CONTENTS

Acronyms ................................................................. v
About the manual ...................................................... vii
Acknowledgements .................................................... vii

1. Introduction
1.1 Why soils are important? ........................................ 1
1.2 We need to change the way we consider soils .............. 2
1.3 Why introduce soil health in farmer field schools? ....... 2
1.4 Producing this manual ........................................... 3
1.5 Aim of this manual and how to use it ....................... 4
1.6 What this manual is not ......................................... 4
1.7 Structure of the manual ......................................... 5

2. Need to know concepts on soil health
2.1 Soil composition .................................................. 7
2.2 Improving soils is a 5 percent deal: the importance of soil organic matter ........................................... 7
2.3 Soil and water ..................................................... 7
2.4 Principle of soil health .......................................... 8
2.5 Soil health in practice ............................................ 9

3. Introductory activities and baseline survey
3.1 Why do introductory activities and baseline surveys? ... 11
3.2 How to do introductory activities and baseline surveys? 11
   3.2.1 Transect walk and informal interviews .................. 11
   3.2.2 Participatory resource mapping .......................... 12
   3.2.3 Focus group discussions .................................... 14
   3.2.4 Community feedbacking meeting ....................... 17

4. Participatory technology development (field studies)
4.1 What are and why do we do participatory technology developments (field studies)? ...................... 19
4.2 Examples of field studies for soil health ........................
   4.2.1 Example 1. Integrating organic and inorganic fertilizer use in paddy rice .................. 21
   4.2.2 Example 2. Amounts and timing of fertilizers to improve the use of nutrients ....... 23
   4.2.3 Example 3. Using Azolla to reduce fertilizer application and improve soils ........ 25
   4.2.4 Example 4. Management of rice straw ................... 26
   4.2.5 Example 5. Green manure and/or crop rotation with legumes ......................... 27
   4.2.6 Example 6. Crop rotation and fertilizers ........................................ 29
5. Agro-eco system analysis (Aesa)

5.1 Why do we do the agro-ecosystem analysis? .................................................. 31
5.2 How do we do the agro-ecosystem analysis? .................................................. 31

5.3 Enhancing the study of soil and soil health in the agro-ecosystem analysis .......... 33
- 5.3.1. Exploring the links between soil, roots and plants: destructive sampling at 3 crop stages .......................... 33
- 5.3.2. AESA questions on soil per stage ................................................................. 35
  - Early Vegetative Stage (4 to 10 days after transplanting) ........................................ 35
  - Mid-Vegetative Stage (2 to 4 weeks after transplanting) ....................................... 35
  - Late Vegetative and Maximum Tillering (5 to 7 weeks after transplanting) ........... 35
  - Panicle differentiation ....................................................................................... 36
  - Booting stage .................................................................................................... 36
  - Flowering and milky stage (35 to 30 days before harvest) ................................. 36
  - Dough stage ...................................................................................................... 37
  - Maturity and harvest ......................................................................................... 37

6. Special topics

6.1 Special topics for soil composition ................................................................. 39
  - Exercise 1. Soil composition ............................................................................. 39
  - Exercise 2. Soil texture ..................................................................................... 41
  - Exercise 3. Mineral fraction and water ............................................................... 43

6.2 Special topics for importance of organic matter ........................................... 44
  - Exercise 4. Observing soil organic matter .......................................................... 44
  - Exercise 5. Study of the decomposition of organic materials in soils .............. 45
  - Exercise 6. Sources of organic material ............................................................. 46

6.3 Special topics for principles of soil health ...................................................... 48
  - Exercise 7. What is a healthy and fully functional soil? Dig a little, learn a lot ....... 48
  - Exercise 8. What is soil health? ........................................................................... 49

6.4 Special topics for soils and water ................................................................ 50
  - Exercise 9. Water holding capacity .................................................................... 50
  - Exercise 10. Run off and soil erosion ................................................................. 52

6.5 Special topic for soil health in practice ........................................................... 54
  - Exercise 11. Tackling soil problems to foster soil health at the local level ........ 54

7. Reference material

7.1 The living soil .................................................................................................. 57

7.2 Discovery-based learning in land and water management: .......................... 57
  - a practical guide for Farmer field school .......................................................... 57

