Sustainable Agriculture Land Management Practices for Climate Change Mitigation

A training guide for smallholder farmers

John Recha, ERMCSD
Martha Kapukha, Vi Agroforestry
Amos Wekesa, Vi Agroforestry
Seth Shames, EcoAgriculture Partners
Krista Heiner, EcoAgriculture Partners

ERMCSD ecoagriculturepartners Vi Agroforestry

Authors

John Recha, ERMCSD
Martha Kapukha, Vi Agroforestry
Amos Wekesa, Vi Agroforestry
Seth Shames, EcoAgriculture Partners
Krista Heiner, EcoAgriculture Partners

Copyright Information

EcoAgriculture Partners
1100 17th St. NW
Suite 600
Washington, DC 20036
USA

Correct Citation

Recha, J., Kapukha, M., Wekesa, A., Shames, S., and K. Heiner. 2014. Sustainable Agriculture Land Management Practices for Climate Change Mitigation: A training guide for smallholder farmers. Washington, DC. EcoAgriculture Partners.

Cover Photos

Front: A farmer shows plots where he has introduced sustainable agriculture land management practices, courtesy of Seth Shames/EcoAgriculture Partners.

Back: Agroforestry, courtesy of Seth Shames/EcoAgriculture Partners.

Correspondence

Please contact corresponding author John Recha at john.recha@gmail.com with inquiries.

Sustainable Agriculture Land Management Practices for Climate Change Mitigation

A training guide for smallholder farmers

John Recha, Martha Kapukha, Amos Wekesa, Seth Shames and Krista Heiner

April 2014

Acknowledgements

This work was undertaken as part of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), which is a strategic partnership of CGIAR and Future Earth. This research was carried out with funding by the European Union (EU) and with technical support from the International Fund for Agricultural Development (IFAD). The views expressed in the document cannot be taken to reflect the official opinions of CGIAR, Future Earth, or donors.

This training guide reflects the insights, ideas and contributions of many people. The authors would like to thank the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) for providing the funding for this manual. Additionally, the authors would like to thank the staff at EcoAgriculture Partners including Louise Buck and Sara Scherr for their guidance and support and Margie Miller for designing and formatting the document. Similarly, the authors would like to thank the staff at Vi-Agroforestry, for their support throughout the development and testing of this training guide. Finally, we would like to thank all of the farmers in Kenya for trying out previous versions of this training guide and providing important, constructive feedback.

Contributors

EcoAgriculture Partners

EcoAgriculture Partners is a pioneering nonprofit organization that improves rural people's lives, reduces hunger, and preserves biodiversity using an innovative whole landscape approach. EcoAgriculture Partners works with collaborators worldwide to support diverse individuals and organizations at the local, national and international levels to create and sustain ecoagriculture landscapes. Find out more at: www.ecoagriculture.org.

Vi Agroforestry

Vi Agroforestry contributes to ecological balance and securing the sources of livelihood for poor people, through the cultivation of trees and related activities. It works with small-scale farmers in Lake Victoria's catchment area in east Africa, strengthening their capacity to adapt to climate change through sustainable agriculture that has co-mitigation benefits. Find out more at: www.viagroforestry.org.

Environmental Resources Management Center for Sustainable Development

The Environmental Resources Management Center for Sustainable Development (ERSCMD) is an international non-governmental organization for affiliate members. The ultimate objective of ERMCSD is to promote the organization and coordination of climate smart agriculture, environmental conservation, natural resources management, and development activities within the eastern Africa region. The organization promotes networking and cooperation among sub-Sahara Africa environmental organizations to share environmental information and build their capacity to participate in regional work related to sustainable development. Find out more at: www.ermcsd.org.

Supporters

CGIAR Research Program on Climate Change, Agriculture and Food Security

CCAFS brings together the world's best researchers in agricultural science, development research, climate science and Earth system science to identify and address the most important interactions, synergies and tradeoffs between climate change, agriculture and food security. Find out more at: www.ccafs.cgiar.org.

Contents

Introduction

This training guide was developed within the context of a participatory action research project focusing on the institutional arrangements of smallholder agricultural carbon projects in Sub-Saharan Africa led by EcoAgriculture Partners and the CGIAR Research Program on Climate Change, Agriculture, and Food Security (CCAFS). The objectives of this project are to identify specific institutional challenges and solutions in carbon projects, implement solutions, and track the impact of these efforts. After conducting analyses to identify specific institutional challenges, project managers jointly determined that the challenge they wanted to work on was that of building local institutions to manage carbon projects. Progress in this area would not only increase the development benefits of the projects, and reduce transaction, staffing, and consulting costs, but will be also be necessary for the long-term success of the projects. For more information on this process, see Shames, S., Q. Bernier, and M. Masiga. 2013. Development of a participatory action research approach for four agricultural carbon projects in east Africa. CAPRi Working Paper No. 113. Washington, D.C.: International Food Policy Research Institute, http://dx.doi.org/10.2499/CAPRiWP113.

The manual was created specifically for use in the Western Kenya Smallholder Agricultural Carbon project, managed by the Swedish NGO Vi Agroforestry, which is the test case for the first Voluntary Carbon Standard (VCS) methodology for generating carbon credits by building organic matter in agricultural soils. Vi Agroforestry takes a holistic approach to project implementation which focuses first on improving farm productivity and livelihoods while generating carbon credits as a co-benefit. The project aims for scale by using its professional staff to train Community Facilitators who coordinate the participation of village-level organizations in the project and provide support to farmers as they implement the sustainable agricultural land management (SALM) practices which generate the carbon credits within the project.

This manual includes introductory modules on climate change and SALM, as well as modules that describe specific SALM practices, including soil nutrient management, tillage and residue management, agronomic practices, integrated pest management, agroforestry, soil and water management and improved livestock management. The manual's structure reflects the categories of SALM set out in the VCS methodology (see http://www.v-c-s.org/SALM_methodology_approved) and the technical guidance of the Carbon Baseline Survey Manual for the project.

The manual can be given all together as part of an extended, multi-day training session, or separated by module and given over several weeks. Each module is designed to be completed in approximately two hours. For each module, the manual contains an overview of the topic, the learning objectives, and suggestions for further reading, along with notes for the trainer on suggested exercises and summary points. The manual describes how to implement specific techniques in each of these categories, as well as summarizing the livelihood, climate change adaptation and climate change mitigation benefits of adopting the practice. It is meant to be accompanied by supplementary training materials including the companion posters, additional readings, and/or the glossary of definitions in Appendix 1. Trainers will rely on practical demonstrations to illustrate and reinforce the lessons. Simplified posters communicating the content of this manual will serve as a companion.

In addition, each module contains several follow-up evaluation questions to assess the learners' competencies, located in Appendix 2. This appendix includes two methods of post-module evaluation. Self-evaluation scorecards can be administered by Vi-Agroforestry staff after each module so students can rate their level of understanding of topics discussed. Then, staff can use group discussion questions as an additional means of determining students' understanding of the topic and willingness to use the methods described.

We hope this manual will improve the ability of the Vi Agroforestry staff and other training professionals to train community facilitators on SALM practices, and serve as a resource for community facilitators training farmers in their communities.

Module 1

Climate change

This module presents an introduction to the concept of climate change, including its causes, effects and importance. Also, this module discusses specific challenges local agricultural systems face, the concepts of climate change mitigation and adaptation, and strategies for dealing with climate change in the agricultural sector.

1.1 Introduction

Exercise 1.1

Group discussion on the effects of climate change. Possible discussion questions are:

- What is climate change and why is it important to you?
- What signs of climate change have you seen or do you expect to see?
- Can you think of ways that each of the economic sectors might be affected by climate change?

Learning objectives

1. Understand the causes of climate change
2. Understand the local effects of climate change
3. Understand the challenges local agricultural systems face and how climate change will impact local agricultural systems
4. Understand climate change adaptation and climate change mitigation
5. Discuss some possible adaptation and mitigation strategies for agriculture systems

The United Nations Framework Convention on Climate Change (UNFCCC) defines "climate change" as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods."

What are the causes of climate change?

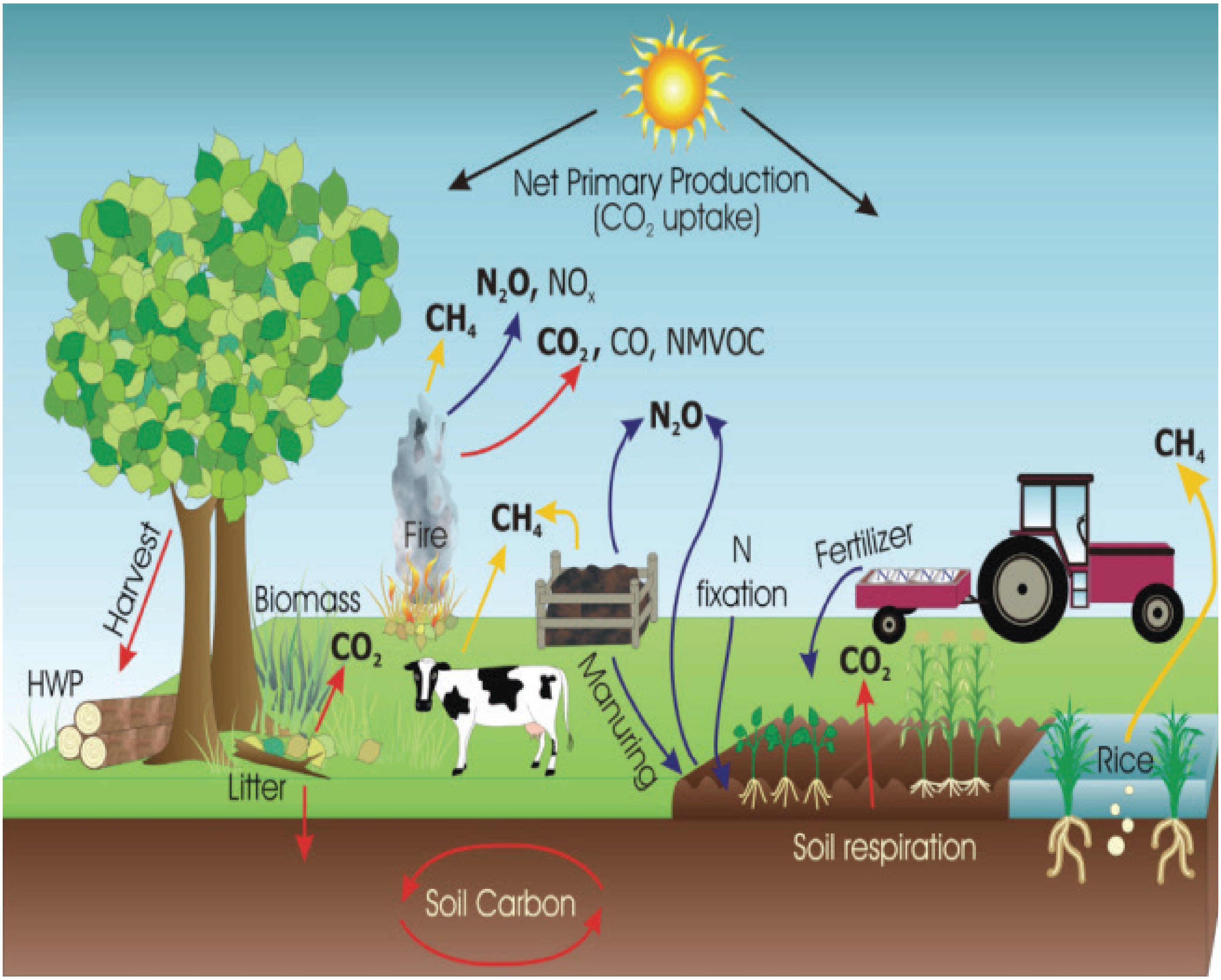
Greenhouse gases (GHGs) that are released by human activities are responsible for climate change and global warming. Th release of GHGs has triggered an increase in temperature that affects weather patterns like rainfall at the local level. Human activities that cause climate change include:

- Burning fossil fuels (coal, oil and gas) through cooking and lighting as well as in vehicles.
- Careless use of fertilizers
- Careless handling of cow dung
- Keeping many heads of livestock
- Over tilling land
- Burning crop residues
- Cutting down trees

Most studies show that average global temperature has increased by 0.50-0.74 degrees Celsius over the past 100 years (1906-2005), and projections through climate change modeling predict the temperature could increase by at least 1.1oC by the year 2100.

