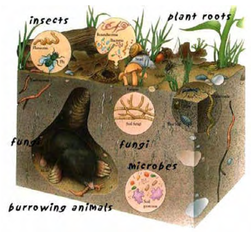
Soil nutrient management

The declining per capita food production in Africa is associated with declining soil fertility in smallholder farms. Soil nutrients are gradually depleted by crop harvest removal, leaching and soil erosion. A shrinking resource base means that farmers observe shorter or no fallow periods, can't afford fertilizer, and must divert crop residues to be used as fodder. This poster presents alternative ways of replenishing soil nutrients for smallholders.

Building soil organic matter

Soil fertility can be replenished by adding organic matter to your soil. Soil organic matter includes living organisms, the remains of microorganisms , plants and animals, and organic compounds.



Soil organic matter (http://www.organic-gardeninfo.com/soil.html, 2013)

Using the techniques explained below to add soil organic matter can:

- increase the amount of water that soil can hold
- provide food for organisms that inhabit the soil
- help minerals bind to soil
- producefriable (easily crumbled) surface soils;
- improve the productivity of the land (increase yields)
- improve the decomposition and mineralization of organic material in the soil (i.e. surface composting)
- protect the soil from excessive heat, exposure to wind, erosion, moisture loss
- trap carbon in the soil to mitigate climate change
- help restore degraded land and prevent soil loss
- reduce or eliminate need for chemical fertilizer

Mulching

Mulching around banana crops (S. Shames)

Mulching is the process of covering the soil surface with organic matter that returns carbon to the soil. Cover the soil with crop residues such as maize stalks, beans, cow peas, sweet potatoes, and deciduous tree litter. It is important to consider plant disease transmittance and multiplication of rodents in the choice and location of mulch material.

Improved fallow

Improved fallow is the planting of fast-growing species of leguminous trees, crops or grasses into a short-term fallow for one or more years. These plants release nitrogen into the soil. The leaves of the plants can be incorporated into the soil to increase carbon in the soil. Plant leguminous shrubs, such as Sesbania, Tephrosia, Crotolaria and Cajanus, in fallow lands. These plants are better than natural fallows for enhancing soil fertility, and they ease the work of tilling the soil.

Manure management

Manure management activities involves the handling of animal dung and urine (farmyard manure). Manure should be covered when liquid, and applied to croplands when solid. This not only builds soil fertility, but also lowers methane and nitrous oxide emissions.

Improved fertilizer use efficiency

Techniques for reducing the amount of fertilizer used on plants and increasing its efficiency include:

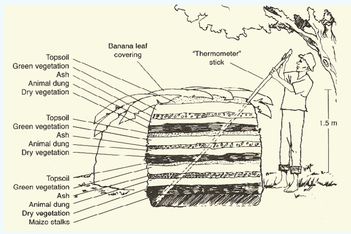
Precise fertilizer application at planting (J. Recha/ERMCSD)

- Using recommended rates of suitable organic and inorganic fertilizers (rates can be found in the Farm Management Handbook of Kenya),
- Placing nitrogen more precisely into the root zone to make it more accessible by crops, and
- Using precision agriculture techniques to determine exactly where to place nutrients, and when and how much to apply. The collection of spatial data from pre-existing conditions in the field (e.g., remote sensing, canopy size, or yield measurement), as well as the recording of detailed logs of all fertilizer applications for spatial and temporal mapping, can help in this process.

Farmers indicate dark leaves of crops that benefited from soil management (S. Shames)

Composting

Composting is the controlled biological and chemical decomposition and conversion of animal and plant wastes with the aim of producing humus. Humus is dark organic material produced by the decomposition of vegetable or animal matter, and is essential to the fertility of the soil. Humus is then applied to soil as a form of organic fertilizer.



