LEARNING AgriCultures

Insights from sustainable small-scale farming

MODULE 2

Soil and Water Systems

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Please note: This module is the first edition. We welcome comments and suggestions for improvement.

This publication forms part of the **Learning AgriCultures** series for educators, providing insights on sustainable small-scale agriculture.

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Summary of this module

Soil and water are fundamental elements in agricultural systems. How much land and water there is available, and the quality of the soil and water, are major factors that influence whether farms are productive or not.

This module discusses soil and water as systems. Certain principles about soil and water systems are common to all farms – such as how nutrient cycles and soil food webs work. Similarly, how water enters the farm and the dynamics of soil moisture follow the same principles everywhere. At the same time, there is a huge variety of soil types and climates around the world. A farmer who lives in a floodplain in Bangladesh needs a different type of management option to one living in dry regions like the Sahel or in the Middle East. People who live in the highlands or in the valleys, or on mountain slopes all have different issues to contend with. While we cannot represent all different situations, this module covers a variety of cases of small-scale farming in different regions for students to develop insights into soil and water sustainability.

The module also discusses socio-cultural, ecological, economic and political aspects of small-scale farmers' contexts and how they affect their choices and decisions about soil and water management. Students learn in this module about how farmers can make the most of their soil and water systems to allow for greater farm sustainability.

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Guide to educators

PURPOSES OF MODULE 2

Figure 1: Educators, the target group of Learning AgriCultures

For educators:
- to use a systems approach to teaching about sustainable soil and water processes with special attention to small-scale farmers.

For students:
- to understand the importance of soil and water processes as part of a system;
- to learn about how soil and water systems can become more sustainable for small-scale farming.

How to teach Module 2

Based on testing, about 16 contact hours will be needed to teach this entire module. This does not include time for conducting interviews with farmers, as well as time students spend on assignments. Obviously educators will need to decide for themselves whether to use the entire module or parts of it when making their lesson plans.

The total time required and duration of each lesson will vary depending on the level of the students, the knowledge of the educator, and how many games and assignments you choose to include in the course. An important component is to visit and interview a farmer – for students to understand the practical realities of farming systems.

What is in Module 2

This module is the second one in the Learning AgriCultures series. Module 2 includes three Learning Blocks and a section with Educational Resources. The three Learning Blocks follow the basic structure and systems' approach of all modules in Learning AgriCultures. The blocks build up information on the module's theme according to: The farm system → The larger context → Sustainability and governance of the entire system. The final section with Educational resources contains support material for educators to make the lessons more insightful and practical.

Specifically, the content of this module is as follows:

LEARNING BLOCK 1:
Soil and water processes as part of farm systems

This section gives a closeup view of soil and water as systems in and of themselves, and as part of the farm system.

LEARNING BLOCK 2:
Relating soil and water systems to the wider context

Four issues are presented that have great impact on soil and water systems around the world: Access to land and other resources, changing land and water management practices, and climate variability and climate change. These issues are presented, relating to the four dimensions of the context (socio-cultural, economic, ecological and political).

LEARNING BLOCK 3:
Toward more sustainable soil and water systems

In this section, we provide ideas on how soil and water systems can become more sustainable, how different kinds of buffers can be established and built up in the farming system. This learning also makes the link to governance issues and possible enabling policies as they relate to soil and water systems.

Figure 2: Symbol to indicate link to Educational resources (below) or suggested questions (above)

EDUCATIONAL RESOURCES:

This section contains support material for educators to stimulate deeper insights and discussions in-class and as assignments. Throughout the main texts, boxes of suggested links to resources (see list below) and to probing questions are indicated by the symbols found in Figure 2.

- ***Games:*** for in-class, to help deepen understanding of soil and water systems;
- ***Cases:*** suggestions for further reading and assignments based on articles from ileia's magazine archive, to expose students to different practical examples of methods farmers use, and stimulate discussion;
- ***Photographs:*** for in-class, these can help get discussions going with students on the practical implications of different issues raised in the module;
- ***Videos:*** for in-class, to complement the teachings with visual examples from around the world;
- ***Farmer interview:*** suggested visit with a small-scale farmer, checklist and further on-farm exercises for students; and
- ***Further references:*** suggestions for other freely available books and articles, interesting websites and videos.

Glossary for the whole series

This is separate to the module and includes definitions for difficult terms for the whole Learning AgriCultures series.

