water supply and quality.

(Sources: World Resources Institute (WRI), 2005; Falkenmark et al., 2007; Zhi You, 2008; IAASTD, 2009b)

Water use efficiency in irrigation systems needs to be disaggregated into conveyance, distribution and field application efficiency. Improved irrigation water management requires considering the efficiency of the whole system. Figure 6 illustrates the sequences of water losses, and Table 2 indicates the efficiency of different irrigation systems.

Table 2: Irrigation efficiency of different irrigation systems.

Irrigation System	Irrigation efficiency	Installation costs
Flooded fields (e.g. rice)	20–50%	low
Other surface irrigation (furrows etc.)	50–60% and higher	low
Sprinkler irrigation	50–70%	medium-high
Drip irrigation	80–90%	high

(Source: Studer, 2009)

Given water scarcity and widespread water wastage and poor management, best practices for irrigated agriculture include the following:

1. Increased water use efficiency: in conveying and distributing irrigation water as well as applying it in the field. Conveyance and distribution can be improved through well maintained, lined canals and piping systems – and above all avoiding leakages. In the field, reducing evaporation losses can be achieved by using low pressure sprinkler irrigation during the night or early morning, and avoiding irrigation when windy. Additionally, deep seepage of water beyond rooting depth needs to be avoided.

2. Spread of limited irrigation water over a larger area, thereby not fully satisfying the crop water requirements i.e. deficit irrigation. It allows achieving considerably higher total crop yields and water use efficiency compared to using water for full irrigation on a smaller area (Oweis and Hachum, 2001).

3. Supplementary irrigation by complementing rain during periods of water deficits, at water-stress sensitivity stages in plant growth. Supplementary irrigation is a key strategy, still underused, for unlocking rainfed yield potential and water productivity / water use efficiency.

Supplementary irrigation

– Yields of sorghum in Burkina Faso and maize in Kenya were increased from 0.5 to 1.5–2.0 metric tonnes per hectare with supplementary irrigation plus soil fertility management (Rockström et al., 2003; Molden et al., 2007).
– A cost-benefit study of maize-tomato cropping systems using supplementary irrigation found annual net profits of US$ 73 in Burkina Faso and US$ 390 in Kenya per hectare. In comparison traditional systems showed net income losses of US$ 165 and US$ 221, respectively (Fox et al., 2005).