What are the general effects of climate change?

- Heatwaves and higher temperatures
- New pest and disease outbreaks
- Extreme events like storms, droughts and floods
- Acidicity in oceans
- Water scarcity
- Unpredictable precipitation patterns
- Climate phenomena like El Niño Southern Oscillation
- Snow and glacial melting
- High intensity rainfall
- Increased rates of soil erosion.
- High rates of soil leaching
- Eutrophication, sedimentation and siltation of rivers
- Loss of biodiversity
- Shifting timing of seasonal events



This picture showing sources and sinks of greenhouse gasses in the agriculture sector highlights the three key greenhouse gases (GHGs) relevant to the agriculture sector: carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O). (Graphic: www.trainingschool.bham.org.uk)

Sources of GHGs in the agriculture sector	*Sinks of GHGs in the agriculture sector*
• CO_2 from burning and decomposition of biomass • CO_2 from soil respiration • CO_2 from combustion of fossil fuels for on-farm equipment (i.e. tractors) • CO_2 from burning of wood for energy • N_2O from soil cultivation • N_2O from manure • N_2O from burning of biomass • CH_4 from burning of biomass • CH_4 from livestock • CH_4 from manure • CH_4 from rice paddies	• CO_2 uptake in soils • CO_2 uptake in trees

Why should we be concerned about climate change?

- Multiple severe impacts are likely to result from climate change.
- Agriculture is highly sensitive to variability and change in climate and markets/price.
- A large percentage of the population depends directly on rain fed agriculture and natural resources.
- There are already high rates of land degradation (erosion and declining soil fertility, increasing water scarcity and loss of biodiversity) and sensitivity to climate variability.
- There are already low yields and high post-harvest losses due to poor land management practices.
- Natural resources and ecosystems including drylands, mountains, rainforests, and wetlands are already fragile.

1.2 What are local agricultural challenges and how are they impacted by climate change?

Exercise 1.2

Brainstorm all of the current challenges for local agricultural systems and the ways local agricultural systems might be affected by climate change. Possible questions include:

- What are key local agricultural challenges?
- How do you think your activities will be affected by climate change?

This can be done as a whole group or in small groups that report back to the whole group. A list of all of the challenges the group identifies can be generated and displayed throughout the training.

Major challenges that the future agricultural systems will face from climate change

- An increase in crop water requirements to meet the increased evapotranspiration demands
- A reduction in the amount of water available to plants in most places due to the predicted shortages in water supplies
- Spatial and temporal changes in the land available for agriculture with tropical countries being more disadvantaged
- Increased degradation of land resources from erosion due to the projected increase in extreme storms, droughts and floods.
- New management challenges such as dealing with changes in the pest populations and new diseases
- Increased cost of inputs due to steep increases in energy and other input costs including taxation
- Competition for land by emerging initiatives like biofuel production, which may further increase food prices and adversely impact the poor
- A decrease in biodiversity and the extinction of some species

1.3 Climate change adaptation in agricultural systems

Exercise 1.3

Group discussion about climate change adaptation strategies. What are some possible ways to adapt to the challenges that climate change will pose to agriculture?

Climate change adaptation is the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects that reduces harm or exploits beneficial opportunities.

Adaptive capacity to climate change is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

As communities are exposed to unexpected or unforeseen changes in weather patterns and increased risk, more robust adaptation plans are required to manage the additional risk.

Some of the adaptation strategies are:

- Reversing land degradation through the adoption of sustainable agricultural land management (SALM) practices;
- Managing heat stress on crops and animals;
- Using crop varieties and management systems that do well under a broad range of soil and climatic conditions;
- Promoting the efficient capture, storage and utilization of rainfall through the adoption of appropriate soil and water conservation practices, the provision of irrigation, and the use of systems and practices with high use efficiency;
- Maintaining soil fertility and productivity by arresting nutrient mining and building or sustaining soil fertility;
- Guarding against pest and disease pressure;
- Enhancing the resilience of communities by targeting investments better and improving their use efficiency;
- Ensuring the maintenance of food and nutritional security; and
- Protecting women and other disadvantaged groups from the adverse impacts of climate change.

1.4 Climate change mitigation in agricultural systems

Exercise 1.4

Group discussion about activities that might mitigate climate change in the agriculture sector. What are some possible ways to mitigate greenhouse gas emissions from agriculture?

Climate change mitigation involves reducing the amount of greenhouse gases in the atmosphere or enhancing their sinks, e.g. by reducing the use of fossil fuels, planting trees, or enhancing mineralization of organic matter into soil organic carbon.

Strategies for reducing greenhouse gas emissions include sustainable land management practices like:

- Soil nutrient management,
- Tillage and residue management,
- Agronomic practices,
- Agroforestry,
- Soil and water conservation, and
- Improved livestock management.

Agroforestry can mitigate climate change (Photo: J. Recha/ERMCSD)

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Climate change results from human activities that release greenhouse gases, which alter the composition of the global atmosphere.
- Climate change may have a significant impact on many economic sectors, including the agriculture sector.
- The agriculture sector is both a source of greenhouse gases and a sink of greenhouse gases.
- Local agriculture systems currently face many challenges, and these may be increased with climate change.
- You can adapt to the effects of climate change in the agriculture sector through sustainable land management practices that manage changes and minimize risks.
- You can mitigate climate change from the agriculture sector by practicing sustainable land management techniques that reduce the amount of greenhouse gasses released into the atmosphere.

Further Reading

Government of Kenya Ministry of Environment and Mineral Resources. 2013. Climate Change Action Plan. http://www.kccap.info/

Intergovernmental Panel on Climate Change (IPCC). 2007. Summary for Policy Makers. In: Climate Change 2007: The Physical Science Basis, S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Eds. Cambridge University Press, Cambridge, UK. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf

IPCC. 2007. Summary for Policymakers. In: Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK. http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-spm.pdf

IPCC. 2007. Summary for Policymakers. In: Climate Change 2007: Mitigation of Climate Change. Contribution to Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, B. Metz, O.R. Davidson, P.R. Bosch, R.Dave, L.A. Meyer, Eds. Cambridge University Press, Cambridge, UK. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-spm.pdf

Kabubo-Mariara, J. and F. K. Karanja. 2007. The Economic Impact of Climate Change on Kenyan Crop Agriculture: A Ricardian Approach. The World Bank Policy Research Working Paper 4334, Washington, DC. http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-4334

UNEP. Fact Sheet: Climate Change in Africa – what is at stake? Excerpts from IPCC reports, the Convention and BAP compiled by AMCEN Secretariat. http://www.unep.org/roa/amcen/docs/AMCEN_Events/climate-change/2ndExtra_15Dec/FACT_SHEET_CC_Africa.pdf.

World Wildlife Fund (WWF). Climate Change Impacts on East Africa: A Review of the Scientific Literature. http://www.wwf.org.uk/filelibrary/pdf/e_africa_climatechange_report.pdf

Module 2

Sustainable agriculture and land management

This section presents an overview of sustainable agriculture and land management (SALM), including an overview of SALM and the rationale for using SALM practices as a solution for improving livelihoods while adapting to climate change and mitigating future climate change.

2.1 Introduction

Exercise 2.1

Ask participants to describe what SALM practices they know of and make a list as a group. Supplement the list the participants made with additional practices, and divide the list into the categories of SALM practices listed. Which categories of SALMS are they already engaging in? Which would they like to start using?

Learning objectives

1. Describe SALM practices
2. Describe why SALM practices are important for livelihoods, climate change adaptation and climate change mitigation

SALM practices are:

- Agricultural practices that preserve and enhance productive capacities of land (for crops, livestock, watersheds, forests)
- Actions to stop and reverse land degradation
- Actions necessary to meet the food needs of the growing population, rehabilitate degraded lands, adapt to changing climate, and mitigate climate change.

Categories of SALMs

- Soil nutrient management
- Tillage and residue management
- Agronomic practices
- Agroforestry
- Soil and water conservation
- Integrated pest management
- Improved livestock management

2.2 Why engage in sustainable land management?

Exercise 2.2

Ask participants to brainstorm why SALM practices would be important. Discuss each option and supplement list with those listed above.

- To stop land degradation and favor enrichment
- To improve the micro-climate and environment
- To feed the soil so that it can feed the crops
- To increase crop diversity and promote higher yields
- To help achieve a stable and balanced ecosystem
- To aid in climate adaptation
- To lower costs of production in the long-run, e.g. through reduced tillage, using compost, etc.
- To preserve soil organic carbon. When soil is made too loose or exposed to direct sun, the stored carbon will be released as GHG emissions.

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- SALM practices are agricultural practices that enhance the productivity of the land, while helping to adapt to climate changes and mitigate climate change.
- SALM practices are beneficial because they can stop land degradation, increase crop diversity, promote higher yields, lower the costs of production, improve the micro-climate for plants, and preserve organic carbon in the soil, among other things.

Further Reading

Liniger, H.P., Mekdaschi Studer, R., Hauert, C. and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO). https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

Nkonya, E., Place, F., Pender, J., Mwanjololo, M., Okhimamhe, A., Kato, E., Crespo, S., Ndjeunga, J. and S. Traore. 2011. Climate Risk Management through Sustainable Land Management in Sub-Saharan Africa. IFPRI Discussion Paper 01126, http://www.ifpri.org/sites/default/files/publications/ifpridp01126.pdf

Working in the field with conservational farming techniques (P. Casier/CCAFS)

Module 3

Soil nutrient management

This module presents an overview of the causes of declining soil fertility and the importance of soil nutrient management. Then, it presents the techniques for more effectively managing soil nutrients, including mulching, using improved fallows, managing manure, composting and improving the efficiency of fertilizer use.

Learning objectives

1. Understand the causes of declining soil fertility and the importance of soil nutrient management for agricultural productivity and climate change mitigation
2. Understand the benefits of mulching and be able to use mulching techniques successfully
3. Understand the benefits of using improved fallows and the techniques involved
4. Understand the benefits of manure management and the techniques for effective manure management
5. Understand the benefits of composting and the process of composting
6. Understand the benefits of efficiently using fertilizers

3.1 Introduction

Exercise 3.1

Group discussion on the causes of soil fertility loss and the importance of soil nutrient management. Possible questions include:

- Have you experienced soil fertility loss?
- What do you think causes soil fertility loss?
- Why is soil nutrient management important?

The declining per capita food production in Africa is associated with declining soil fertility in smallholder farms. This is because nutrient capital is gradually depleted by:

- Crop harvest removal,
- Leaching, and
- Soil erosion.