LEARNING BLOCK 1

Soil and water processes as part of farm systems

Photo: *Chetha Organic Organization, India*

What do we mean when we talk about soil or water as systems? And how do they interact with one another? What does this mean for farmers and the sustainability of their farms? This block focuses on processes at the farm level, first introducing the main ecological aspects of soil, water, and on their interaction as soil moisture. We will move beyond the farm level in the subsequent blocks.

1.1 Introduction

Whether we realise it or not, soil affects each of us in our everyday lives. Besides being fundamental to the production of our food and other agricultural products, the soil performs a wide range of functions that go beyond farming. It regulates water, sustains plant and animal life, recycles organic wastes, recycles nutrients, stores carbon, filters out pollutants, and serves as a physical support for structures. For farmers, understanding the functioning of the soils on their farms - and how to make the best use of the water available - form the base of their livelihoods. In this block, attention is given to particular aspects of soil and water processes, as well as practices that farmers use to improve the sustainability of their farms.

1.2 Systems thinking about the soil

1.2.1 What is soil?

When we refer to soil, we talk about the earth that is lying above the rock surface. Soils form from the weathering of rocks (the soil's so-called "parent material"), over a long period of time. This weathering occurs because of mechanical forces (physical disintegration of rock because of e.g. water, ice and air movement, as well as activities of plants, animals and people) or chemical forces (decomposition of rock, chemically altering the parent material). Soils vary from being a few millimetres deep – in the case of very young soils or soils eroded by external forces (such as from water, wind or human activities) – to several metres deep. Soil consists of several distinct layers (or "soil horizons"), all of which have their own characteristics. All of these soil horizons together form a distinct "soil profile" (see Figure 3).

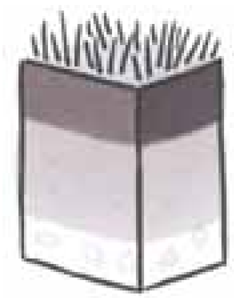


Figure 3: Soil profile showing three distinct layers

Farmers need to understand the soil on their farms very well in order to make the most of it for the growth of their plants and livestock. Around the world, farmers have different ways of explaining how their soils function. For example, they have their own terms and concepts such as temperature, colour and texture, to distinguish between soil types. It is important to understand farmers' views on their soil in order to see how to support them in improving their practices. Below, we focus on the scientific interpretation and terminology to explain soil.

Although they vary greatly from place to place, all soils include five different basic components that are essential to life:

- *Organic Matter:* non-living material coming from decaying plants and animals. Organic matter usually takes up only a small proportion (usually between 1 to 6 percent) of the soil. The quality of the soil's organic matter has a fundamentally important impact on plant growth.
- *Soil biota:* the living and largely invisible part of the soil, made up of soil micro-organisms such as bacteria and fungi, as well as soil animals such as worms and insects. The biota form a soil "food web" as shown below in Figure 6).
- *Soil Minerals:* these take up about half of the soil volume. The mineral elements exist as different-sized soil particles, classified (from large to small size) as sand, silt and clay, of which clay has the greatest capacity to hold nutrients.

These elements are essential to plant growth, as explained below in sub-section 1.2.2 on the soil's nutrient system. The connection between the mineral and organic components of soil systems is very close, as we will see in Figure 5 below.

- *Water*: the amount of water or moisture present in soils varies greatly between soil systems and also over time, but on average it takes up about a quarter of soil volume. The capacity of soils to retain moisture also varies but greatly determines farm productivity. Soil moisture gets more attention under section 1.2 on Systems thinking about water below.
- *Air:* this contains oxygen, hydrogen, nitrogen and carbon in gaseous forms. These are essential for plant growth.

Use the **Soil Game** (R1.1) to help students understand these five components of soils.

Soil classification

While these are the basic elements of soils all over the world, huge variations in soil types can be found even over short distances. This is so because of different conditions under which they have developed: variations in climate; the rock material that the soil has developed from; the different activities of plants, animals and people; the topography of the terrain (e.g. whether it is on a slope or in a valley); and how old the soil is (time). While farmers have different ways of classifying the soils they work with, many attempts have been made to distinguish soil types around the world, according to specific characteristics. A general way of classifying soils is according to their textures, or the size of their main soil particles: *sand* is the largest size, *clay* is the finest particle size and *silt* is in-between). Classifications are typically named for the primary constituent particle size or a combination of the most abundant particle sizes, e.g. "sandy clay" or "silty clay." A fourth term, *loam*, is used to describe a roughly equal concentration of sand, silt, and clay, and leads to the naming of even more classifications, e.g. "clay loam" or "silt loam."