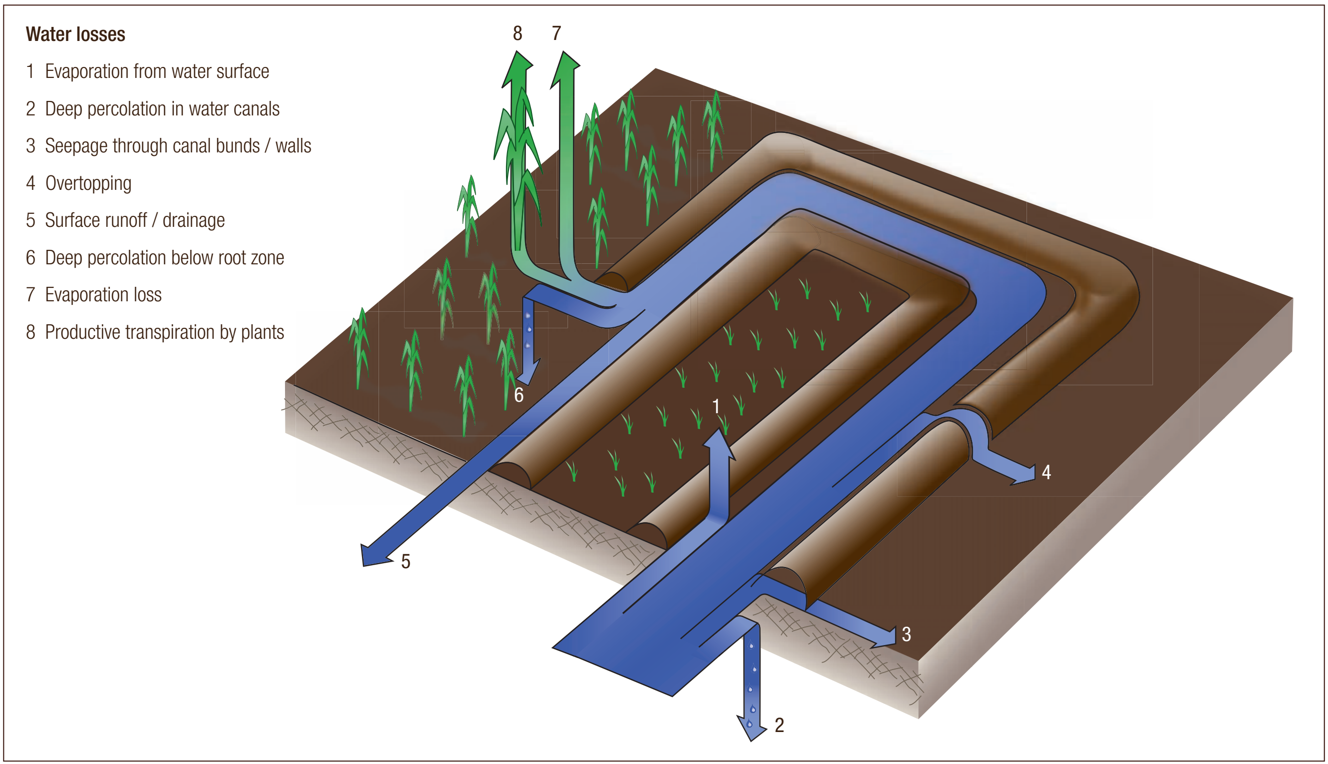

Figure 6: Water losses in irrigation systems: from source to plant illustrating the small fraction of water used productively for plant growth compared to the total water directed to irrigation systems (based on Studer, 2009).

4. Water harvesting and improved water storage for irrigation during times of surplus and using the water for (supplementary) irrigation during times of water stress. Small dams and other storage facilities as described in the SLM group of rainwater harvesting, which are combined with community level water management, need to be explored as alternatives to large-scale irrigation projects (IAASTD, 2009b).

5. Integrated irrigation management is a wider concept going beyond technical aspects and including all dimensions of sustainability. It embraces coordinated water management, maximised economic and social welfare, assured equitable access to water and water services, without compromising the sustainability of ecosystems (Studer, 2009).

Improving water productivity in rainfed and irrigated agriculture (Principles)

'More crop per drop' by:

– reducing water loss
– harvesting water
– maximising water storage
– managing excess water

Any efforts towards better water management must be combined with improved soil, nutrient, and crop management, and these synergies can more than double water productivity and yields in small-scale agriculture (Rockström et al, 2007).

There is need for a 'green water revolution' to explore the potential of increasing water use efficiency for improved land productivity. First, priority must be given to improved water use efficiency in rainfed agriculture; here is the greatest potential for improvements not only related to yields but also in optimising all round benefits. Practices that improve water availability relate to soil cover and soil organic matter improvement, measures to reduce surface runoff (see 'Cross-Slope Barriers') as well as to collect and harvest water.

For irrigated agriculture, conveyance and distribution efficiency are key additional water saving strategies. The emphasis should be on 'upgrading' rainfed agriculture with water efficient supplementary irrigation.

Soil fertility

Healthy and fertile soil is the foundation for land productivity. Plants obtain nutrients from two natural sources: organic matter and minerals. Reduced soil fertility undermines the production of food, fodder, fuel and fibre. Soil organic matter, nutrients and soil structure are the main factors influencing soil fertility. Many of Africa's soils are heavily depleted of nutrients, and soil organic matter is very low: below 1.0% or even 0.5% in the top soil (Bot and Benites, 2005).

Soil organic matter is a key to soil fertility. Organic matter includes any plant or animal material that returns to the soil and goes through the decomposition cycle. Soil organic matter (SOM) is a revolving nutrient fund: it contains all of the essential plant nutrients, and it helps to absorb and hold nutrients in an available form (Bot and Benites, 2005). Soil organic matter has multiple benefits; it is also fundamental for good soil structure through the binding of soil particles, for water holding capacity, and it provides a habitat for soil organisms.

Soil texture also influences soil fertility. The presence of clay particles influences the soil's ability to hold nutrients. Very sandy soils usually have a lower nutrient holding capacity than clay soils, and hence need particular attention in terms of soil fertility management.