8. Building a farmer field school curriculum ....................................................... 59
References ........................................................................................................... 63

Annexes

ANNEX I. Material for introductory activities ......................................................... 65
   a. Field observation form for transect walk ...................................................... 65
   b. Interview guide with individual families ...................................................... 67
   c. Guide questions for focus group discussions with community members ....... 68

ANNEX II. Material for Agro-ecosystem analysis .................................................. 69
   a. AESA observations for insects, disease, rats, natural enemies .................... 69
   b. Guidelines for drawing .............................................................................. 69

ANNEX III. Material for special topics ................................................................. 70
   a. Special topics for soil composition and local knowledge
      Describe a soil sample and local soil classification ........................................ 70
   b. Special topics for importance of organic matter
      Demonstrating soil microbes and discuss their functions .............................. 70
      Earthworm zoo ............................................................................................ 72
   c. Special topics for principle of soil health
      What is a soil system? .................................................................................. 72
      Is the soil a living thing? .............................................................................. 73
   d. Special topics for soils and water
      Soil as a sponge .......................................................................................... 74

Figures

Figure 1 Soil functions which sustain the life on earth ......................................... 1
Figure 2 Different moments of the second workshop with facilitators
   (i) discussing soil health concepts and exercises,
   (ii) testing the special topics and
   (iii) discussing AESA observations related to soil in the field ......................... 3
Figure 3 Graphical representation of the three dimensions of soil health .......... 7
Figure 4 Local facilitators and community members interviewing farmers ........ 10
Figure 5 Draft of a village resource map produced during the first workshop ...... 12
Figure 6 Scheme to prioritize the number of problems to be tackle/studies during the FFS 15
Figure 7 Graphic representation of the root analysis to assess Nitrogen fixation in legume crops 28
Figure 8 Graphical representation of the AESA ................................................... 33
Figure 9 Crop calendar, rice phases and suggested time interval for the three destructive samples 34
Figure 10 Root analysis during the workshop ...................................................... 35
Acronyms

AESA  Agro-ecosystem analysis
NSP   Plant production and protection division
C     Carbon
FAO   Food and Agriculture Organization of the United Nations
FFS   Farmer field school
IPM   Integrated pest management
N     Nitrogen
OM    Organic matter
P     Phosphorus
PTD   Participatory technology development
K     Potassium
SOM   Soil organic matter
UN    United Nations
ABOUT THE MANUAL

The contents of the manual are intended for use by FFS facilitators and trainers in the implementation of a season-long FFS on paddy rice with a strengthened component on soil health. Some of the exercises presented in this manual were adapted from existing manuals, some were developed during a series of workshops on soil health for FFS facilitators, and some were developed based on activities carried out with farmers during pilot soil health-FFSs in the Philippines. The content and relevant exercises can also be adapted for use in other crops and farming systems such as other cereals, pulses or vegetables, with or without livestock. The Manual contains basic concepts on soil health with related exercises pertaining to the following areas that are usual components of a FFS:

- Baseline survey
- Participatory technology development (PTD)/field studies
- Agro-ecosystem analysis (AESA)
- Special topics

As the Manual was developed together with FFS facilitators and trainers, it demonstrates the ability of trainers to adapt to the local situation and develop methods and materials accordingly. It is hoped that this output will encourage further experimentation in the field on the topic of soils, soil health and nutrient management, and for FFSs to document their experiences and exchange learnings with other FFSs, farmers and colleagues working in the field of soil health and sustainable intensification of crop production.

ACKNOWLEDGEMENTS

This document was developed through the combined efforts of staff from the FAO Plant production and protection division (NSP), the FAO Regional Office for Asia and the Pacific in particular the Pesticide Risk Reduction Programme GCP/RAS/229/SWE, the Philippine National Save and Grow Programme under the Philippine Department of Agriculture and local government Farmer Field School (FFS) programmes in selected provinces in the Visayas and Mindanao. The workshops and field activities were coordinated by the Philippine National Save and Grow Programme Coordinator, Dr Jesse S. Binamira. The Soil Health For Paddy Rice - A Manual for Farmer Field School Facilitators was compiled by Dylan Warren Raffa and Alma Linda Morales-Abubakar and reviewed by Jan Willem Ketelaar, Debra Turner, Marjon Fredrix, Dr. Arief Lukman Hakim and Dr Jesse S. Binamira.