Another main distinguishing characteristic for soil classification is climatic zone. *Humid tropical* climates in general have high temperatures and rainfall, leading to deep, strongly weathered and leached soils with low nutrient contents. In the tropics, lush vegetation is almost the only source for replenishing nutrients. *Arid tropical climates* have low precipitation and high evaporation rates, and therefore give rise to soils that contain variable amounts of easily soluble components, such as calcium carbonate, which is left behind after evaporation of water from the soil; this may 'cement' the soil and reduce infiltration capacities. In *temperate climates*, soil formation is more or less restricted to the warmer part of the year, resulting in less weathered and shallower soils when compared to tropical regions. In the sub-arctic and northern temperate regions, major changes in the past have had an interesting effect on the present soil distribution; there, large glaciers during the Ice Ages removed all soil material, and so new soils started forming only after the retreat of the ice. Consequently, soils of these regions are relatively young and "immature". In arctic climates, soil formation is restricted to an even shorter time of the year than in temperate regions; arctic soils are also strongly influenced by freeze-thaw processes and the presence of a permanently frozen sub-soil known as "permafrost".

1.2.2 The soil's nutrient system

All soils include different chemical elements that are important to the survival of plants. Of these, 16 elements are essential for plant growth, though some are needed in greater quantity than others. These are:

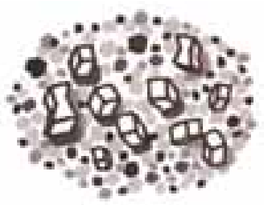


Figure 4: Inorganic nutrient store in "soil solution"

- *The three "building blocks" that form about 96% of plant dry matter:* hydrogen, oxygen and carbon; these come mainly from air and water, though as Box 2 shows, carbon in the soil is a very important element of soil organic matter, for various reasons;
- *Thirteen nutrients:* plants need large quantities of "macro-nutrients" to build up protein and for the good functioning of all living cells (primarily nitrogen, phosphorus and potassium; and secondarily calcium, magnesium and sulphur); and smaller quantities of "micro-nutrients" (boron, copper, iron, chloride, manganese, molybdenum and zinc). Even though plants need fewer micro-nutrients, they are still important for good growth.

Nutrients mainly come from the soil, from decomposing plant residues, animal remains, soil minerals, organic manures or compost, and soil micro-organisms; but they also come from the application of inorganic fertilizers; nitrogen-fixation by micro-organisms in conjunction with roots; gases from the atmosphere; or from nutrient-rich sediments deposited through erosion and flooding. But just as too small amounts of nutrients cause weak growth, too much can also cause harm to plants, as well as polluting waterways when leached out of the soil. Leaching of nutrients such as nitrogen is one of the main problems that arises when applying inorganic fertilizers to the soil as they allow for an immediately available supply of specific nutrients, which may not all be able to be taken up by the plants. Box 1 provides a very brief overview of the importance of the different elements to plant growth. Our intention is to provide a systems' approach to soils, and we will not go into biochemical details (find further references under Educational Resources).

Nutrient uptake

Nutrients are taken up by plants through the roots. For most nutrients, the presence of water makes it easier to take them up, particularly for Nitrogen. Good water management in the soil is therefore very important for plant growth – we will talk more about importance of soil moisture in section 1.3, on Systems thinking about water.

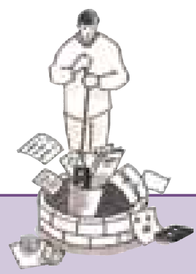
In general, for plants to be able to absorb essential nutrients from the soil, the nutrients must be in soluble, inorganic form. They must therefore be converted, or mineralised, from organic to inorganic form to be able to be taken up into the roots (see Inorganic pool in Figure 5: Soil nutrient cycle). Many different organisms in the soil play a role in breaking down materials and making nutrients more or less available to plants as well (see sub-section 1.2.3 on Soil food web). Note that commercial fertilizer application does not need to be converted as it is immediately available in its inorganic form.