Declining soil fertility: The reason for a decline in SOM and the closely linked nutrient content is simply that the biomass and nutrient cycle (Figure 7) is not sustained, meaning more material in the form of soil organic matter and / or nutrients (especially the macro-nutrients of nitrogen, phosphorous and potassium) leaves the system than is replenished. This results from various causes:

- removal of crop products and residues (plant biomass),
- loss through soil erosion,
- leaching of nutrients (below the rooting depth),
- volatisation of nutrients (e.g. nitrogen),
- accelerated mineralisation of SOM through tillage.

The gains or replenishments are derived from residues of plants grown or nutrient accumulation (e.g. nitrogen fixing), external input of organic matter, manure and fertilizer, and nutrients through the weathering and formation of the soil.

Nutrient deficit in SSA's soils

Nutrient depletion in African soils is serious:

– Soils on cropland have been depleted by about 22 kg nitrogen (N), 2.5 kg phosphorus (P), and 15 kg potassium (K) per hectare per year.
– Nutrient losses due to erosion range from of 10 to 45 kg of NPK/ha per year.
– 25% of soils are acidic with a deficiency in phosphorus, calcium and magnesium, and toxic levels of aluminium.
– Main contributing factors to nutrient depletion are soil erosion by wind and water, leaching and off-take of produce.

Low use of fertilizer:

– With an average annual application of 8-15 kg/ha, the use of fertilizer in Africa compares very poorly to an average global value of 90 kg/ha.
– Land users in Niger use manure on 30-50% of their fields at a rate of 1.2 tonnes/ha, which results in a production of only about 300 kg grain/ha.

Nutrient amount removed is higher than input:

– Negative nutrient balance in SSA's croplands - with at least 4 times more nutrients removed in harvested products compared with the nutrients returned in the form of manure and fertilizer.
– Current annual rates of nutrient losses are estimated to be 4.4 million tonnes of N, 0.5 million tonnes of P, and 3 million tonnes of K. These losses swamp nutrient additions from chemical fertilizer applications, which equal 0.8, 0.26, and 0.2 million tonnes of N, P, and K, respectively.
– Negative nutrient balance: 8 million tonnes of NPK/year.

(Sources: Sanchez et al., 1997; Sanchez, 2002; FAOSTAT, 2004; McCann, 2005; Henao and Baanante, 2006; Verchot, et al, 2007; Aune and Bationo, 2008; WB, 2010)

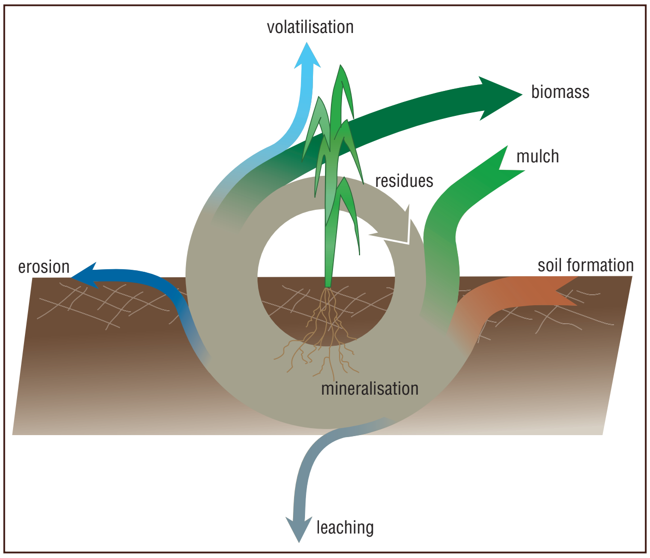

Figure 7: The nutrient and carbon cycle showing the main losses and gains / replenishments of soil organic matter, biomass and nutrients.

Enhancing and improving soil fertility through SLM: SLM practices should maintain or improve a balanced SOM–nutrient cycle, meaning that net losses should be eliminated and organic matter and / or nutrients added to stabilise or improve the soil fertility.

Replenishment of soil nutrients is a major challenge for SSA. As illustrated in the box on page 28, SSA soils have a significantly negative nutrient balance. Replenishment and reduced loss of soil nutrients can be achieved through the following options:

1. Improved fallow-systems: The deliberate planting of fast-growing species - usually leguminous - into a fallow for rapid replenishment of soil fertility. These can range from forest to bush, savannas, grass and legume fallows. The case study on 'Green Manuring with Tithonia' in Cameroon presented in Part 2 shows the importance of nutrient fixing plants planted either in sequence, intercropped or in rotation.