Layers of compost (http://www.cd3wd.com/cd3wd_40/Biovision/export/defaultct206$soilFertilityManagement.html)

The Do's of Composting

- DO mix a variety of vegetable food scraps with grass clippings and leaves.
- DO keep the pile damp, but never soggy.
- DO turn the pile often. The more often you turn your pile, the quicker it will break down into compost.
- DO monitor the temperature of the compost using a stick as a thermometer.

The Don'ts of Composting

- DON'T add clippings, which tend to compact, inhibiting the flow of air through the pile.
- DON'T add weeds that contain seeds or root easily from cuttings.
- DON'T add dairy products, meat, bones or animal waste.
- DON'T add diseased plants.
- DON'T add mounds of biomass without mixing in something brown (like shredded dry leaves or newspapers), or there will be a bad odor.
- DON'T use unfinished compost on plants, as it will rob them of nitrogen.

Tillage and residue management

This module presents an overview of the benefits of tillage and residue management and techniques for implementation.

What is tillage management?

Tillage management is any form of conservation tillage where residue, mulch, or sod is left on the soil surface to reduce soil disturbance and decrease emissions release.

Conservation tillage (H. Liniger)

How is it helpful for livelihoods?

Recent studies on tillage show that conservation tillage increases soil carbon in the upper layers. This is of crucial importance for the productivity of most tropical soils.

How is it helpful for climate change adaptation?

Reducing soil disturbance helps to stabilize soil structures and organic matter, increase water infiltration and prevent erosion. Conservation tillage also helps conserve soil moisture.

How is it helpful for climate change mitigation?

Reduced till practices sequester carbon in regions with relatively high precipitation, high productivity, and a large amount of crop residues as carbon input to the soil. GHG mitigation potential of tillage management is **0.44-1.89 tCO_2-eq/ha/yr.**

There are several types of reduced tillage :

Ridge Tillage

A method of preparing the seedbed and planting in the same operation on a pre-formed ridge remaining from the previous year's crop. The soil is left undisturbed before planting.

Strip Tillage

A method of preparing the seedbed and planting on a strip 2 to 8 inches wide and 2 to 4 inches deep in the row area. The soil is left undisturbed before planting.

Minimum Tillage

A cultivation operation whereby soil is disturbed as little as possible to produce a crop. Mulch residue from the previous crop is left on the soil surface which aids in retarding weed growth, conserving moisture, and controlling erosion.

No-Till/Zero Tillage/Slot Planting

A form of minimum tillage where a slot is opened in the soil only sufficiently deep and wide to properly deposit and cover seeds. This is a once-over crop planting system where the seed is planted in a slot created with a coulter in an otherwise undisturbed soil surface. This system makes maximum use of crop residue.

What is residue management?

Residue management is the sound handling and utilization of plant and crop residues. It combines mulching, composting, integrative livestock and manure management and ideally leaves 30% or more of the soil covered with crop residues after harvest.

Trash Lines

A special form of residue management promoted in the Kenyan context, trash lines are made from crop residues, grass and other organic materials collected from the field. They are constructed along the contour line in order to slow down surface runoff and reduce soil erosion and gradually accumulate soil leading to the building of terraces along the contour.

Trash lines in Kenya (S. Shames/EcoAgriculture Partners)

How is it helpful for livelihoods?

Plant residues converted into organic matter are the major source of carbon in soil. In an integrated system, crops and livestock interact to create a synergy, with recycling allowing the maximum use of available resources. Crop residues can be used for animal feed, while livestock and livestock by-products can enhance agricultural productivity by intensifying nutrients that improve soil fertility, reducing the use of chemical fertilizers.

How is it helpful for climate change adaptation?

Crop residues placed along the contour lines can slow down surface runoff, reduce soil erosion and improve water infiltration.

How is it helpful for climate change mitigation?

Avoiding burning of residues avoids emissions of aerosols and GHGs generated from fire. GHG mitigation potential of residue management is **0.44-1.89 tCO_2-eq/ha/yr**.