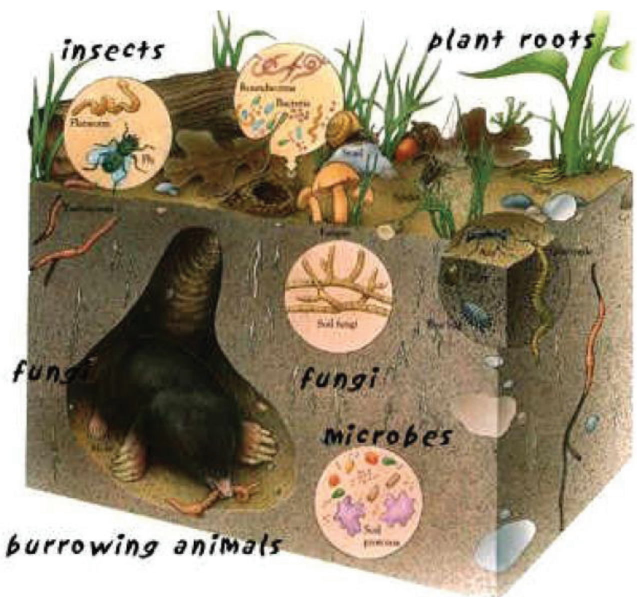
The use of crop residues by farmers as fodder and shorter or no fallow periods, due to a shrinking land resource base, can be balanced by the addition of organic manure and chemical fertilizers, which most smallholder farmers in the region cannot afford.

There is, therefore, a need to develop appropriate soil nutrient and cropping systems that minimize the need for chemical fertilizers and also find ways to integrate livestock into the farming system.

The focus of any soil fertility replenishment should be integrated nutrient management involving the application of leguminous mulches, agroforestry, and composting as well as technologies that reduce the risks of acidification and salinization.

Soil fertility depletion results from an imbalance of nutrient inputs and harvest removals and other losses, and it is reaching critical levels among smallholder famers (with depletion of soil organic matter being a contributory factor).

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



What is soil organic matter?

Soil organic matter includes all organic (or carbon-containing) substances within the soil. Soil organic matter not only stores nutrients in the soil, but it is also a direct source of nutrients. Some of the world's most fertile soils tend to contain high amounts of organic matter.

Soil organic matter includes:

- Living organisms (soil biomass);
- The remains of microorganisms that once inhabited the soil;
- The remains of plants and animals; and
- Organic compounds that have been decomposed within the soil and, over thousands of years, reduced to complex and relatively stable substances commonly called humus.

As organic matter decomposes in the soil, it may be lost through several avenues. Since organic matter performs many functions in the soil, it is important to maintain soil organic matter by adding fresh sources of animal and plant residues, especially in the tropics where the decomposition of organic residues is continuous throughout the year.

Important functions of soil organic matter

Although surface soils usually contain only 1-6 % organic matter, soil organic matter performs very important functions in the soil. Soil organic matter:

- Acts as a binding agent for mineral particles;
- Is responsible for producing friable (easily crumbled) surface soils;
- Increases the amount of water that a soil may hold; and
- Provides food for organisms that inhabit the soil.

Humus is an integral component of organic matter because it is fairly stable and resistant to further decomposition. Humus is brown or black and gives soils its dark color. Like clay particles, humus is an important source of plant nutrients.

3.2 Mulching

Exercise 3.2

Demonstrate mulching. If there is someone who is already using this technique, it could be helpful to visit their farm. If a field visit is not possible, a step-by-step drawing of the mulching techniques could be effective.

What is mulching?

Mulching is the process of covering the soil surface with organic matter to create conditions that are more favorable for plant growth (i.e. creating an optimal climate independent of weather conditions), improving the decomposition and mineralization of organic material in the soil (i.e. surface composting), and protecting the soil from erosion.

How is it helpful for livelihoods?

Mulching can improve the productivity of the land (i.e. crop yields) by making conditions more favorable for plant growth, i.e. conserving soil moisture, improving soil fertility and reducing soil erosion.

Mulching around banana crops (S. Shames/EcoAgriculture Partners)

How is it helpful for adaptation to climate change?

- Mulching can help prevent erosion and increase soil fertility.
- Mulching can help protect the soil from excessive heat, exposure to wind, and moisture loss.

How is it helpful for climate change mitigation?

By retaining crop residues, mulching tends to increase the carbon in the soil because these residues are the precursors for soil organic matter, the main store of carbon in the soil. GHG mitigation potential of mulching is **0.02-1.42 tCO2-eq/ha/yr**. In other words, this practice can sequester 0.02 to 1.42 tons of carbon dioxide (or the equivalent of other greenhouse gasses) per hectare over the course of one year.

How do you do it?

- 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 (rats, mice) in the choice and location of mulch material.

3.3 Improved fallow

Exercise 3.3

Discuss as a group the potential benefits and drawbacks of using improved fallows. This might help participants to understand that the long-term benefits often outweigh the short-term costs of this strategy.

What is improved fallow?

The planting of fast-growing species of leguminous trees or crops into a short-term fallow for one or more years to improve soil fertility.

How is it helpful for livelihoods?

Improved fallows help restore fertility to land whose nutrients is depleted. Plant species like grasses or legumes that fix nitrogen grow during the fallow period. As the nitrogen fixing plants grow, excess nitrogen is released back into the soil. Nitrogen is a vital nutrient for plants and plant growth. Planting nitrogen fixing plants is very important for rebuilding soil fertility and improving crop yields.

How is it helpful for adaptation to climate change?

- Improved fallows can help restore degraded land which can be important for adapting to climate change.
- They also can help to protect the soil from excessive heat, exposure to wind, and moisture loss.

How is it helpful for climate change mitigation?

- Improved fallows require less fertilizer and therefore have fewer greenhouse gas emissions.
- The leaves of the leguminous plants can be incorporated into the soil, increasing the carbon in the soil. GHG mitigation potential of improved fallows is **1.17-9.51 tCO2-eq/ha/yr**.

How do you do it?

Plant leguminous shrubs, such as *Sesbania*, *Tephrosia*, *Crotolaria* and *Cajanus*, in fallow lands. These plants are better than natural fallows for enhancing soil fertility, especially for restoring nitrogen and improving other soil properties, and they ease the work of tilling the soil.

3.4 Manure management

Exercise 3.4

Hold a demonstration of how manure should be handled and applied.

What is manure management?

Manure management activities involve the handling of animal dung and urine (farmyard manure) predominately in the solid form when applying it to croplands.

How is it helpful for livelihoods?

Applications of manure in the croplands enable achieving and maintaining a fertile soil, which can increase crop yields.

How is it helpful for adaptation to climate change?

The application of manure can improve productivity and produce greater crop yield which is important for adapting to climate change.

How is it helpful for climate change mitigation?

Methane emissions from animal waste strongly depend on the specific manure management system and on the conditions and manner in which the system operates. However, generally handling manure in the solid form instead of the liquid form will suppress CH_4 emissions. Covering liquid manure also reduces N_2O emissions. GHG mitigation potential of manure management is **0.02-1.42 tCO2-eq/ha/yr**.

How do you do it?

- Handle manure in the solid form instead of the liquid form when applying it to croplands.
- Cover liquid manure.

3.5 Composting

Exercise 3.5

Hold a field demonstration of composting.

What is composting?

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

How is it helpful for livelihoods?

- Compost functions as a form of organic fertilizer made from leaves, weeds, manure, household waste and other organic materials, thus it can reduce the cost of fertilizer from other sources.
- Proper compost management leads to an increased proportion of humic substances in the soil due to high micro-organic activity, and therefore applying compost leads to quantitative and qualitative improvements of the humus content of the soil, which leads to an increase in crop yields.

How is it helpful for adaptation to climate change?

- Composting helps to improve soil fertility which is helpful in reducing the impacts of climate change.
- Composting helps increase soil moisture and soil cover, as well as reduce soil loss.

How is it helpful for climate change mitigation?

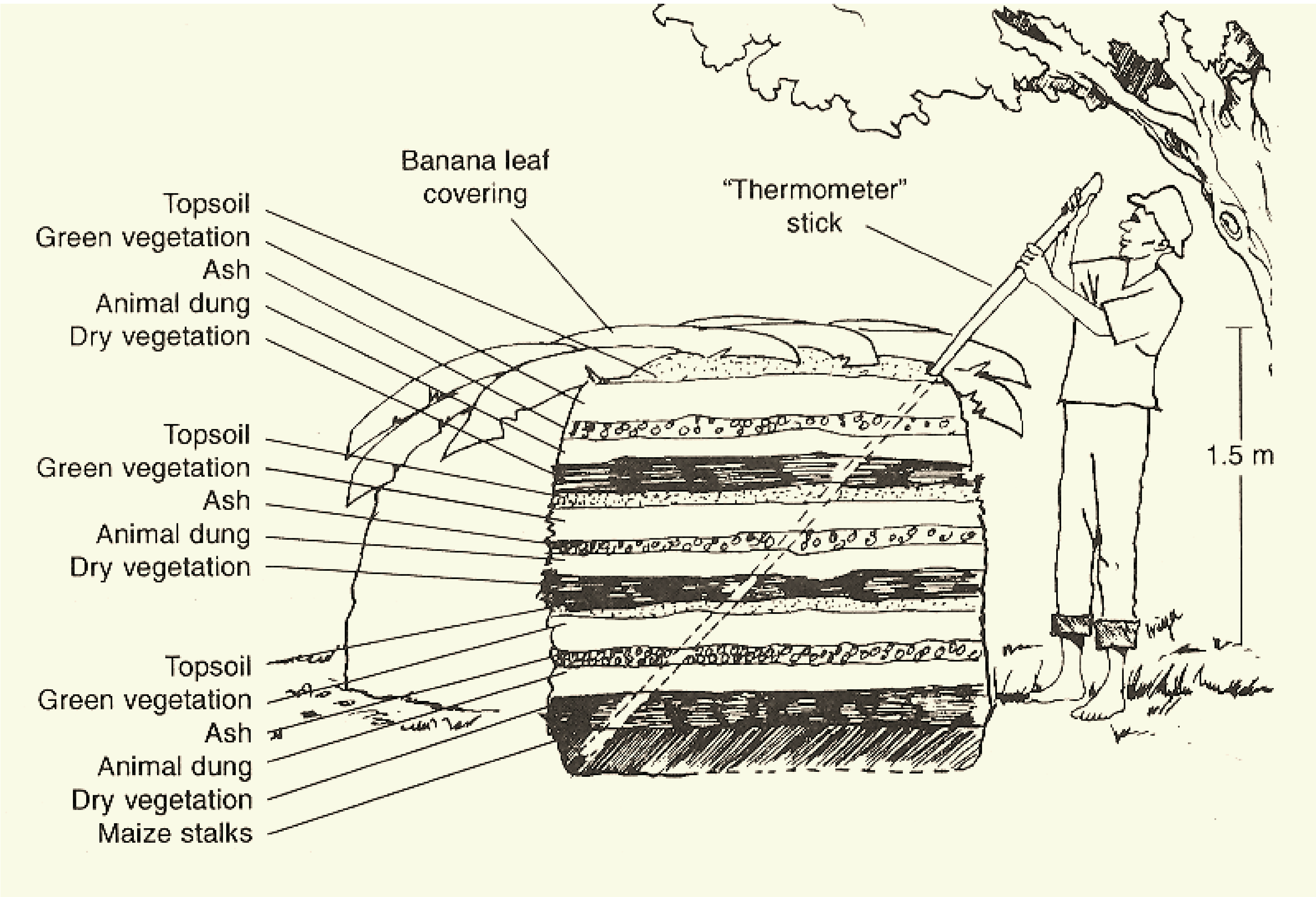
Composting helps reduce the need for fertilizer which decreases greenhouse gas emissions. GHG mitigation potential of composting is **0.02-1.42 tCO2-eq/ha/yr**.

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

How do you do it?

The Do's of Composting	*The Don'ts 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.	• 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 or insect-infested 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.