2. Residue management: A practice that ideally leaves 30% or more of the soil surface covered with crop residues after harvest. It requires residue from the previous crop as the main resource (thus burning is discouraged) – it also helps reducing erosion, improving water infiltration and therefore moisture conservation. There are positive impacts also on soil structure and surface water quality (see SLM group 'Conservation Agriculture').

3. Application of improved compost and manure: Compost (mainly from plant residues) and manure (from domestic livestock) help to close the nutrient cycle by ensuring that these do not become losses to the system. By building up SOM they help maintain soil structure and health, as well as fertility. Furthermore they are within the reach of the poorest farmers (see case studies on: 'Night Coralling' in Niger and 'Compost Production' in Burkina Faso).

4. Tapping nutrients: This takes place through the roots of trees and other perennial plants when mixed with annual crops (e.g. in agroforestry systems). Trees act as nutrient pumps: that is they take up nutrients from the deep subsoil below the rooting depth of annual crops and return them to the topsoil in the form of mulch and litter. This enhances the availability of nutrients for annual crops.

Composting, manuring and mulching in a banana plantation, Uganda. (William Critchley)

5. Application of inorganic fertilizer: Inorganic fertilizers are derived from synthetic chemicals and / or minerals. However there is a debate around the use of fertilizer in SSA. The mainstream view is that fertilizer use needs to be increased from the current annual average of about 9 kg/ha to at least 30 kg/ha. The other side points towards undesirable environmental impacts, such as soil acidification, water pollution and health problems (IAASTD, 2009b). However, without a combination of organic matter application and inorganic fertilizer, soil fertility is unlikely to meet production demands: thus the concept of 'Integrated Soil Fertility Management' should be supported. The examples of 'Microfertilization' in Mali and 'Precision Conservation Agriculture' in Zimbabwe presented in Part 2 show that it is possible to substantially increase millet and sorghum yields and profitability by using micro-doses of inorganic fertilizer in combination with techniques that conserve and concentrate soil moisture and organic matter.

6. Minimum soil disturbance: Tillage systems with minimum soil disturbance such as reduced or zero tillage systems leave more biological surface residues, provide environments for enhanced soil biotic activity, and maintain more intact and interconnected pores and better soil aggregates, which are able to withstand raindrop impact (and thus reduce splash erosion). Water can infiltrate more readily and rapidly into the soil with reduced tillage, and this also helps protect the soil from

erosion. In addition, organic matter decomposes less rapidly under these systems. Carbon dioxide emissions are thus reduced. No tillage, as described in the case studies on large and small scale conservation tillage in Kenya presented in Part 2, has proven especially useful for maintaining and increasing soil organic matter.

Improving soil fertility and the nutrient cycle (Principles)

– Reduce 'unproductive' nutrient losses: leaching, erosion, loss to atmosphere.
– Reduce mining of soil fertility: improve balance between removal and supply of nutrients - this is achieved through:
  – cover improvement (mulch and plant cover),
  – improvement of soil organic matter and soil structure,
  – crop rotation, fallow and intercropping,
  – application of animal and green manure, and compost (integrated crop-livestock systems),
  – appropriate supplementation with inorganic fertilizer,
  – trapping sediments and nutrients (e.g. through bunds; vegetative or structural barriers / traps).

These should be enhanced through improved water management and an improved micro-climate to reduce losses and maintain moisture.

Plants and their management

Improved agronomy is an essential supplement to good SLM practices. The Green Revolution in Asia made great advances in increasing agricultural production in the 1960s and 70s based on improved agronomic practices. As illustrated in figure 2, Africa has, over the last 50 years, increased its agricultural production mainly through expansion of agricultural land. The 'original' Green Revolution has largely failed in Africa (see next box) although achievements in crop breeding have been made and efforts are still ongoing to achieve the following:

- higher yielding varieties,
- early growth vigour to reduce evaporation loss,
- short growing period and drought resilience,
- better water use efficiency / water productivity in water scarce areas,
- tolerance to salinity, acidity and / or water logging,
- disease and pest resistance.

'Improved' varieties have potential advantages but their additional demands on applications of fertilizers, pesticides or herbicides need to be taken into account – as does costs and supply of seeds. They often create dependency on seed producers.