Agronomic practices

This poster presents an overview of agronomic practices to improve soil quality. These methods introduce nutrients into the soil while protecting it from excessive heat, exposure to wind, and moisture loss. They lower the need for expensive inputs, and help the environment by increasing biodiversity and decreasing excessive use of water and fertilizer. They can also increase cash flow and improve economic stability by diversifying crop production.

Cover crops

Cover crops are planted to conserve the soil on bare or fallow farmland. Cover crops help protect the soil from excessive heat, exposure to wind, and moisture loss. They also mitigate carbon emissions, and increase nitrogen in the soil, which improves crop yields. Plants used as cover crops include lablab beans, star grass and guinea grass.

Green manure

Green manure is a term for fast growing legumes like cow peas and mucuna that are planted several weeks or months before the main crop is planted to enrich the soil. When the legume flowers, it is ploughed into the soil. Tree legumes used as green manure are also called "fertilizer trees". They are more permanent than other types of green manure.

Intercropping

Intercropping is planting two or more crops in the same field at the same time, such as maize with beans, groundnuts or potatoes.

Intercropping discourages insects and diseases (S. Shames/ EcoAgriculture Partners)

Relay cropping

Relay cropping is planting temporary cover crops within the main crop before it is harvested in order to ensure the continuous use of land and the availability of organic materials while reducing vulnerability to soil erosion.

Alley cropping

Alley cropping is growing annual crops between rows of trees or shrubs to form hedgerows. Shrubs to be planted within crop land include *Sesbania sesban*, *Gliricidia sepium* or *Calliandra* species.

Intercropping of groundnuts and coffee plants (S. Shames/ EcoAgriculture Partners)

Contour strip cropping

Contour strip cropping is planting alternative strips 15 – 45 meters wide of grasses or grain with other crops along the contour to conserve moisture and reduce erosion on gentle slopes and unstable soils.

Crop rotation

Crop rotation involves planting a rotating variety of crops in the same spot over time. Often, farmers will plant maize (a high feeder cereal), followed by beans (a nitrogen-fixing legume), and then potatoes and cassava (root vegetable cover crops) in a sequence. This practice maintains the fertility of the soil and ensures that the root systems explore the soil to different depths. It also helps to avoid the build-up of insect and disease populations that thrive on one plant family.

Improved crop varieties

Farmers can use crop varieties that have been developed through research and testing to have special qualities such as fast maturation rates, high yields, and pest and disease tolerance. They may plant improved crop varieties like hybrid maize, grafted mangoes, indigenous vegetables, mosaic resistant cassava, groundnuts and tissue culture bananas. Using improved varieties can increase production yields while reducing the need for expensive fertilizer. Higher yields can in turn increase the amount of residue available to reintroduce nutrients into the soil.

Improved sorghum (J.Recha/ERMCSD)

Integrated pest management

Integrated pest management (IPM) is a strategy to prevent and manage pests with a minimal impact on human health, the environment and other species through the anticipation of pest problems and management of pest populations to reduce losses to crops. While IPM takes more time and close monitoring than simply using pesticides, it has multiple advantages for farmers.

Putting the right plant in the right place

Consider neighboring plants, soil pH, moisture, drainage and exposure to sun and wind when choosing plants for a specific site.

Starting with healthy transplants

Buy only plants that are free of pests, and don't crowd them when planting.

Keeping plants healthy

Properly irrigated and fertilized plants are less likely to suffer a pest attack, and can better withstand pest damage if an infestation does occur.

Remove pest-infested leaves as soon as you see them. (M. Acosta, CIAT/CCAFS)

Removing unhealthy plants

Remove pest-infested leaves and fruit and prune out diseased and dead branches of woody plants as soon as you see them.

Biological method

Biological pest management keeps pest populations in check using beneficial insects. These insects include pollinators (bees and flies), as well as predatory insects that eat damaging insects.

Protecting beneficial insects

If you must use insecticides, take precautions to protect beneficial insects.