Special thanks go to the facilitators, trainers and farmers that every day translate concepts into practice by discussing, trying and experimenting new ways of farming. Their effort is fundamental to improve the sustainability of crop production and preserve natural resources for the future generations.
1 INTRODUCTION

1.1 Why soils are important?

- **Soil is a vital natural resource that sustains life on earth.** About 95 percent of the food produced worldwide depends directly or indirectly on soils (FAO, 2015).

- **Soil is also very important to combat climate change** as it is the largest carbon pool on earth (FAO, 2017a).

- **Soils host more than one-quarter of the global biodiversity**

- The number of microorganisms in a teaspoon of soil is much higher than the number of people on earth!

- The huge variety of organisms living in soils, both visible to the eye and microscopic, mediate many important natural processes such as climate regulation, soil structure maintenance, pest regulation, water and nutrient cycling (Figure 1).

- However, **soil is a non-renewable natural resource.** It takes about 100 years to form 1 cm of soil while degradation can be really fast.

- Currently, **about 30 football fields of soil are lost every minute** through degradation processes like soil erosion, acidification, contamination, salinization and compaction.

- If we continue to manage soil as we do now we will only have topsoil for another 60 years.

- Guaranteeing food and healthy ecosystems for our daughters, sons, grandchildren and great-grandchildren depends on how we decide to manage our soils.

![Figure 1: Soil functions which sustain the life on earth](image-url)
1.2 We need to change the way we consider soils

The widespread occurrence of soil degradation calls for a shift in the way we consider and manage our soils, particularly given the importance of soils for agricultural production, food security and nutrition, farmers livelihoods, as well as for a healthy and functioning ecosystem. One of the problems is that soil is too often conceptualized as a lifeless medium to be filled up with nutrients and water to produce crops. Similarly, soil management is often reduced to the application of the right doses of fertilizers.

Considering the complexity of soils and their role in terrestrial ecosystems, can this be enough? Have we ever wondered how soils recycle nutrients or contribute to the water cycle? Have we ever considered the role of fungi, bacteria and other soil organisms in improving soil characteristics and releasing nutrients for the use of plants? Have we ever thought about the role of those biological communities in controlling pests and diseases? Have we ever reflected on how to use all those natural processes to improve crop production in a more sustainable way and rely less on ‘topping up’ the soil with additional nutrients?

When we started working on Integrated Pest Management (IPM) in FFSs we had to change our mindset from a pesticide-oriented to an ecosystem-based approach. The success and the achievements of IPM are now very well known and internationally recognized. However, the importance and complexity of soils is not necessary reflected in our current FFSs, although some important work on soils in FFSs has been carried out for instance in Indonesia. We therefore need to trigger a shift in the way soils are considered, similar to what was done when we started to use IPM to deal with pest outbreaks.

1.3 Why introduce soil health in farmer field schools?

Firstly, FFSs have proven that discovery-based approaches to adult education are particularly effective for agricultural matters. This is because FFSs allow farmers to visualize processes and understand cause-effect relationships of agricultural practices, not only on their crops, but on the agroecosystem as a whole. This discovery-based approach is even more necessary when working with soils, as soil processes and ecology are often invisible to the human eye and difficult to understand and conceptualize, especially in the short term.

Secondly, fostering knowledge about soil health and actually enhancing soil health at the field level means exploring and adapting practices which enhance ecological processes (for example, nutrient cycling and soil structure maintenance) in local conditions. Yet, these practices are very knowledge-intensive and require investments in farmers’ education.

A Farmer Field School (FFS) is a field-based group learning process. About 25-30 farmers meet one morning every week for an entire cropping season and carry out experiential learning activities to gain an ecological perspective of managing ecosystems as well as skills in informed decision-making based on location-specific conditions. A FFS is facilitated by skilled extension workers or farmers using non-formal education methods.