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



Demonstration of precise fertilizer application on small smallholder farm at planting (J. Recha/ERMCSD)

3.6 Improved fertilizer use efficiency

Exercise 3.6

Hold a field demonstration.

What is improved fertilizer use efficiency?

Improved fertilizer use efficiency involves various techniques for reducing the amount of fertilizer required for plants to grow effectively.

How is it helpful for livelihoods?

By improving efficiency, it reduces the amount of fertilizer needed, which reduces the cost of fertilizer inputs.

How is it helpful for adaptation to climate change?

Precision agriculture techniques can also help to retain water and nutrients in the root zone, which are important for adapting to climate change.

How is it helpful for climate change mitigation?

By reducing the amount of fertilizer required for plants to grow effectively, the GHG emissions from fertilizer usage decrease. GHG mitigation potential of improved fertilizer use efficiency is **0.02-1.42 tCO2-eq/ha/yr**.

How do you do it?

- Use recommended rates of suitable organic and inorganic fertilizers. (These rates can be found in the Farm Management Handbook of Kenya.)
- Place the nitrogen more precisely into the root zone to make it more accessible by crops.
- If possible, use precision agriculture techniques to improve fertilizer application by helping determine exactly where to place nutrients, how much to apply, and when to apply. Three techniques can help achieve this objective:
    - The collection of spatial data from pre-existing conditions in the field (e.g., remote sensing, canopy size, or yield measurement);
    - The application of precise fertilizer amounts to the crop when and where needed; and
    - The recording of detailed logs of all fertilizer applications for spatial and temporal mapping.

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Soil fertility is gradually declining in Africa from leaching, soil erosion and the removal of crop harvests.
- Soil organic matter performs many functions in the soil, and it is important to maintain it by adding fresh sources of animal and plant residues.
- Mulching is the process of covering the soil surface with organic matter. It can improve the productivity of the land, prevent soil erosion, increase soil fertility, protect the soil from excessive heat, wind and moisture loss, and increase the carbon in the soil.
- An improved fallow is created by planting a fast-growing leguminous species into a short-term fallow to improve soil fertility. It can restore the fertility of degraded land, protect the soil from excessive heat, wind and moisture loss, require less fertilizer, and increase the carbon in the soil.
- Manure management involves handling manure in its solid form when applying it to croplands. Applications of manure can enhance soil fertility, improve the productivity of the land, and handling it effectively can reduce methane emissions.
- Composting is the controlled decomposition of plant and animal waste to produce an organic fertilizer. Applications of compost can reduce the need for fertilizer, increase crop yields, increase soil moisture, and reduce soil loss.
- Improved fertilizer use efficiency involves various techniques for reducing the amount of fertilizer required for plants to grow effectively. It can reduce the cost of fertilizer inputs, help retain water and nutrients in the root zone, and reduce emissions from fertilizer use.

Further Reading

Bryan, E., C. Ringler, B. Okoba, J. Koo, M. Herrero, and S. Silvestri. 2011. Agricultural Management for Climate Change Adaptation, Greenhouse Gas Mitigation, and Agricultural Productivity: Insights from Kenya. International Food Policy Research Institute Discussion Paper 01098. http://www.ifpri.org/sites/default/files/publications/ifpridp01098.pdf

FAO. 2001. Rural communities actively implementing conservation agriculture. In Conservation agriculture: Case studies in Latin America and Africa. http://www.fao.org/docrep/003/y1730e/y1730e04.htm Accessed: December 10, 2013.

Jaetzold, R. H. Schmidt, B. Hornetz, C. Shisanya. 2005 Farm Management Handbook of Kenya Vol. II: Natural Conditions and Farm Management Information: West Kenya. GTZ, Nairobi. http://www2.gtz.de/dokumente/bib/07-1282.pdf

Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO). https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

Organicgardeninfo.com. 2103. Healthy Organic Gardening Soil. http://www.organicgardeninfo.com/soil.html. Accessed: December 10, 2013.

Paustian, K., N.H. Ravindranath, A. van Amstel, M. Gytarsky, W. Kurz, S. Ogle, G. Richards, Z. Somogyi. 2006. Volume 4: Agriculture, Forestry and Other Land Use. IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc.ch/meetings/session25/doc4a4b/vol4.pdf

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C., Scholes, B. and O. Sirotenko. 2007. Agriculture. In: Metz, B., Davidson, O.R., Bosch, P.R., Dave, R. and L.A. Meyer, eds. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. P. 498-540. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter8.pdf

Healthy soil will allow maize to flourish (S. Shames/EcoAgriculture Partners)

Module 4

Tillage and residue management

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

4.1 Tillage management

Exercise 4.1

Have a group discussion of possible ways to reduce tillage. What are the benefits and challenges of implementing these practices?

Learning objectives

1. Understand the benefits of tillage management and learn techniques for reducing tillage.
2. Understand the benefits of managing residue and learn techniques for managing residue.

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.

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.

Conservation tillage (H. Liniger)

How is it helpful for adaptation to climate change?

- 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 only under certain climatic conditions, i.e. 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.**

How do you do it?

There are several types of reduced tillage practices.

- 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.

4.2 Residue management

Exercise 4.1

Take a field visit to a farm practicing residue management techniques discussed below.

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.

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 adaptation to climate change?

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**.

How do you do it?

- Burning of residues should be limited and carefully managed.
- A special form of residue management promoted in the Kenyan context are "trash lines", which 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)

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Tillage management practices reduce soil disturbance from planting. This increases the amount of carbon in the soil, helps stabilize the soil, increases water infiltration, conserves soil moisture, and prevents erosion.
- Residue management is the sound handling and utilization of crop residues, which ideally leaves at least 30% of the soil covered with crop residues after harvest. Plant residues increase the carbon in the soil, reduce soil erosion and improve water infiltration when placed along contours, and proper management of residues reduces the need for burning.

Further Reading

Bryan, E., C. Ringler, B. Okoba, J. Koo, M. Herrero, and S. Silvestri. 2011. Agricultural Management for Climate Change Adaptation, Greenhouse Gas Mitigation, and Agricultural Productivity: Insights from Kenya. International Food Policy Research Institute Discussion Paper 01098. http://www.ifpri.org/sites/default/files/publications/ifpridp01098.pdf

FAO. 2001. Rural communities actively implementing conservation agriculture. In Conservation agriculture: Case studies in Latin America and Africa. http://www.fao.org/docrep/003/y1730e/y1730e04.htm Accessed: December 10, 2013.

Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO). https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

Organicgardeninfo.com. 2103. Healthy Organic Gardening Soil. http://www.organicgardeninfo.com/soil.html. Accessed: December 10, 2013.

Paustian, K., N.H. Ravindranath, A. van Amstel, M. Gytarsky, W. Kurz, S. Ogle, G. Richards, Z. Somogyi. 2006. Volume 4: Agriculture, Forestry and Other Land Use. IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc.ch/meetings/session25/doc4a4b/vol4.pdf

Smith P, Martino D, Cai Z, Gwary D, Janzen H, Kumar P, McCarl B, Ogle S, O'Mara F, Rice C, Scholes B, Sirotenko O. 2007. Agriculture. In: B Metz, OR Davidson, PR Bosch, R Dave, LA Meyer, eds. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. P. 498-540. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter8.pdf

Module 5

Agronomic practices

This module presents an overview of agronomic practices to improve soil quality, enhance water use efficiency, and improve the environment through better fertilizer management.

5.1 Introduction

Exercise 5.1

Break into small groups (one for each type of agronomic practice). Allow the groups to discuss the practice, how to implement it, and possible benefits. Then report back to the larger group.

Learning objectives

1. Define agronomic practices
2. Understand the benefits of using several types of agronomic practices

Agronomic practices are techniques farmers incorporate into their farm management systems to improve soil quality, enhance water use efficiency, manage crop residue and improve the environment through better fertilizer management. These steps decrease input costs and also improve the environment by decreasing water use and over-fertilization.

In this module, we'll explore four main types of agronomic practices.

- Cover crops and green manure
- Intercropping, alley cropping, relay cropping and contour strip cropping
- Crop rotation
- Improved crop varieties

5.2 Cover crops and green manure

What are cover crops and green manure?

Cover crops are planted to conserve the soil on bare or fallow farmland. Green manure is a fast growing legume sown in a

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

field several weeks or months before the main crop is planted. Tree legumes used as green manure are also called "fertilizer trees". They fix nitrogen in the soil and are more permanent than other types of green manure.

How are they helpful for livelihoods?

Cover crops and green manure increase the nitrogen in the soil, which improves crop yields.

How are they helpful for adaptation to climate change?

- Cover crops conserve the soil.
- Cover crops can also help protect the soil from excessive heat, exposure to wind, and moisture loss.

How are they helpful for climate change mitigation?

Cover crops and green manure add carbon to the soils) and may also extract plant-available nitrogen unused by the preceding crop, thereby reducing N2O emissions. GHG mitigation potential of cover crops is **0.51-1.45 tCO2-eq/ha/yr.**

How do you do it?

Plant lablab beans as cover crops as well as other grasses (star grass, guinea grass, T/Nzoia variety) and legume plants (cow peas, mucuna). When the legume flowers, plough it into the soil.

5.3 Intercropping, alley cropping, relay cropping and contour strip cropping

What are these practices?

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

Banana trees and coffee plants grown together (S. Shames/EcoAgriculture Partners)

Alley cropping (http://www.ingafoundation.org/gallery/#.Uw4RovldX_E)

- Alley cropping: 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.
- Relay cropping: Planting temporary crops (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.
- Contour strip cropping: 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.

How are these practices helpful for livelihoods?

- They improve economic stability by providing several types of crops.
- They increase cash flow.
- They improve the productivity of the land.

How are these practices helpful for adaptation to climate change?

- They improve plant and animal diversity.
- Intercropping can also help protect the soil from excessive heat, exposure to wind, and moisture loss.

How are these practices helpful for climate change mitigation?

Mitigation potential for intercropping, alley cropping, relay and contour strip cropping is **0.51-1.45 tCO2-eq/ha/yr**.

5.4 Crop rotation

What is crop rotation?

Crop rotation involves planting suitable crops such as legumes and grasses in rotation with other crops in order to maintain the fertility of the soil.

How is it helpful for livelihoods?

- Crop rotation helps maintain the fertility of the soil.
- Crop rotation also helps to avoid the build-up of pests, weeds, and diseases and it ensures that the root systems explore the soil to different depths.

How is it helpful for adaptation to climate change?

Crop rotation improves the fertility of the soil, which helps with adapting to changes in climate.

How is it helpful for climate change mitigation?

GHG mitigation potential of crop rotation is **0.51-1.45 tCO_2-eq/ ha/yr**.

How do you do this?

The main practices are planting cereals (high feeders), legumes (nitrogen fixing) and root crops (cover crops) in a sequence. Maize, beans (intercrops and pure stands), cassava, and potatoes are used mostly.

5.5 Improved crop varieties

What are improved crop varieties?

They are 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.

How are they helpful for livelihoods?

Using improved varieties can increase production yields and require less fertilizer, which would reduce input costs.

How are they helpful for adaptation to climate change?

Farmers can select crop varieties that withstand effects of climate change (i.e. drought tolerant, pest resistant, etc.).

How are they helpful for climate change mitigation?

- Using improved varieties can increase soil carbon or residues that can be managed to store carbon in the soil for a long period of time
- Also, by reducing reliance on fertilizer, using improved varieties can reduce emissions. GHG mitigation potential of improved crop varieties is **0.51-1.45 tCO_2-eq/ha/yr**.

How do you do it?