Creating habitat for beneficial insects

Provide insectary plants, water, and groundcover and coarse mulches where non-flying beneficial insects can hide from predators.

Physical method

Physically removing or trapping pests can be very successful and causes little disruption to your farm's ecosystem.

Hand picking

Every few days, hand pick large, clearly visible or slow-moving insects by hand in early morning.

Pruning

If pests are concentrated at one or two sites on a plant, you may be able to prune them out.

Chemical method

Chemical control raises concerns about safety for humans, plants and the ecosystem. Consider chemical controls only if other techniques do not result in adequate pest control. Choose a chemical labeled for your specific intended use that meets the following criteria:

- Least harmful to the environment
- Least toxic to the applicator
- Most specific to the pest
- Least harmful to beneficial organisms

Farmers practicing integrated pest management may use plants that are more resistant to attack by diseases and insects. (S. Shames/EcoAgriculture Partners)

How to do IPM

Assessing bean pests and disease in Uganda (N. Palmer/CIAT)

Monitor

Check your plants regularly (two or three times per week during the height of the growing season) for signs and symptoms of pest damage.

Identify pests

Locate and identify the pest that is doing the damage. Try to determine when in the life cycle it is most susceptible to control measures.

Establish the plant's tolerance level

Determine how much damage each plant can tolerate without yield decrease or failure.

Develop a pest management strategy

Develop a strategy to manage the pest using cultural, physical, biological and/or chemical methods.

Evaluate results

Continue monitoring your plants and determine how effective your strategy was. Record your observations for future reference.

Cultural method

Cultural pest management methods prevent pest problems by keeping plants healthy and growing vigorously.

Choosing resistant/tolerant varieties

When possible, choose plants that are not prone to serious pest problems.

Rotating annual plants

Grow members of the same plant family in different places each year to ensure that insect and pest populations do not build up in one spot.

Companion planting

Companion planting involves growing two or more specific types of plants together in a combination that will discourage disease and insect pests.

Intercropping

Intercropping involves breaking up pure stands of a single crop in order to interrupt the movement of insects and diseases.

Agroforestry practices

Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and animals on the same land management unit. The integration can be either in a spatial mixture or in a temporal sequence. There are ecological and economic interactions between woody and non-woody components in agroforestry.

Trees on cropland (S. Kilungu/CCAFS)

Dispersed trees on cropland

Trees may be grown in fields while crops are grown alongside or underneath. This practice can be implemented by protecting and managing the trees that are already there or by planting new trees.

Buffer zone agroforestry

These are agroforestry practices carried out around protected areas to reduce human pressure on protected forest reserves.

Alley cropping

Rows of woody plants are grown with annual crops planted in the alleys in between in order to maintain or increase crop yields by improving the soil and micro-climate through the cycling of nutrients, mulching and weed control.

Trees on boundaries

This involves planting trees on farm boundaries. It requires agreements between the neighbors involved to avoid conflicts due to the shading effects of the trees.

Woodlots

Woodlots are an area on the farm set aside for the production of wood, and sometimes flowers for nectar. Examples of woodlots commonly planted by people in Kenya include: *Casuarina*, *Sesbania*, and *Markhamia* species.

Woodlot in Kenya (J. Recha/ERMCSD)

Live fences and hedges

Live fences made of woody plants establish boundaries around farms and homesteads, and control livestock grazing.

Trees along streams and rivers (riparian buffers)

Managed forest and shrub belts in areas bordering lakes, streams, rivers and wetlands can enhance and protect aquatic and riparian resources, as well as generate income from forest products.

Incorporating leafy plants into soil (S. Shames)

Biomass transfer

Biomass transfer involves the incorporation of leafy plants into the soil. It transfers nutrients from an area of a farm into the cropland. The most used plants in Kenya are: *Tithonia diversifolia* and *Lantana camara*.

Shifting cultivation

This is a practice in which land is cleared and cropped with agricultural crops for a period of two to three years and then left untended for natural vegetation to regenerate.