Box 1: Brief overview of the 16 elements necessary for plant growth

Elements	Important functions and roles in plants
Hydrogen (H)	Necessary for building sugars and building the plant; comes almost entirely from water (H_2O)
Oxygen (O)	Necessary for cellular respiration; comes from carbon dioxide (CO_2 - carbon and oxygen) and water (H_2O- hydrogen and oxygen)
Carbon (C)	Backbone of many plants' organic molecules; is part of the carbohydrates that store energy in plants (also see Box 2 below for special significance of Soil Organic Carbon (SOC))
Macronutrients	
Nitrogen (N)	An essential component of all proteins; photosynthesis
Phosphorus (P)	Important for plant growth and flower/seed formation; Energy storage/transfer, root growth, straw strength, disease resistance.
Potassium (K)	Regulates the opening and closing of the stoma, important for regulating water; reduces water loss from leaves and increases drought tolerance; crop disease resistance
Calcium (Ca)	Important constituent of cell walls, regulates transport of other nutrients into the plant and is also involved in the activation of certain plant enzymes
Magnesium (Mg)	Among other roles, this is an important part of chlorophyll, a critical plant pigment important in photosynthesis
Sulphur (S)	Structural component of some amino acids and vitamins, and is essential in the manufacturing of chloroplasts (green pigments which are necessary for photosynthesis)
Micronutrients	
Boron (B)	Important in sugar transport, cell division, and synthesising certain enzymes
Copper (Cu)	Necessary for proper photosynthesis, involved in many enzyme processes and in the making of lignin
Iron (Fe)	Necessary for photosynthesis and respiration
Chloride (Cl)	Important in the opening and closing of stomata; also plays a role in photosynthesis (specifically for splitting water)
Manganese (Mn)	Necessary for building chloroplasts, for photosynthesis; enzyme function
Molybdenum (Mo)	Helps enzymes in building amino acids; legume N-fixation
Zinc (Z)	Required in a large number of enzymes

Nutrient losses

Nutrients that get taken up by plants will be removed for harvesting or feeding of animals, which leads to nutrient losses from the soil. Nutrients can also be lost directly from the soil - through erosion and runoff (by water and wind), leaching (water that percolates through the soil, carrying dissolved nutrients downward beyond the reach of roots); and direct losses of gaseous forms of nutrients (e.g. nitrogen and sulphur) into the air (volatilisation). Nutrient losses are further increased when removing crops from the farm, and when their residues are not returned to the land. Nutrient losses are not only costly and wasteful, but they can be a source of environmental contamination when they reach lakes, rivers, and groundwater.



Use the **Diet-Soil nutrient Game** (R1.2) to get a discussion started with your students by comparing main soil nutrients to the local diet.

EDUCATIONAL RESOURCES

for Module 2

How can students reflect more deeply about concepts of soil and water sustainability and small-scale farming? Throughout the three learning blocks, different educational resources have been suggested to help stimulate discussions and as material for assignments. These are brought together in this section, and include games, exercises, articles, photos, videos, farmer interview checklist and field exercises, as well as references for further reading.

R1. Games

In this section, we offer two games to help get students to understand specific aspects of soil and water systems better.

R1.1 Soil Game

Objectives of the game: To get students to understand the importance of all five elements in the soil.
Total time involved: 20-30 minutes
Number of participants needed: at least 10
Materials: Photocopy and cut out cards as per below

Methodology:

- Divide the students up into five groups.
- Cut the cards from the two sheets. There are fifty cards in total. The cards contain images of (1) organic matter (2) soil biota (3) soil moisture (4) soil minerals (5) air. Shuffle the fifty cards and give each group ten cards at random.
- Now tell the groups that they have 10 minutes to change some of their cards with other groups and that the challenge is to come to a balanced soil in the end.
- Keep an eye on the time and let the groups interact and change cards for 10 minutes. Then let each group display their final selection of cards.
- The best score is to have soil that has all five elements. In principle one could have two cards of each of the five elements. Discuss with students that a healthy soil is a healthy mixture of (1) organic matter (2) soil biota (3) soil moisture (4) soil minerals (5) air. If even one element is missing – the soil will not sustain farming. Explain again what the different components stand for (See sub-section 1.2.1 on pp 10-11).

Discussion:

On the basis of the final selection of the groups: what happens if soils have too much moisture or too much organic material. Or can there never be too much?

R2. Articles of practical experiences

Objective: To use articles on small-scale farming experiences from around the world to deepen learnings about soil & water sustainability.
Materials: All articles can be retrieved from ILEIA's website (see links by articles), while a selection of articles (indicated by [A]) is included in the Appendix at the end of this section.
Methodology: These cases can be used as additional reading material, as part of classroom discussions, or as part of student assignments. One suggestion is to have students prepare presentations on the basis of the cases and address specific questions as part of this. Some questions are suggested.