Plant improved crop varieties like hybrid maize, grafted mangoes, indigenous vegetables, mosaic resistant cassava, groundnuts and tissue culture bananas.

Improved sorghum (J.Recha/ERMCSD)

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Agronomic practices are techniques farmers use to improve soil management and crop production. These steps decrease costs and improve the environment through better fertilizer and water management.
- Cover crops and green manure are planted on bare or fallow land to conserve soil and increase soil fertility. They can help improve crop yields, protect the soil from excessive heat, wind and moisture loss, and add carbon to the soil.
- Intercropping, alley cropping, relay cropping and contour strip cropping are techniques for planting crops that improve the productivity of the land by increasing the diversity of crops planted. They can help improve economic stability and protect the soil from excessive heat, wind and moisture loss.
- Crop rotation involves planting legumes and grasses in rotation with other crops. It helps maintain the fertility of the soil and helps avoids the build-up of pests, weeds and diseases.
- Improved crop varieties are crop varieties that have been researched and tested to have special qualities. They can increase production yields, require less fertilizer, withstand the effects of climate change, and increase soil carbon.

Further Reading

Bryan, E., Ringler, C., Okoba, B., Koo, J., Herrero, M. and S. Silvestri. 2011. Agricultural Management for Climate Change Adaptation, Greenhouse Gas Mitigation, and Agricultural Productivity: Insights from Kenya. International Food Policy Research Institute Discussion Paper 01098. http://www.ifpri.org/sites/default/files/publications/ifpridp01098.pdf

FAO. 2001. Rural communities actively implementing conservation agriculture. In Conservation Agriculture: Case studies in Latin America and Africa. http://www.fao.org/docrep/003/y1730e/y1730e04.htm Accessed: December 10, 2013.

Follett, R.F. 2001. Soil management concepts and carbon sequestration in cropland soils (ISTRO Keynote paper, Fort Worth., TX; July 3-5, 2000). Soil and Tillage Research. 61:77-92.

Freibauer, A., M.D. Rounsevell, P. Smith, J. Verhagen. 2004. Carbon sequestration in the agricultural soils of Europe. Geodera, 122 (1):1-23.

Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO). https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

Organicgardeninfo.com. 2103. Healthy Organic Gardening Soil. http://www.organicgardeninfo.com/soil.html. Accessed: December 10, 2013.

Paustian, K., N.H. Ravindranath, A. van Amstel, M. Gytarsky, W. Kurz, S. Ogle, G. Richards, Z. Somogyi. 2006. Volume 4: Agriculture, Forestry and Other Land Use. IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc.ch/meetings/session25/doc4a4b/vol4.pdf

Smith P, Martino D, Cai Z, Gwary D, Janzen H, Kumar P, McCarl B, Ogle S, O'Mara F, Rice C, Scholes B, Sirotenko O. 2007. Agriculture. In: B Metz, OR Davidson, PR Bosch, R Dave, LA Meyer, eds. Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press. P. 498-540. http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter8.pdf

Module 6

Integrated pest management

This module begins with an overview of integrated pest management (IPM) and the basic techniques for implementing IPM. Then, it presents specific cultural, biological, physical and chemical methods of implementing IPM.

6.1 Introduction

Exercise 6.1

Find out what participants already know about integrated pest management. How do they control pests currently, and what challenges are they facing?

Learning objectives

1. Understand the definition of IPM.
2. Understand the techniques for IPM.
3. Understand how to use cultural, biological, physical and chemical methods of IPM.
4. Understand the benefits and disadvantages of using IPM.

What is integrated pest management?

Integrated pest management (IPM) is a strategy to prevent and suppress pests with a minimal impact on human health, the environment and other organisms. It is a management approach that encourages natural and cultural control of pests 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 and the environment. There are many non-chemical techniques available to reduce and control pests, such as modifying habitat, improving soil health, and using resistant plant varieties.

How is it beneficial for livelihoods?

- It increases productivity by reducing pest damage and promoting healthy plants.
- It reduces risks, such as exposure to pesticide and consumption of their residues, that are associated with pest management to public and farmer health
- It decreases pesticide use and increases adoption of more ecologically benign control tactics.
- It can increase the cost-effectiveness of pest management programs.

How is it helpful for adaptation to climate change?

- It protects other species by reducing impact of pest management activities on the ecosystem
- It reduces the potential for air and ground water contamination.

How is it helpful for climate change mitigation?

- IPM reduces emissions which otherwise would have been produced from use of pesticides and chemicals.
- It can also help to maintain soil biota, and sometimes involves biomass transfer, which builds soil organic matter, recycles nutrients and stabilizes soil carbon.

6.2 IPM basics

Exercise 6.2

List the steps to developing IPM (monitoring, identifying pests, establishing tolerance level, developing pest management strategy, monitoring results) as a group and discuss each one individually.

IPM has several steps. First, farmers must focus on preventing problems by monitoring plants, identifying pests and choosing a combination of tactics to keep pests. Tactics for managing pests may include cultural, mechanical, biological and chemical methods. IPM stresses trying the least toxic methods first.

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

How to do IPM

Monitor

Regularly check your plants for signs and symptoms of pest damage. Check each plant two or three times per week during the height of the growing season. Inspect the undersides of leaves and the inner parts of plants. You can also check your plants at night with a flashlight.

Look closely at any plant that is missing leaves, flowers or fruit. Also look for plants whose color, texture or size looks unusual. Compare each plant to others of the same variety and to what it looked like in previous years during the same season.

Identify pests

Most plant problems are due not to pests, but to nonliving factors like poor growing conditions, temperature extremes, poor water management, soil compaction or mechanical injury. When you discover a plant problem, the first step is to rule out these factors as the cause.

If you conclude that you do have a pest problem, the next step is to find the pest itself or typical signs and symptoms associated with it. Remember that many organisms do no damage, and many others are beneficial. Make sure the organism you identify is the one actually doing the damage and not just one that happens to be present. You can use plastic bags and glass jars to collect pests for identification purposes.

Once you identify the pest, try to determine when it is most susceptible to control measures. For example, an insect may be soft-bodied as a larva and hard-bodied as an adult. Typically, soft-bodied insects are controlled more easily than hard-bodied ones. Also, it usually is easier to control relatively immobile insects than those that fly.

Establish the plant's tolerance level

Consider how much damage each plant can tolerate. Some food plants can tolerate quite a bit of defoliation without exhibiting decreased yields. Seedlings are less able to withstand pest damage than are mature plants. Use references and experience to help you determine whether a plant is likely to withstand pest damage.

Develop a pest management strategy

After you have identified a pest and decided its damage is unacceptable, you need to develop a pest management strategy. Your strategy may involve the use of more than one method.

Evaluate results

Evaluation is an important and often overlooked part of a pest management program. Did your strategy work? Was the pest controlled to your satisfaction? You can answer these questions by continuing to monitor your plants carefully. Record your observations for future reference.

6.3 IPM Methods

Exercise 6.3

Break into small groups to discuss the four methods of IPM. Have the participants make a list of questions or things that are unclear about the method. Discuss all of the questions as a large group.

Cultural method

Cultural pest management methods prevent pest problems by keeping plants healthy and growing vigorously. Others directly address specific pest problems. Some of them are:

Choosing resistant/tolerant varieties

- Selection of plants strongly influences what pests you are likely to encounter. When possible, choose plants that are not prone to serious pest problems.
- A plant's level of resistance is determined by its physical characteristics or chemical composition. "Tolerant" varieties can tolerate a lot of damage without a significant decrease in appearance or yield. Some of the most common pest problems can be avoided by choosing resistant or tolerant varieties.

Putting the right plant in the right place

- Place plants in an environment where they will grow well. Although some plants will grow in a wide variety of environments, most require fairly specific conditions.
- 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, wounds and symptoms of insect or disease problems. Choose healthy-looking plants with good color.
- Give plants a good start by planting them properly. Crowded plants invite pests.

Keeping plants healthy

- Healthy plants are less likely to suffer a pest attack, and can better withstand pest damage if an infestation does occur.
- An under-fertilized plant is stressed and vulnerable to pest attack, and an over-fertilized plant may have excess succulent growth that can invite disease and insect pests.
- Provide adequate but not excessive irrigation. Drought-stressed plants are more susceptible to pest attack. Plants in excessively wet soil are vulnerable to attack by root-disease organisms.
- Adding organic matter to soil helps retain water and nutrients, improves drainage, and encourages beneficial soil micro-organisms.

Removing unhealthy plants

- Remove pest-infested leaves and fruit as soon as you see them. If an annual plant is badly infested with insects or disease, remove the entire plant. Prune out diseased and dead branches of woody plants.
- Add disease- or insect-infested plant parts to your compost pile only if you are hot composting. Otherwise, destroy them.

Rotating annual plants

- When the same plants are grown in the same soil each year, insect and disease populations build up. By growing a different plant in the same place each year, you will deprive pests of their hosts.
- Since insects and diseases often infest members of the same plant family, it is best to rotate to a member of a different family.

Companion planting

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

- One plant can act as a "trap" and draw pests away from the other.
- One plant may produce a repellent or toxic substance that discourages or harms pests.
- One plant may provide habitat for natural enemies of the other plant's pests.

Intercropping

- Intercropping involves mixing plants to break up pure stands of a single crop.
- The physical separation of individual plants of one type by those of another may interrupt the movement of insects and diseases.

Biological method

In a well-balanced ecosystem, insect pest populations are kept in check by natural enemies such as other insects, birds, bats, frogs and toads. Disease organisms are kept under control by competition from other microorganisms, and weeds are controlled by insects and other animals. You can use biological controls to help keep pest numbers low, but usually some pests need to be present for natural enemies to survive.

Beneficial insects

- Most insects are not pests. Only those that feed on desirable plants or transmit disease cause problems for farmers.
- Beneficial insects include pollinators (bees and flies), as well as predatory insects that eat damaging insects.

Protecting beneficial insects

All beneficial insects are susceptible to insecticides. If you decide to use an insecticide, take the following measures to protect beneficial insects:

- Choose the least toxic pesticide that will be effective.
- Spot spray only infested plants.

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

- Do not spray plants in bloom.
- Spray early in the day when many insects are less active.

Creating habitat for beneficial insects

- Many beneficial insects feed on nectar and pollen in addition to pest insects. The flowers that attract them are sometimes referred to as insectary plants.
- By scattering insectary plants throughout your farm and landscape, you can attract beneficial insects. Or consider reserving an area for insectary plants.
- Many non-flying predators need a place to hide from their enemies. Groundcover and coarse mulches such as bark dust and straw provide this habitat. Beneficial insects also need water.

Physical method

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

Hand picking

- Hand pick large, clearly visible or slow-moving insects by hand. This technique requires careful observation of affected plants, including the undersides of leaves. You must hand pick most species every few days to keep damage at an acceptable level.
- The best time to collect most insects is early morning, when temperatures are cool and insects are sluggish. At night, use a flashlight to find pests that hide during the day.

Pruning

- If pests are concentrated at one or two sites on a plant, you may be able to prune them out.
- In addition, regular pruning makes a plant less dense, which allows beneficial insects to locate their prey more easily. It also improves air circulation, which decreases the incidence of foliage diseases.
- Before pruning for pest control, evaluate whether potential pest damage is greater than potential pruning damage.

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.

- When choosing a chemical, always make certain it is labeled for your specific intended use. Choose the chemical 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
- Labels give a general idea of toxicity by the use of signal words. Pesticides labeled "Caution" are the least toxic, those labeled "Warning" are more so, and those labeled "Danger" are the most toxic.