Plantation crop combination

This practice involves growing shade tolerant crops such as coffee, tea and beans under trees that provide microclimate conditions suitable for the growth of the crops.

Banana trees above coffee crops in Uganda (S. Shames/ EcoAgriculture Partners)

Trees in homesteads

This is a practice where trees are grown in homesteads or adjacent to the homestead. These trees include fruit trees, nuts, shade and ornamental trees.

Nitrogen-fixing tree species planted within maize crops (C. Pye-Smith/ICRAF)

Improved fallows

This is the targeted use of a fast growing tree species to obtain the benefits of a natural fallow. Nitrogen fixing trees and shrubs are planted with the main aim of improving nutrient input into soil. They fix nitrogen and add organic matter to the soil.

Trees in rangeland and grazing land

Trees scattered in rangeland provide shade for livestock and herdsmen, and fodder and wood.

Trees planted on the slope of a hill to control erosion (S. Shames/ EcoAgriculture Partners)

Shamba system

The shamba system is a practice in which crops are planted between tree seedlings during the first few years after planting.

Trees in home gardens

Home gardens are common in the humid tropics and are characterized by the intensive use of multi-purpose trees, shrubs, food crops and animals.

Fodder lots and fodder banks

Trees and shrubs with palatable leaves and pods, as well as grasses, can be grown as fodder. Areas where fodder is grown are known as fodder lots. Fodder accumulated in excess of seasonal requirements is stored in a fodder bank.

Windbreaks

A windbreak is one or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind. Well-designed windbreaks (i.e. not too dense) not only reduce wind speed but increase humidity and reduce loss from the soil.

Trees on soil conservation structures

Living barriers of trees and shrubs planted along the contour lines of a slope control soil and water erosion while providing useful products such as food, fuel, building poles, fodder or gum.

Bees colonizing a hive (J. Recha/ERMCSD)

Apiculture

Apiculture (beekeeping) is an agroforestry practice that enhances the environment and contributes to crop production while generating income through honey and other products.

Soil and water management

Soil management is the prevention and reduction of the amount of soil lost through erosion. It seeks to increase the amount of water seeping into the soil and reduce the speed and amount of water run-off. Water management involves improving water use efficiency and minimizing losses of water from evaporation, runoff or drainage. The following techniques will help you manage soil to conserve water and reduce erosion.

Sprinkler irrigation

Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air and irrigated on the entire soil surface through spray heads so that it breaks up into small water drops which fall to the ground.

Drip irrigation

This system delivers water directly to the root zone of a plant, where it seeps slowly into the soil one drop at a time. Since drip irrigation delivers water directly to the plants you want to grow, the soil surface between the plants remains drier, discouraging weed seeds from sprouting.

Laying a drip irrigation kit (K. Opondo)

Digging a drainage channel (S. Shames/EcoAgriculture Partners)

Diversion ditches and drainage channels

Diversion ditches and drainage channels remove excess water from the land. They can increase yields in flood-prone zones due to increased water drainage. By facilitating good aeration of the soil, they can also help avoid emission of N_2O gas.

Drainage and infiltration ditches

This is a wide channel that collects surface run-off water, where it can slowly infiltrate into the ground. The ditch will tend to silt-up, which hinders infiltration, and must be cleaned out regularly.

Infiltration ditch in Kenya (S. Shames/EcoAgriculture Partners)

Furrows and broad beds

In this technique, crops are grown on broad beds, which are about 170 cm wide. In between the broad beds are trenches called "furrows". The furrows are blocked at the lower end. When one furrow is full, the water backs up into the head furrow and flows into the next field furrow.

Terraces

Terraces are promoted in hilly regions with substantial erosion hazards. The terrace walls or "risers" are earth structures and the beds are leveled in order to encourage rainwater infiltration. Terraces can improve crop performance by reducing soil erosion and increasing soil moisture. Terraces can also make cultivating on steep slopes easier.