Figure 30: Using LEISA articles to stimulate discussion on practical implications

[A] Article R2.1: TALKING SOIL SCIENCE WITH FARMERS (2008)

(Refer to game R1.2)

[A] Article R2.2: BURNING AND SOIL FERTILITY IN NORTHERN GHANA (1999)

Suggested questions:
- Looking at the nutrient cycle above, what do you think happens to nutrients if you burn the biomass?
- How will this affect the nutrient cycle?
- Why is burning a good option if you can shift land every few years?
- What could be a disadvantage to women if burning is stopped?
- Comparing the three methods, how is labour affected?

R3. Photo gallery

Objectives: To use as illustrations for teaching, to stimulate discussions – to help students understand the links between what is going on in the wider context and soil and water systems on the farm
Total time involved: Presentation during class time (20-30 minutes)
Materials: Photo gallery as powerpoint presentation with beamer, or printout (see Appendix at end of Module)

Methodology:
- Present the photographs and ask a number of questions about the photo to help stimulate ideas: for example, what do they observe in the photo, and what does it mean in relation to soil and water systems (reflect on more than simply ecological aspects)
- Use the photographs to discuss similar initiatives in your region.

Photo Nr	Title	Explanation
1	**Sand-blocked water channel in Rajasthan, India**	Rajasthan is the dryest region of India. It is a vast, arid, unfriendly and tough terrain with shifting sand dunes, sparse population, extreme temperatures, stunted vegetation and very little arable land. Faced with deep brackish groundwater, erratic rainfall and recurring droughts, local communities have developed a tradition of seasonal migration and livestock rearing. The region is cross-cut by canals but with the drought the canals have dried up and farmers realised their vulnerability.
2	***Waru waru* (or raised-bed) agriculture is a technology developed over centuries in the Peruvian Andes**	Archaeological excavations of raised fields demonstrated that farmers began constructing them by 1000 BC. *Waru waru* agriculture makes it possible to bring into production the low-lying, flood prone, poorly drained lands found all over the *Altiplano* (mountain plains). When filled with water, the shallow canals ensure a microclimate that acts as a buffer against night frosts and provides moisture during droughts, and drainage during the rainy season. The canals also act as barriers to keep out crawling insect pests. The *waru waru* system provides small-scale farmers with greater harvest security, and reduces the risks associated with frosts and drought.
3	**Small check dams to control erosion in Eritrea**	There are several measures to reduce exposure to erosion. Check dams that can be easily made from local rocks slow down the run-off and serve to accumulate sediment. Often the soil moisture behind the check dams is better too, as can be seen from the adjacent vegetation.
4	**Water availability programme, India**	In Andhra Pradesh as in other areas in India there has been intense development of boreholes of irrigation causing ground water tables to fall in several areas. The Andhra Pradesh Farmer Management Groundwater Systems Project successfully introduced local management of groundwater making sure the gap between water available and consumed was closed. One part of it were discussion in hydrological units on water availability. The different glasses with coloured water show the amount of water in different years highlighting the variability.
5	**Soil in farmers' field still moist and holds together, Eritrea**	Even five months after flooding - the farmer shows how moist his soil still is, due to excellent moisture conservation practices. In this semi-arid climate, soil moisture comes from occasional floods in the summer season (June-August). To preserve moisture, the land is ploughed soon after the flood irrigation and mulched by "planking" (putting boards on the soil) to prevent evaporation.

R4. Videos

Objectives: To offer visual examples from around the world to complement teachings and to deepen students' understanding of sustainable soil and water practices in small-scale farming, as well as practical initiatives towards sustainability.
Total time involved: Video durations shown below – add time for classroom discussion
Materials: Videos are available on CD-Rom or to be downloaded from Internet (need computer and beamer)
Methodology:
- Present the videos to illustrate points coming up in the lessons, to stimulate discussions.
- Use the videos to discuss related issues and initiatives in your region.

R4.1 Water movement in soil

Link from: http://soils.usda.gov/education/
Duration: 3:10 (suggested for Learning Block 1)
This video explains basic processes of water movement in the soil (produced by United States Department of Agriculture).