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- IPM is a strategy to prevent and suppress pests with minimum impact on human health and the environment.
- IPM involves monitoring pest populations, identifying pests, establishing your tolerance level, developing a strategy for pest management and then evaluating your results.
- The cultural method for IPM involves choosing plant varieties that are pest resistant, putting plants in the right place, starting with healthy transplants, keeping plants healthy, keeping the garden/farm clean, rotating annual plants, utilizing companion planting and intercropping, and spraying plants with water.
- The biological method for IPM involves keeping pests in check using natural enemies such as beneficial insects.
- The physical method for IPM involves physically blocking or removing pests from plants through hand picking, pruning, trapping, and mulching.
- The chemical method for IPM should be considered only if the other methods are not adequate. Botanical insecticides, which are less toxic to the environment, can also be used.
- IPM increases the productivity of crops by reducing pest damage, decreases the cost of pest management, protects non-target species and human health, reduces the potential for air and water contamination, and builds soil organic matter. However, it takes more time and knowledge to implement effectively.

Further Reading

Cornell University. 2014. The Integrated Pest Management Strategy. Accessed 17 Jan, 2014. http://www.biocontrol.entomology.cornell.edu/ipm.html

CropLife International. 2008. Trainee Manual: Introduction to Integrated Pest Management. CropLife International: Brussels. http://www.croplife.org/ipm

Gredler, Gail. 2011. Integrated Pest Management. In *Kentucky Master Gardener Manual*. University of Kentucky: Lexington. http://www2.ca.uky.edu/agc/pubs/ent/ent69/ent69.pdf

Michigan State University. 2014. Integrated Pest Management Academy. Accessed 21 Jan, 2014. http://www.ipm.msu.edu/agriculture/integrated_pest_management_academy

Module 7

Agroforestry practices

This module presents an overview of agroforestry, including its attributes and benefits for livelihoods, climate change adaptation and climate change mitigation. It also describes many specific agroforestry practices.

7.1 Introduction

Exercise 7.1

A quick pre-test on the importance of improved agroforestry and various techniques.

Learning objectives

1. Understand the logic behind agroforestry practices and the benefits from using them
2. Learn specific agroforestry techniques

What is agroforestry?

Agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or 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.

Agroforestry attributes

- Productivity: It must maintain or increase production.
- Sustainability: It must meet the needs of the present generation without compromising the ability of future generations to meet their own needs.
- Adoptability: It should be culturally acceptable and environmentally friendly.

How is it helpful for livelihoods?

- It reduces poverty through increased production of agroforestry products for home consumption and sale.
- It increases yields by restoring farm soil fertility and creating favorable micro-climates for food crops.

How is it helpful for adaptation to climate change?

- It increases the diversity of on-farm trees, crops and tree cover to cushion farmers against the effects of global climate change.
- It enhances or maintains wildlife habitat as well as biological diversity.
- It reduces deforestation and pressure on woodlands by providing fuelwood grown on farms.
- Trees provide microclimate conditions that are suitable for crop growth by protecting the soil from excessive heat, exposure to wind, and moisture loss.
- It increases food security by increasing the production of fruits, nuts and edible oils.
- It improves nutrition to lessen the impacts of hunger and chronic illnesses..
- It augments accessibility to medicinal trees, the main source of medication for 80% of Africa's population.

How is it helpful for climate change mitigation?

- Trees store carbon. The key characteristics that differentiate how much carbon is stored are tree density and the products derived from the system.
- The soils of agroforestry systems contain significant quantities of carbon. Generally the amount of carbon stored in a system's soil remains steady, increasing slowly with time. Green house mitigation potential of agroforestry is **0.44-1.89 tCO_2-eq/ha/yr**.

What are other benefits?

- Odor, dust, and noise reduction
- Green space and visual aesthetics

7.2 Specific agroforestry practices

Exercise 7.2

Break into small groups and assign one or two techniques to each group. Allow the groups to discuss the technique and think of examples of how this technique could be applied. Then each of the small groups can report back to the larger group. Alternatively, a field visit to a farm that uses many of these agroforestry practices could be useful here.

Dispersed trees on cropland

Trees may be grown in fields while crops are grown alongside or underneath. The practice of growing trees in this way can be done either by protecting and managing the trees that are already there or by planting new trees.

Trees on cropland (S. Kilungu/CCAFS)

Buffer zone agroforestry

These are agroforestry practices carried out around protected forest areas to serve the following functions:

- Reduce human pressure on protected forest reserves;
- Improve living standards of people around protected areas within the ecosystem;
- Sustain water quantity and quality;
- Reduce soil erosion; and
- Enhance the production of multiple products

Alley cropping

Alley cropping is also known as alley farming or hedgerow intercropping. Rows of woody plants are grown with annual crops planted in the alleys in between. The main purpose of this method is 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.

Boundary planting between small-holder plots (H. Liniger)

Live fences and hedges

Live fences are established all around the farm; it is common to establish such a fence around homesteads. It is relevant in most farming systems except irrigation schemes. It is particularly important in controlling livestock grazing.

Shamba system

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

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.

Fodder lots and fodder banks

Areas where trees or shrubs are grown in a stand to produce fodder are known as fodder lots. Trees and shrubs may be intercropped with fodder grasses to maximize fodder production. Trees and shrubs with palatable leaves and/or pods are attractive to farmers as feed supplements for their livestock because they require little or no cash for inputs; they can be grown on boundaries as trees (often pollarded to reduce competition) or as hedges.

A fodder bank is a store of conserved grasses (hay or silage) which is deliberately accumulated over and above the normal seasonal requirements, for use by livestock in unpredictable, lean times such as an unseasonal dry period, a severe hail storm, or an armyworm outbreak.

Trees in rangeland and grazing land

Scattered trees in rangeland are beneficial in many ways, e.g. providing shade for livestock and herdsmen, and fodder and wood. Normally, such trees are scattered at random and there is no need to be particular regarding any regular spatial arrangement.

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.

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. It aims at improving nitrogen, potassium, phosphorus, manganese and calcium in the soil. The most used plants in Kenya are: *Tithonia diversifolia* and *Lantana camara*.

Trees along streams and rivers (riparian buffers)

These are managed forest and shrub belts in areas bordering lakes, streams, rivers, and wetlands. Integrated riparian management systems are used to enhance and protect aquatic and riparian resources as well as generate income from timber and non-timber forest products (e.g. medicines and fruits).

Incorporating leafy plants into soil (S. Shames/EcoAgriculture Partners)

Windbreaks

A windbreak is a plantation usually made up of 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.

Plantation crop combination

This practice involves growing shade tolerant crops such as coffee, tea and beans under trees such as *Grevillea robusta*, *Cordia abyssinica*, *Faidhebia abyssinica*, and *Cordia Africana*. The crops in most cases are plantation crops. The focus is on perennial components such as coffee tea which produce high value products. Trees provide microclimate conditions suitable for the growth of the tree species.

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

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. The practice is common where land is regularly fallowed especially in semiarid areas. Nitrogen fixing trees and shrubs include *Sesbania sesban*, *Markhamia lutea* (siola), *Calliandra calothyrsus*, *Casuarina equisetifolia* (whispering pine), and *Leucaena leucocephala* (Lusina).

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

Trees in home gardens

In a home garden, perennial crops and annual crops are grown side by side. Animals are also usually included in the system.

The home garden is able to provide an extra and continuous flow of products for daily use. They are common in the humid tropics and are characterized by the intensive use of multi-purpose trees, shrubs, food crops and animals.

Woodlots

Woodlots are an area on the farm set aside specifically for wood production. Woodlots of may be include a single species or a mixture of several species. Woodlots can also be useful for beekeeping by providing flowers for nectar. Examples of woodlots commonly planted by people in Kenya include: *Casuarina, Sesbania, Gliricidia, Grevillea* and *Markhamia* species.

Woodlot in Kenya (J. Recha/ERMCSD)

Trees on soil conservation structures

In traditional systems, lines of grasses, stones, crop residues and other organic debris are placed along hillsides to control water and soil erosion. Contour vegetation strips are living barriers of trees and shrubs which are planted along the contour lines of a slope. These lines of vegetation can serve the same purpose and can also provide useful products such as food, fuel, building poles, fodder or gum. There are many factors to consider when building contour strips, as bad design can lead to even more severe erosion.

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

The effectiveness of the vegetation strips depends on the:

- Type of trees planted,
- Spacing of the trees and the width of the strip,
- Steepness of the slope,
- Amount of rainfall, and
- Soil type.

The effectiveness of contour strips for water and soil conservation depends on the:

- Design of the systems,
- Soil,
- Climate,
- Slope aspect, and
- Land use of the individual fields.

7.3 Apiculture

Apiculture is the art and science of raising bees. It is an agroforestry technique with untapped potential and a quick investment pay back. Beekeeping has traditionally been practiced in Kenya. Over 80% of honey produced locally still comes from traditional hives. There is a need to embrace modern technology, such as the use of modern beehives like Langstroth and Kenya Top bar hives, in beekeeping.

Bees colonizing a hive (J. Recha/ERMCSD)

Why adopt beekeeping?

- It is simple and relatively cheap to start.
- Beekeeping enhances the environment through the pollinating activity of bees.
- Beekeeping is completely sustainable.
- It generates income and requires very low levels of inputs.
- Beekeeping provides an opportunity to harvest and add value to a local resource to generate wealth and beat poverty.
- It contributes immensely to crop production through pollination and complements existing farming systems.

- It requires little land (50 colonies require a ¼ acre) which does not have to be fertile.
- Honey is a source of non-perishable food.
- Many products can be obtained which are great source of income (i.e. honey, beeswax, pollen, propolis, bee venom, royal jelly, bee colonies, bee brood, queen bees, and package bees).
- Most hive products have therapeutic value and provide a remedy for a number of ailments (apitherapy).

Challenges of beekeeping

- Farmers lack adequate skills on managing bees and handling hive products.
- There is inadequate training for both farmers and extension staff.
- There is limited access to appropriate beekeeping equipment.
- There is an underdeveloped marketing system of hive products both locally and internationally due to problems of quality and marketing organizations.
- There is a lack of adequate and intense research on of the existing beekeeping technologies, equipment, honey bee and product utilization.
- There is a low prioritization of beekeeping in relation to other enterprises in the wider agricultural sector.

Choosing a site for an apiary

When choosing a location for your bees, you should search for a site with the following characteristics:

- Permanent water
- Well-drained soils
- Tall trees
- Bee forage (*Gliricidia*, *Calliandra*, *Grevillea*, Mangoes)
- Little noise

Bee keeping in Kenya (J. Recha/ERMCSD)

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Agroforestry is when trees and deliberately integrated with crops and/or animals to promote beneficial ecological and economic interactions.
- Agroforestry techniques reduce poverty through increased production of agroforestry products and increasing yield of crops. It also increases plant diversity, maintains wildlife habitat, improves the micro-climate conditions for crop growth, and provides many other benefits. Agroforestry systems also store carbon in the trees and soils.
- There are numerous techniques for implementing agroforestry, including planting dispersed trees on cropland, alley cropping, planting trees on boundaries, live fences and hedges, establishing buffer zones, biomass transfer, the shamba system, shifting cultivation, plantation crop combinations, fodder lots and fodder banks, planting trees in rangelands, homesteads, along streams, and on soil conservation structures, improved fallows, windbreaks, apiculture, home gardens, and woodlots.

Further Reading

Bryan, E., C. Ringler, B. Okoba, J. Koo, M. Herrero, and S. Silvestri. 2011. Agricultural Management for Climate Change Adaptation, Greenhouse Gas Mitigation, and Agricultural Productivity: Insights from Kenya. International Food Policy Research Institute Discussion Paper 01098. http://www.ifpri.org/sites/default/files/publications/ifpridp01098.pdf

FAO. 2001. Rural communities actively implementing conservation agriculture. In Conservation agriculture: Case studies in Latin America and Africa. http://www.fao.org/docrep/003/y1730e/y1730e04.htm Accessed: December 10, 2013.

Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO). https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Xu, J., A. Mercado, J. He. I. Dawson. 2013. An Agroforestry Guide for Field Practitioners. The World Agroforestry Centre, East Asia, Kunming, China. http://www.worldagroforestry.org/downloads/publications/PDFs/B17460.PDF

Module 8

Soil and water management

This module provides an overview of soil and water management and describes why it is beneficial for livelihoods, climate change adaptation and climate change mitigation. Then, it presents a variety of techniques to manage soil to conserve water and reduce erosion.

8.1 Introduction

Exercise 8.1

Group brainstorming activity to identify the benefits of improved soil and water management. A field visit, pictures or videos could be used to give the participants a better idea of what these techniques look like in practice.

Learning objectives

1. Understand the benefits of soil and water management
2. Understand techniques to more effectively manage soil and water in agriculture landscapes

Water is a scarce resource in Kenya; its conservation and sustainable use is important to farmers. Sustainable agriculture conserves water and soil through a variety of methods.

What is soil 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.

What is water management?

Water management involves improving water use efficiency and minimizing losses of water from evaporation, runoff or drainage. This includes various techniques, such as storing water in reservoirs to allow it to sink into the soil and increase soil moisture levels. It also includes using a protective cover of vegetation on the soil surface to slow down the flow of running water and spread the water over a large area.

In addition to many of the practices already mentioned (agronomic measures, agroforestry, residue management, mulching, and trashlines), there are also many structural measures which can help to conserve soil and water.

How is it helpful for livelihoods?

- Conserving water helps prevent water scarcity and makes it available for crops, livestock and domestic use over a longer period.
- Soil and water management increases soil organic matter, improves soil fertility and controls soil erosion, improving crop and pasture yields.
- Soil and water management measures improve the supply of fuel and forest products.
- Soil and water management measures increase the value of land
- More and better livestock fodder is available with improved soil and water management.
- These techniques can increase productivity by improving soil fertility, preventing soil erosion and increasing water infiltration into the soil.

How is it helpful for adaptation to climate change?

- Climate change may impact the distribution of water resources. These techniques can help control excess water runoff, making them important strategies for adapting to climate change.
- Conservation and collection of rainwater help to reduce risks associated from rainfall shortage.
- Water diversion structures can help to reduce risks from extreme weather events like floods by controlling excess water.
- Soil and water management can rehabilitate degraded land and enhance biodiversity.

How is it helpful for climate change mitigation?

Effective soil and water management can increase the productivity of land, increasing plants, trees and organic matter in the soil, and pulling carbon dioxide out of the atmosphere. GHG mitigation potential of soil and water management is **0.55-2.82 tCO_2-eq/ha/yr**.

8.2 Improved irrigation

Improved irrigation involves the efficient utilization of water for agricultural purposes. Small-scale irrigation increases the water use efficiency of the crops.

How is it beneficial?

- It improves livelihoods by increasing the productivity of the land.
- It can decrease the growth of weeds.
- It promotes adaptation to a changing climate by increasing the efficiency of water used for crops.
- More effective irrigation measures can enhance carbon storage in soils through enhanced yields and residue returns.

How do you do it?

- Sprinkler irrigation is a method of applying irrigation water which is similar to rainfall. 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 system delivers water directly to the root zone of a plant, where it seeps slowly into the soil one drop at a time. Almost no water is lost through surface runoff or evaporation, and soil particles have plenty of opportunity to absorb and hold water for plants. It also means very few nutrients leach down beyond the reach of plant roots. Furthermore, since drip irrigation delivers water directly to the plants you want to grow, less water is wasted on weeds. The soil surface between the plants also remains drier, which discourages weed seeds from sprouting.

8.3 Diversion ditches and drainage channels

Diversion ditches and drainage channels remove excess water from the land. Diversion ditches and drainage channels 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 N2O gas.

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

8.4 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 make cultivating on steep slopes easier. Terraces with diversion ditches can help control excess water runoff, helping with adaptation to climate change.

A fanya juu terrace is created by digging a trench and throwing the soil upslope to form a ridge. A diversion ditch must be established above the bench system so that runoff water from the upper part of the watershed is properly disposed of. To stabilize the soil, the "risers" may be planted with grasses such as napier. The terraces tend to have a more fertile strip of deeper soils held back by the terrace structures.

Terraces (J. Recha/ERMCSD)

8.5 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 and a few crop seeds are planted.

Planting basins improve water use efficiency by the crops due to increased rates of water infiltration into the soil, which can improve crop yields and the increase the intensity of agricul-

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

ture. Planting basins are important for conserving water in areas where there is not enough rainfall or when rainfall is sporadic. The manure in zai pits can increase soil fertility.

8.6 Other water catchments

These techniques are used to stop water runoff and soil erosion and increase water infiltration. They are also used when rehabilitating waste, eroded or degraded land.

Broad beds and furrows

The field 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. Broad beds, where the crops are grown and which are about 170 cm wide, are planted between the field furrows. They are similar to infiltration ditches.

Broad beds and furrows (http://www.agritech.tnau.ac.in/agriculture/agri_majorareas_watershed_watershedmgt.html)

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.

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

Contour bunds

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

Contour bunds
(http://www.wesnetindia.org/photo_gallery.php)

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.

Half-moon micro-catchments
(http://www.ewt.org.za/programmes/RRP/riperian.html)

Road catchments

Road catchments are structures that divert water runoff from roads and from other unproductive areas, such as paths and homestead compounds, and channel it into crop fields, thus improving productivity. When constructing a road catchment, it may be possible to divert water from structures that already exist, such as the ditches below fanya juu terraces. Or, special bunds can be built around fields close to the road.

Drainage and infiltration ditches

These are wide channels that collect surface run-off water, allowing it to slowly infiltrate into the ground. The ditches will tend to silt-up, which hinders infiltration, and must be cleaned out regularly.

8.7 Restoration and rehabilitation of degraded land

Surplus degraded wasteland or agricultural land can be set aside from production for several years to be restored and rehabilitated through a variety of practices.

- Natural regeneration includes managing the land to allow the natural process of restoration to occur. Vegetation is allowed to return to the land and biomass builds up above and below ground.
- Assisted natural regeneration speeds up the restoration of the land by helping the natural processes of regeneration. This can include planting tree seedlings and other favorable species, and protecting an area from fire and exploitation.
- Enrichment planting helps to restore over-exploited species and is often used with assisted natural regeneration to restore a specific area of land by directly planting certain types of tree species.
- Fire management techniques help to control fire outbreaks by burning patches of grass and undergrowth early in the dry season, when the fire will not become out of control, to help prevent more intense and damaging fires later in the season.

Why is restoration beneficial?

- Allowing land to regenerate often increases the amount of land covered with vegetation, which increases the amount of carbon stored above and below ground. Also, reducing the frequency and intensity of fires allows more vegetation to remain in the landscape and store carbon.
- Rehabilitating degraded land can improve yields over the long-term due to reduced soil and water erosion. GHG mitigation potential of restoration and rehabilitation of degraded land is **1.17-9.51 tCO2-eq/ha/yr**.

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

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Soil management is the prevention and reduction of the amount of soil lost through erosion.
- Water management involves improving water use efficiency and minimizing losses of water from evaporation, runoff or drainage.
- Soil and water management prevent water scarcity, increase soil organic matter, improve soil fertility, improve crop yields and fodder, reduce risks from rainfall shortage and extreme weather events, and rehabilitate degraded land.
- There are many structural measures which can help to conserve soil and water, including Terraces, diversion ditches, drainage channels, planting basins and pits, broad beds, contour bunds, water pans, half-moon catchments, retention/infiltration ditches, road catchment ditches, improved irrigation, and the restoration and rehabilitation of degraded land.

Further Reading

Bryan, E., C. Ringler, B. Okoba, J. Koo, M. Herrero, and S. Silvestri. 2011. Agricultural Management for Climate Change Adaptation, Greenhouse Gas Mitigation, and Agricultural Productivity: Insights from Kenya. International Food Policy Research Institute Discussion Paper 01098. http://www.ifpri.org/sites/default/files/publications/ifpridp01098.pdf

Duveskog, D. 2003. Soil and Water Conservation With a Focus on Water Harvesting and Soil Moisture Retention: A Study Guide for Farmer Field Schools and Community-based Study Groups. Farmesa, Kenya. ftp://ftp.fao.org/agl/agll/farmspi/FARMESA_SWC1.pdf

FAO. 2001. Rural communities actively implementing conservation agriculture. In Conservation agriculture: Case studies in Latin America and Africa. http://www.fao.org/docrep/003/y1730e/y1730e04.htm Accessed: December 10, 2013.

FAO. 2011. The State of the World's Land and Water Resources for Food and Agriculture: Managing Systems at Risk. FAO and Earthscan, London. http://www.fao.org/docrep/017/i1688e/i1688e.pdf
Follett, R.F. 2001. Soil management concepts and carbon sequestration in cropland soils. Soil and Tillage Research. 61:77-92.

Lal, R. 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. Science. 304, 1623. http://globalchangebiology.wikispaces.com/file/view/Lal+2004.pdf

Liniger, H.P., R. Mekdaschi Studer, C. Hauert and M. Gurtner. 2011. Sustainable Land Management in Practice – Guidelines and best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies (WOCAT) and Food and Agriculture Organization of the United Nations (FAO). https://www.wocat.net/fileadmin/user_upload/documents/Books/SLM_in_Practice_E_Final_low.pdf

Mati, M.M. 2007. 100 Ways to Manage Water for Smallholder Agriculture in Eastern and Southern Africa: A Compendium of Technologies and Practices. IMAWESA, SWMnet Working Paper 13. http://www.asareca.org/swmnet/downloads/1179993482SWMnet%20Working%20Paper%2013%20100%20Ways%20of%20AWM%20in%20ESA.pdf

Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Module 9

Improved livestock management

This module gives an overview of improved livestock management practices, discusses the benefits of improved livestock management, and presents several techniques for improving livestock management, including improved feeding practices, long-term livestock management changes, livestock health programs, animal breeding, and mixed farming.

9.1 Introduction

Exercise 9.1

Brainstorm the benefits of improved livestock management as a group.

Learning objectives

1. Understand the benefits of improved livestock management
2. Understand practices that improve livestock management

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.

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

- 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 tCO2-eq/ha/yr** (for East Africa).

9.2 Techniques

Exercise 9.2

Small groups discuss each of the techniques and then present to the larger group.

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).

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.

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 animal feeding practices (S. Shames/EcoAgriculture Partners)

Wrap up

Trainers should briefly summarize what was learned in the module. Possible summary points include:

- Improved livestock management practices are implemented with the goal of increasing the production of livestock and reducing emissions of methane.
- There are several techniques for improving livestock management, including improved feeding practices, making long-term changes to livestock management like the stocking rate or type of livestock kept, keeping animals healthy, using improved breeds, and integrating livestock and crop production.

Further Reading

IFAD. 2010. Integrated crop-livestock farming systems. IFAD, Livestock Thematic Papers: Tools for Project Design. http://www.ifad.org/lrkm/factsheet/integratedcrop.pdf

Livestock and Land. What are Best Management Practices? http://www.livestockandland.org/PDF/BMP%20Brochure.pdf

Pell, A. N. 1999. Integrated Crop-livestock Management Systems in Sub-Saharan Africa. Environment, Development and Sustainability, 1(3-4): 337-348. http://link.springer.com/article/10.1023%2FA%3A1010035123959

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

Appendix 1

Glossary

Acidification

The process of becoming acid or being converted into an acid.