Terraces (J. Recha/ERMCSD)

Digging trenches for fanya juu terraces (Trees for the Future)

Fanya juu terraces

A fanya juu terrace is made by digging a trench and throwing the soil upslope to form a ridge. A diversion ditch must be established above the bench system to properly dispose of runoff water. To stabilize the soil, plant risers with grasses such as napier.

Restoration and rehabilitation of degraded land

Surplus degraded wasteland or agricultural land is set aside from production for several years. Practices like natural regeneration, assisted natural regeneration, enrichment planting and fire management improve the water retention of soil.

Water pan lined with plastic (J. Recha/ERMCSD)

Water pan

A water pan is a shallow hole that collects and holds runoff water. Sometimes the pans are lined with plastic to prevent water loss.

Half-moon micro-catchments

These catchments are made by digging pits and then using the soil to construct a semi-circular mound with the tip facing uphill. The pits are filled with manure and are often used for harvesting tree seedlings. They help keep moisture and improve soil fertility on sloped areas.

Road catchments

Road catchments are structures that divert water runoff from roads, ditches, and other unproductive areas, and channel it into crop fields.

Contour bunds

A series of small mounds are placed along the contour of a slope to retain water and reduce erosion. They can also help prevent flooding.

Planting banana trees in pits (S. Shames/EcoAgriculture Partners)

Planting basins and pits

Planting basins and pits are circular holes within the crop fields which harvest runoff water. Zai pits are shallow, wide pits in which manure is added to increase soil fertility, and a few crop seeds are planted.

Improved livestock management

Local chickens under improved management (J. Recha/ERMCSD)

This poster gives an overview of improved livestock management, discusses its benefits, and presents several techniques for its implementation.

Improved animal feeding practices (S. Shames/EcoAgriculture Partners)

What is improved livestock management?

While improved livestock management practices are tailored to a particular land management situation and geographical location, they are all implemented for the same basic goal of reducing emissions of methane and increasing the production of livestock. They include improved feeding practices, long term livestock management changes, livestock health program, breeding and mixed farming.

What are its benefits?

- Increased productivity of livestock, which also spreads the energy cost of maintenance across a greater feed intake, often reducing methane output per kg of animal product.
- Proper animal housing and management of animal waste contribute to good animal health.
- Carbon accrual on optimally grazed lands is often greater than on ungrazed or overgrazed lands. GHG mitigation potential of improved livestock management is **0.00-0.01 tCO_2-eq/ha/yr** (for East Africa).

Long term livestock management changes

These involve changes to the stocking rate of animals, as well as strategically choosing the type of livestock to keep (e.g. big ruminants, small ruminants, or poultry) depending on locally available resources.

Livestock health programs

Animal health greatly influences reproduction and weight gain, which are the key aspects of successful livestock production. Vaccinations, regular health checks, disease surveillance, treatment, and culling of diseased animals are some of the practices.

Animal breeding

There is a need to have livestock with improved characteristics of production. Some breeds may be hardier but have very low production that leads to net losses to farmers. Unhealthy stock wastes feed and requires additional labor.

Proper animal housing contributes to good animal health (R. Kozar/EcoAgriculture Partners)

Mixed farming

Integrating livestock and crop production has several advantages. First, growing row crops only on more level land and using steeper slopes for pasture or forages reduces soil erosion. Second, rotating pasture and forage crops enhances soil quality, reduces erosion and facilitates optimal dung collection and use. Livestock manure can be managed to build soil fertility. It should be covered to avoid releasing greenhouse gases into the atmosphere.

Improved feeding practices

These measures can improve fodder quality:

- Cultivating a daily supply of cut-green fodder.
- Cutting fresh fodder into small pieces using simple machines (e.g. Chuff Cutter) can maximize fodder utilization.
- Using crop residues like straws and stovers (from maize, sugarcane, sorghum, millet, rice, etc.) as fodder.
- Using specific agents and dietary additives (e.g. animal salt licks with minerals).