R4.2 Soil and water conservation

Link from: http://www.thewaterchannel.tv/index.php?option=com_hwdvideoshare&task=viewvideo&Itemid=53&video_id=243
Duration: 5:20 (suggested for Learning Block 1)
This video shows three methods of soil and water conservation: terracing land, building sand dams and planting trees, applied in Southern Africa (produced by Excellent Development Limited, 2006)

R4.3 Soil and water conservation

Link from: http://www.thewaterchannel.tv/index.php?option=com_hwdvideoshare&task=viewvideo&Itemid=70&video_id=166
Duration: 18:44 (suggested for Learning Block 2)
This video gives a presentation of the soil and water conservation approaches and technologies throughout the world, and the documentation work of WOCAT (World Overview of Conservation Approaches and Technologies) (produced by WOCAT/FAO, 2001)

R5. Farmer visit and field exercises

Figure 31: Visits to farmers bring practical realities alive

Objectives: To get very close to practical realities of small-scale farmers and their soil and water issues; to understand learnings better by seeing a farm and talking to a farmer directly; also to allow students to get practical experience in interviewing and synthesising information.
Time involved: Take time ahead of the interview to prepare interview questions and field exercises. Time for the visit depends on how far farmers live from the school; the interview should last at least 2 hours. Field exercises half a day
Materials: For the interview: pen and paper to take notes, camera and/or video camera; For field exercises, see below.
Methodology:
- Ask farmers about their soil and water practices and how to make them more sustainable (see R5.1 for interview checklist)
- Take the opportunity to also ask students to do some simple soil and water exercises during the visit (see R5.2 for some ideas)
- Following the visit, ask students to make presentations or a written report on their findings.

R5.1 Farmer interview checklist

Ask farmers to describe the soils on their farm and surrounding farms, to categorise the different soils in the area and to describe what makes for a “good soil” and a ”bad soil”. Listen very carefully and try to understand and replicate how farmers distinguish between soils. This is very important, for students to:
- get an understanding of the local types of soils and the differences between them;
- understand what is important in the experience and local knowledge of farmers: the categories and terms farmers use contain a lot of experience and understanding;
- be able to communicate easily with farmers as you understand the terms they are using.

R6. Further references for Module 2

This section provides a list of freely accessible resources that can help educators and students dig deeper into issues coming up in this module. Resources include books and guides, as well as websites that offer further resources, photos and videos.

R6.1 Books and guides

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)

compiled by Deborah Duveskog, FARMESA/FAO

Available at Ministry of Agriculture and Rural Development, Kenya, Directors office, Kilimose.Cathedral Rd. P.O Box 30028, Nairobi, Kenya

Downloadable as PDF from: ftp://ftp.fao.org/agl/agll/farmspi/FARMESA_SWC1.pdf

Climatic conditions of the semi-arid regions put high demands on farm water management. This study guide is filled with information, exercises and experiments on water harvesting and soil moisture retention. Based on experiences from FARMESA (Farm Level Applied Research Methods for Eastern and Southern Africa) the study guide is intended to assist farmer groups in learning and experimenting on improved soil and water management. Included is also information on how to set up and run a farmers field school.

Water harvesting and soil moisture retention

By Anschuetz J et al. 1997. Agrodok Series 13, 92p.

Available from: Agromisa, PO Box 41, 6700 AA Wageningen, The Netherlands.
Downloadable as PDF from: www.agromisa.org/agrodoks/Agromisa-AD-13-E.pdf
This practical booklet, part of the Agrodok series, describes how rainfall and runoff water can be used to greater effect in agriculture. Many techniques are described briefly and clearly. The water-harvesting techniques covered in this booklet are particularly relevant for arid and semi-arid areas and the section on soil moisture retention contains information valuable for sub-humid regions. (IHG)

Ideas for groundwater management

By Chevalking, S., L. Knoop and F. van Steenbergen. ISBN:978-90-79658-01-52008. Wageningen, The Netherlands: MetaMeta and IUCN

Downloadable as PDF from: www.metameta.nl/downloads/ideas_for_groundwater_management.pdf
Groundwater is best described as the world's real hidden treasure. Almost everything it has, made a difference in providing safe drinking water and livelihood security in times of drought. Major agricultural economies in arid and semi-arid regions are sustained by groundwater use. The aim of this book is to provide ideas on different aspects of groundwater management. This ranges from areas where there is an abundance of subsurface water to areas where the resource is scarce.

InnoWat: Water, innovations, learning and rural livelihoods

By Cleveringa, R., Kay, M. & Cohen, A. (Eds.) (2009), IFAD, International Fund for Agricultural Development, Via Paolo di Dono 44, 00142, Rome, Italy

Downloadable as PDf from: www.ifad.org/english/water/innowat/index.htm
The InnoWat kit is providing tools for project development, implementation and pro-poor waterrelated interventions. The kit includes **synthesis of strategic approaches and additional** fact sheets, topic sheets, tools sheets and case studies. The strategic papers are mostly focusing on the work sphere of IFAD but some of the information in the kit can also be of interest for others.