Agroforestry

A system of land use in which harvestable trees or shrubs are grown among or around crops or on pastureland, as a means of preserving or enhancing the productivity of the land.

Assisted natural regeneration

A practice used to accelerate regeneration by assisting the natural processes. It involves promoting tree seedlings and favorable regeneration species (e.g. leguminous species) while protecting the site from fire. Enrichment planting is often applied in combination with assisted natural regeneration.

Atmosphere

A layer of gases surrounding a material body of sufficient mass that is held in place by the gravity of the body.

Carbon dioxide (CO2)

One of the most abundant gasses in the atmosphere. Carbon dioxide plays an important part in vital plant and animal process, such as photosynthesis and respiration.

Carbon sequestration

The process of removing carbon from the atmosphere and depositing it in a reservoir.

Composting

The biological process of breaking up organic waste, such as food waste, manure, leaves, grass trimmings, paper, worms, and coffee grounds, etc., into an extremely useful humus-like substance by various micro-organisms including bacteria, fungi and actinomycetes in the presence of oxygen.

Contour bunds and catchment strips

Structures developed besides the crop fields in order to harvest rain water. Crops are grown behind the bund leading to increased yield production. The structures increase water infiltration, help prevent erosion, and improve soil fertility.

Cover Crop

A type of plant grown to suppress weeds, help build and improve soil, and control diseases and pests. Cover crops are also called "green manure" and "living mulches."

Decomposition

A process where organic substances are broken down into simpler forms of matter.

Enrichment planting

A practice that is applied in combination with assisted natural regeneration. The technique is suitable for the restoration of over-exploited, forest-dominated ecosystems, especially the restoration of sensible buffer strips along waterways.

Erosion

The process of eroding or being eroded by wind, water, or other natural agents.

Fire management

Techniques for controlling fires such as carrying out "early burning," which includes burning patches of grass and undergrowth early in the dry season before the vegetation becomes so dry that more intense and damaging fires occur. Simultaneously the reduction of the use of fire agriculture will be promoted.

Fodderlot

An area restricted to the growing of fodder (trees and/or shrubs), especially for cattle or other livestock.

Green manure

Cover crops that are grown with the intention of turning them back into the soil to provide nutrients to the soil much like manure does.

Greenhouse effect

A phenomenon whereby the earth's atmosphere traps solar radiation, caused by the presence of gases in the atmosphere, like carbon dioxide, water vapor, and methane that allow incoming sunlight to pass through but absorb heat radiated back from the earth's surface.

Greenhouse gas (GHG)

Greenhouse gases include methane, chlorofluorocarbons and carbon dioxide. These gases act as a shield that traps heat in the earth's atmosphere.

Greenhouse gas emissions

Emission into the earth's atmosphere of any of various gases, especially carbon dioxide, that contributes to the greenhouse effect.

Heat stress

Heat stress is a situation where too much heat is absorbed by a plant or an animal and causes stress, illness or even death.

Humus

A brown or black organic substance consisting of partially or wholly decayed vegetable or animal matter that provides nutrients for plants and increases the ability of soil to retain water.

Integrative livestock feeding systems

A form of mixed production that utilizes crops and livestock in a way that they can complement one another through space and time.

Land surface

Any part of the earth's surface not covered by a body of water.

Leguminous mulches

A protective covering of leguminous organic plant material (beans, peas, and soybeans) laid over the soil around plants to prevent erosion, retain moisture and enrich the soil with nitrogen.

Methane (CH4)

A greenhouse gas, produced primarily by anaerobic (oxygen-deficient) processes, such as the cultivation of rice paddies or animal digestion. Like CO_2, its concentration in the atmosphere is increasing due to anthropogenic activities such as agricultural practices and landfills.

Micro-catchment

A method of harvesting surface runoff from a catchment area over a flow distance less than 100 m. Soil and rainfall characteristics have important role to play as they influence the process of infiltration and thus the runoff generation in the catchment area.

Microclimatic condition

Any climatic condition in a relatively small area.

Mineralization

Decomposition or oxidization of the chemical compounds in organic matter into plant-accessible forms.

Mitigation co-benefits

Effects that are additional to direct reductions of GHG and impacts of climate change and are estimated to be large, relative to the costs of mitigation.

Mulch

A protective covering of organic material laid over the soil around plants to prevent erosion, retain moisture and sometimes to enrich the soil.

Natural regeneration

Deliberately managing the land to enhance and accelerate the natural processes of ecological succession in order to re-establish healthy vegetation on farmland and restore vegetation and biomass accumulation on degraded land.

Natural resource capital

The elements of nature that produce value (directly and indirectly) to people, such as the stock of forests, rivers, land, minerals and oceans.

Nitrogen fixing

The natural process by which nitrogen (N_2) in the atmosphere is converted into ammonia (NH_3).

Nitrous oxide (N2O)

A gas produced by both biological mechanisms in the oceans and soils, and by industrial combustion, vehicle exhausts, biomass burning and the use of chemical fertilizers

Riparian buffers

Land adjacent to streams where vegetation is strongly influenced by the presence of water. They are often thin lines-of-green containing native grasses, flowers, shrubs and trees that line the stream banks. They are also called vegetated buffer zones.

Salinization

The accumulation of soluble salts of sodium, magnesium and calcium in soil to the extent that soil fertility is severely reduced.

Appendix 2

Post-module evaluation

This appendix includes two methods of post-module evaluation. Self-evaluation scorecards can be administered by Vi-Agroforestry staff after each module. Students should circle the number that best describes their level of understanding of topics discussed. Then, staff can use group discussion questions as an additional means of determining students' understanding and willingness to use the methods described.

Levels of understanding

1 = None (I don't know anything about it.)
2 = Poor (I have heard of it.)
3 = Fair (I have a fairly good idea of what it is.)
4 = Good (I can describe it in detail.)
5 = Excellent (I can explain it to other people.)

Module 1: Climate change

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of climate change.	1	2	3	4	5
2. Rate your level of knowledge of the causes of climate change.	1	2	3	4	5
3. Rate your level of knowledge of the possible local impacts of climate change.	1	2	3	4	5
4. Rate your understanding of strategies for climate change mitigation in agricultural systems.	1	2	3	4	5
5. Rate your level of understanding of strategies for climate change adaptation in agricultural systems.	1	2	3	4	5

Group discussion questions

1. What challenges will climate change pose to agricultural systems?
2. How do you intend to adapt to these challenges?
3. How can you mitigate climate change by reducing the greenhouse gas emissions of agriculture?

Module 2: Sustainable agriculture and land management (SALM)

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of SALM practices.	1	2	3	4	5
2. Rate your level of understanding of why it is important to use SALM practices.	1	2	3	4	5

Group discussion questions

1. Name three kinds of SALM practices and their benefits.
2. Which practices are you already using?
3. Which practices would you like to start using?
4. Which practices are you hesitant to start using, and why?

Levels of understanding

1 = None (I don't know anything about it.)
2 = Poor (I have heard of it.)
3 = Fair (I have a fairly good idea of what it is.)
4 = Good (I can describe it in detail.)
5 = Excellent (I can explain it to other people.)

Module 3: Soil nutrient management

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of the benefits of mulching and mulching techniques.	1	2	3	4	5
2. Rate your level of understanding of the benefits of using improved fallows and how to implement an improved fallow.	1	2	3	4	5
3. Rate your level of understanding of the benefits of manure management and manure management techniques.	1	2	3	4	5
4. Rate your level of understanding of the importance of composting and the process of composting.	1	2	3	4	5
5. Rate your level of understanding of improved fertilizer use efficiency and techniques.	1	2	3	4	5

Group discussion questions

1. What are the causes of declining soil fertility?
2. Which soil nutrient management practices are you already using?
3. Which practices would you like to start using?
4. Which practices are you hesitant to start using, and why?

Module 4: Tillage and residue management

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of the benefits of tillage management and techniques for reducing tillage.	1	2	3	4	5
2. Rate your level of understanding of the benefits of residue management and techniques for managing residue.	1	2	3	4	5

Group discussion questions

1. What are the benefits of tillage management?
2. What are the benefits of residue management?
3. Which tillage and residue management practices are you already using?
4. Which practices would you like to start using?
5. Which practices are you hesitant to start using, and why?

Levels of understanding

1 = None (I don't know anything about it.)
2 = Poor (I have heard of it.)
3 = Fair (I have a fairly good idea of what it is.)
4 = Good (I can describe it in detail.)
5 = Excellent (I can explain it to other people.)

Module 5: Agronomic practices

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of agronomic practices.	1	2	3	4	5
2. Rate your level of understanding of the benefits of cover crops and green manure and how to do it.	1	2	3	4	5
3. Rate your level of understanding of benefits intercropping, alley cropping, relay cropping and contour strip cropping and how to do it.	1	2	3	4	5
4. Rate your level of understanding of the benefits of crop rotation and how to do it.	1	2	3	4	5
5. Rate your level of understanding of the benefits of improved crop varieties and how to which ones to use.	1	2	3	4	5

Group discussion questions

1. Name three agronomic practices and how they will benefit livelihoods, climate change adaptation, and climate change mitigation.
2. Which agronomic practices are you already performing?
3. Which would you like to start using?
4. Which practices are you hesitant to start using, and why?

Module 6: Integrated pest management (IPM)

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of IPM.	1	2	3	4	5
2. Rate your level of understanding how to implement IPM, including cultural, biological, and physical methods.	1	2	3	4	5
3. Rate your level of understanding of the benefits and disadvantages of using IPM.	1	2	3	4	5

Group discussion questions

1. What are the benefits of IPM?
2. What IPM techniques would you use on your plot? Why?
3. Which IPM techniques would be the most challenging to implement? Why?

Levels of understanding

1 = None (I don't know anything about it.)
2 = Poor (I have heard of it.)
3 = Fair (I have a fairly good idea of what it is.)
4 = Good (I can describe it in detail.)
5 = Excellent (I can explain it to other people.)

Module 7: Agroforestry practices

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of agroforestry and the benefits of agroforestry.	1	2	3	4	5
2. Rate your level of understanding of specific agroforestry practices.	1	2	3	4	5

Group discussion questions

1. What are the benefits of agroforestry?
2. What agroforestry practices are you already performing?
3. Which agroforestry practices would be easiest to adopt?
4. Which would be the most challenging to adopt?
5. What are some strategies for overcoming these challenges?

Module 8: Soil and water management

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of the benefits of using improved soil and water management.	1	2	3	4	5
2. Rate your level of understanding of improved irrigation practices.	1	2	3	4	5
3. Rate your level of understanding of specific water catchments and how to construct them.					

Group discussion questions

1. Which of these practices do you already use to capture water runoff?
2. Which would be easiest to adopt?
3. Which would be the most challenging to adopt?
4. What are some strategies for overcoming these challenges?

Levels of understanding

1 = None (I don't know anything about it.)
2 = Poor (I have heard of it.)
3 = Fair (I have a fairly good idea of what it is.)
4 = Good (I can describe it in detail.)
5 = Excellent (I can explain it to other people.)

Module 9: Improved livestock management

Scorecard questions	None	Poor	Fair	Good	Excellent
1. Rate your level of understanding of the benefits of improved livestock management.	1	2	3	4	5
2. Rate your level of understanding of specific techniques to improve livestock management.	1	2	3	4	5

Group discussion questions

1. Name three techniques to improve livestock management. Explain how they are done, and why they are beneficial.
2. Which techniques would you or your community find most challenging to implement? Why?
3. What strategies can you use to overcome those challenges?

ERMCSD

ecoagriculturepartners

Vi Agroforestry