Organic agriculture and low external input agriculture have emerged in response to these concerns – but also because they relate more closely to the traditions and values of African agriculture. Organic agriculture improves production by optimising available resources, maximising nutrient recycling and water conservation. According to IFOAM (2009) organic agriculture is based on the principles of health, ecology, fairness and care. In Part 2 an example on 'Organic Cotton' in Burkina Faso is presented. All the strategies involved seek to make the best use of local resources.

Some advancements and drawbacks of the 'Green Revolution' in SSA

Cereal yields have remained largely stagnant at around 1 tonne/ha from the 1960s to 2000 in the SSA region. This is in stark contrast to the experience of the 'original' Green Revolution in Asia during the 1960s and 70s. Here, intensified production of cereals (especially wheat and rice) led to large production increases due to the introduction of new, high-yielding varieties. The new varieties however required irrigation and large amounts of chemical fertilizers and pesticides to produce their high yields. This then raised concerns about costs and potentially harmful environmental effects. It led to a loss of agro-biodiversity and the genetic pool through dependence on monocultures and replacement of land races (FAO, 2008a).

Agricultural intensification in SSA has largely failed because it has not addressed (1) depletion of organic matter through removal of crop residues for fodder and fuel, insufficient return of organic matter to the soil – causing low response to fertilizers; (2) degradation of soil structure through reduced organic matter combined with destructive tillage practices – leading to compaction, sealing, crusting, decreased infiltration and increased erosion; (3) adverse changes in the soil nutrient balance due to failure to replace essential nutrients removed from the soil and / or imbalanced fertilizer application – e.g. pushing production with nitrogen application but not replacing other essential nutrients, which become the limiting factor; (4) pollution of soil and water though inappropriate application of fertilizers, pesticides and herbicides.

(Source: IAASTD, 2009b)

A major limiting factor to plant productivity are weeds. Good SLM practices can reduce the weed infestation considerably by providing cover by crops, residues and mulch, and by minimum soil disturbance. On grazing land the control of undesirable species should be a key focus. In forests the problem of invasives is also a concern.

Adverse impacts of pest and diseases are various and a major threat to agricultural production. One way forward that resonates with SLM is to select more resistant species and varieties and follow the principles of integrated pest management (IPM) using biological and natural mechanisms as far as possible. IPM is an ecological approach with the main goal of significantly reducing or even eliminating the use of pesticides, through managing pest populations at an acceptable level as described in the case study 'Push-pull integrated pest and soil fertility management' from Kenya presented in Part 2.

However, improved agricultural production does not help if the post harvest management is lacking. Given the high rates of post harvest losses (reaching 30-100%), major efforts are needed to secure the harvest from damage.

A 'new' green revolution? The aim of a 'new' green revolution in SSA is to promote rapid and sustainable agricultural growth based on the smallholder farmer sector with minimal resources (and minimal government support), to ensure that smallholders have good seeds and healthy soils, access to markets, information, financing, storage and transport and last, but not least, policies that provide them with comprehensive support (TerrAfrica, 2009). In contrast to the 'original' green revolution in Asia, the 'new' green revolution intends to be both pro-poor and pro-environment.

Statement by Kofi A. Annan

Chair of the Board of the Alliance for a Green Revolution in Africa (AGRA)

'…..To feed the continent's 900 million people, Africa needs its own food security. This can only be achieved through an uniquely African Green Revolution. It must be a revolution that recognises that smallholder farmers are the key to increasing production, promotes change across the entire agricultural system, and puts fairness and the environment at its heart….. '
(AGRA, 2010)

Screening for drought tolerance of pigeon peas and lablab. (Hanspeter Liniger)

There is still huge potential to increase plant productivity through a 'new' green revolution. The major challenges are the following:

- Using breeding advances while increasing diversity: more productive and resilient varieties of crops, adapted to thrive in a variety of environmental conditions;
- Capitalising on the enormous plant genetic resources in SSA by including local land races and wild varieties into breeding schemes. Exchange of seeds among small-scale farmers is an efficient way to release and spread plant varieties. This includes not only crops but also improved fodder production on grassland / grazing land as well as fibre and fuel production in agroforestry systems and on forest land;
- Recognising that integrated soil fertility management and IPM are key;
- Developing more effective partnerships and networks for an interactive research system - making indigenous knowledge and local innovation available;
- Stressing the role of gender in agriculture: the recognition that the majority of smallholders in SSA are women must be brought into all supporting policy and practice;
- Marketing of produce (including value chain development) and procuring basic inputs are often critical constraints.