Gender and water. Securing water for improved rural livelihoods: the multiple-uses systems approach

By Robina Wahaj and Maria Hartl, 2007.

International Fund for Agricultural Development (IFAD), Rome, Italy.
Downloadable as PDF from: www.ifad.org/gender/thematic/water/gender_water.pdf
Securing water is critical to achieving food sovereignty and improving livelihoods. Women manage water resources for domestic and productive uses, and they are getting more attention in the planning of water projects. Multi-purpose water systems address women's concerns better than single-use projects. But further gender-sensitive planning and monitoring is necessary throughout the whole project cycle, as is participation of women in decision-making.

The preparation and use of compost

By Madeleine Inckel,Peter de Smet, Tim Tersmette and Tom Veldkamp, 2005. 65 pp. ISBN 90-8573-006-6. Agrodok no 8. Agromisa, P.O. Box 41, 6700 AA Wageningen, the Netherlands.

Downloadable as PDF from: www.agromisa.org/agrodoks/Agromisa-AD-8-E.pdf

This small manual gives a clear overview of the processes taking place in the soil during composting, and makes practical suggestions on different composting methods, useful for both the tropics and subtropics. Suggestions include different approaches and theories to experiment with: different types of heaps, liquid teas and fermentation methods. It is a practical guide, useful for farmers, students, educators and agricultural field workers. This revised edition is also available in French, Portuguese and Spanish.

Conservation agriculture in Africa series

By Bernard Triomphe, JosefKienzle, Martin Bwalya, Soren Damgaard-Larsen (eds.), 2007. Produced by AfricanConservation Tillage Network / Centre de Coopération Internationale de Recherche Agronomique pour le Développement / Food and Agriculture Organization of the United Nations. Published by ACT : P.O. Box 14733, Westlands, Nairobi 00800, Kenya.

Downloadable as PDF files from:www.worldagroforestry.org/sites/relma/relmapublications

This jointly facilitated series documents the current situation and lessons learned on conservation agriculture (CA) in Africa. It includes eight case studies with examples from Ghana, Zambia, Uganda, Kenya and Tanzania. The booklets provide insights and critical reflection on not only the benefits of CA but also the challenges confronting farmers, such as difficulties in keeping the soil covered, gaining access to equipment and weed control; as well as the challenges faced by institutions in implementing participatory approaches to CA technology.

R6.2 Interesting websites

Conservation and Sustainable Management of Below Ground Biodiversity

http://www.bgbd.net

The Conservation and Sustainable Management of Below Ground Biodiversity is a project co-ordinated by the Tropical Soil Biology and Fertility Institute and supported by the Global Environment Facility and the UN Environment Programme. Its goal is to generate information and knowledge to better manage and conserve below-ground biodiversity in tropical agricultural landscapes.

Food and Agriculture Organisation (FAO)

http://www.fao.org

Gender and Water Alliance

http://www.genderandwater.org/

Established during the second World Water Forum (WWF) in March 2000, this is a global network set up to promote equitable access to and management of safe and adequate water. Its programme and activities include recording and sharing of knowledge and information on gender mainstreaming policies, and reinforcing the profile of gender equity issues at international water related conferences. Their website includes many documents and resources, all of them grouped according to the different “water sectors”: agriculture and food, drinking water, environment, sanitation, and integrated water resource management.

Global Soil Map

http://www.globalsoilmap.net/

This is the website that aims to create a new digital world soil map. The site contains country soil maps from a large number of countries.

Groundwater Management

www.groundwatermanagement.org

Training kits, exercises and reference materials concerning participatory groundwater management are part of this site on groundwater management. Intended to bring together scattered experience on groundwater management and its aspects, the site managers welcome collaboration as well as relevant material.

Holistic Agriculture Library

http://www.soilandhealth.org/01aglibrary/01aglibwelcome.html

This internet-based library provides access to many important documents on soils and sustainable practices. It includes interesting historical books that are no longer published, such as old texts from the early 1900s as well as more recent classics.

International Commission on Irrigation and Drainage

http://www.icid.org/

The International Commission on Irrigation and Drainage (ICID) is a NGO based in New Delhi, India. The mission of ICID is to stimulate and promote the development of agriculture in managing water and land resources for irrigation, drainage, flood management and river training applications, including research and development and capacity building for achieving sustainable irrigated agriculture.

International Development Research Centre (IDRC)

www.idrc.ca

IDRC is a Canadian Crown corporation that works in close collaboration with researchers from the developing world in their search for the means to build healthier, more equitable, and more prosperous societies. Concerning groundwater and water supply IDRC has focused on water supply technologies, such as improved water pumps and rooftop water collection systems. Now, the focus lies on water treatment and quality control, water demand management and the devolution of water management to lower levels of government, local organizations and communities. The development of simple water testing kits, which can be used by local people to examine the quality of water, is one example.

Laboratoire d'étude des Interactions Sol - Agrosystème - Hydrosytème

http://www.umr-lisah.fr/

Research facility to look into the interaction between soil, water systems and farming systems. Contains references to papers with a focus on North Africa.

Practical Action

http://www.practicalaction.org

Practical Action believes that simple technologies can be used to challenge poverty.

As part of this programme, the organisation works with people to help them adapt to the effects of climate change. Projects supported in this programme include rainwater harvesting in Zimbabwe, the use of "crescent terraces" in Sudan, and the development of technologies in Bangladesh for growing food on flooded land. The website includes a lot of information about the more than 100 projects implemented by this NGO, as well as a section on "Practical Answers" where you can download technical briefs on adaptation to climate change, and send in technical questions.

Soil maps of Africa

http://eusoils.jrc.ec.europa.eu/esdb_archive/EuDASM/africa/index.htm

This site is a digital archive of a large number of scanned detailed soil maps of Africa – categorised per country.

The Water Channel:

www.thewaterchannel.tv

This website is dedicated to web-based videos on all sorts of water issues relevant to educators on sustainable management. It caters to a broad-based audience, making a large amount of video material available.

Tropical Soil Biology and Fertility Institute

http://www.ciat.cgiar.org/tsbf_institute/

TSBF Institute of CIAT (TSBF-CIAT)

WCA InfoNET

http://www.wca-infonet.org

The WCA infoNET information system is a growing database of information on water
conservation and use in agriculture. It was launched to the public in August 2001 and is managed by the International Programme for Technology and Research in Irrigation and Drainage (IPTRID), hosted by FAO. This site includes documents, data, computer programs, discussion groups and links to other relevant websites.

World Association of Soil and Water Conservation (WASWC)

http://www.waswc.org

This organisation provides an interesting forum on sustainable soil and water management practices and policies around the world. It does this through a newsletter and a number of other publications. The newsletter (available in English, Spanish, French, Chinese, Portuguese, Bahasa, Russian, Vietnamese, Arabic and Thai) includes a diverse range of subjects, reporting on important SWC workshops and conferences, policy discussions and highlighting relevant research findings from around the world.

World Overview of Conservation Approaches and Technology

http://www.wocat.net/

WOCAT is dedicated to supporting and documenting sustainable land management practices. It has an extensive data base of local practices – that are available through a range of publications and training programmes

World Soil Information, ISRIC

www.isric.nl

World Soil Information is an independent foundation with a global mandate, involved in a wide range of national and international projects. Among its objectives, ISRIC aims to inform and educate (for example, through the World Soil Museum). It maintains the World Data Centre for Soils since 1989, serving the scientific community. ISRIC also undertakes applied research on land and water resources. ISRIC has built up a collection of more than 20,000 articles, country reports, books and maps with emphasis on developing countries.

World Water Council

http://www.worldwatercouncil.org/

The World Water Council is an international water policy think tank, dedicated to contribute to improved management of the world's water resources. The mission of the World Water Council is to promote awareness and build political commitment on critical water issues at all levels, including the highest decision-making level, to facilitate the efficient conservation, protection, development, planning, management and use of
water in all its dimensions on an environmentally sustainable basis for the benefit of all life on earth.

Worldwide Portal to Information on Soil Health

http://mulch.mannlib.cornell.edu

This portal is presented as an international clearing-house and search engine for internet resources on soil covers, organic inputs and soil management. Put together and managed between the Tropical Soil Cover and Organic Resource Exchange Consortium, Cornell University's Mann Agricultural Library and the Agricultural Network Information Center, it offers an extensive database of annotated English and Spanish language resources (documents, events, links to organisations, networks, journals and publications). Also available through the portal are the archives of many different electronic discussions, as well as a series of on-line learning modules.