(Go to: http://www.fao.org/3/a-i5296e.pdf for more information about FFS.)
1.4 Producing this manual

In recent years, regional FFS practitioners expressed the need to integrate soil health modules into existing FFS programmes. As a response, in 2016 FAO initiated a pilot soil health work programme under its Regional Rice Initiative (RRI) and with the national IPM program in the Philippines. The work included a series of three workshops on soil health for experienced FFS facilitators as well as the implementation of 28 pilot FFSs in the Philippines. This manual was written as a result.

In addition to the FFS facilitators from the Philippines IPM program, the first workshop (December 2016) included experienced FFS trainers from Laos and Indonesia. The purpose of the workshop was to understand how soils were currently considered in FFSs in the region and to discuss the concept of “soil health” as an innovative approach in the way to look at soils in FFSs. The second workshop (June 2017) served to: (i) identify and document the key concepts of soil health to be included in the curricula of the pilot soil health FFSs; (ii) select suitable observations of soil health for the agroecosystem analysis (AESA); (iii) select a variety of special topics and group dynamics exercises related to soil health for use in the FFSs; and (iv) try the new ideas on AESA, special topics and group dynamic exercises out with farmers. Participants reconvened in December 2017 in a third workshop to share, discuss and document their experiences for this manual.

Figure 2
Different moments of the second workshop with facilitators

i discussing soil health concepts and exercises,
ii testing the special topics and
iii people working on a rice paddy field.

© FAO/Debra Turner.
1.5 Aim of this manual and how to use it

This manual was mainly written by facilitators for facilitators, with the assistance of local and international soil scientists and other experts, and aims to support FFS facilitators, trainers and master trainers in integrating soil health into FFS curricula.

The focus of this FFS soil health manual is on rice cropping, and especially paddy rice, which represents a special case compared to upland crops due to flooding and the soil’s anoxic conditions. However, the use of the manual for other crops grown in non-flooded conditions is also appropriate with additional or adapted AESA observations and other activities (for example, special topic exercises on soil structure and aggregate analysis).

Many interesting soil management ideas and concepts emerged during the workshops. However, the idea was to select those which are really needed for farmers to improve their soils. To this end the participants worked in order to identify the concepts that farmers “need to know”, those that would be “good to know” and those that would be “nice to know” to improve their soils.

This exercise was critical as:

i  Farmers – and people in general - attach a practical meaning to learning and become engaged in the learning process when they recognize a specific need;

ii  Time limitation is an issue for facilitators who are too often requested to integrate additional topics in their already busy season-long FFS curricula. Therefore, this manual is built around the concepts that farmers need to know to improve their soils and towards integrating these concepts in each key FFS activity, including field studies and special topics, and in expanding the AESA to cover aspects of soil health.

1.6 What this manual is not

This manual is not a cookbook with ready recipes. It is up to farmers with the assistance of FFS facilitators to choose and/or adapt appropriate exercises that are based on their needs and that are relevant to the local conditions.

This manual is not a final product. Rather it should be seen as a living document that will largely benefit from feedback and adjustments following field-testing and validation.

This manual on soil health provides additional material for learning in a FFS. Other field guides on IPM, Save and Grow provide complementary information on what can be done in a FFS, and remain useful resources when planning the FFS learning content.
1.7 Structure of the manual

Following this first introductory chapter, chapter 2 identifies and outlines the must-know concepts and skills that farmers need to improve their soils. Those concepts are then integrated into the subsequent chapters, which reflect the season-long FFS activities beginning with the initial assessment and baseline survey (Chapter 3). Concepts of soil health are included in participatory technology development (PTD) in Chapter 4, AESA (Chapter 5) and special topics (Chapter 6). Chapter 7 briefly presents two key publications for those looking for additional exercises and material. Chapter 8 reports an example of how to strengthen the soil health aspects in an existing curriculum through a selection of the exercises and observations presented in this manual. Annex I presents useful material for the introductory activities. Annex II provides a short description on AESA process. Finally Annex III presents a selection of additional special topics that were not included in Chapter 6 but could be considered when building a FFS curriculum.
2 NEED TO KNOW CONCEPTS ON SOIL HEALTH

2.1 Soil consist of:

<table>
<thead>
<tr>
<th>i</th>
<th>a mineral fraction</th>
<th>ii</th>
<th>organic matter</th>
<th>iii</th>
<th>water</th>
<th>iv</th>
<th>air</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mainly defined by the proportion of sand, silt and clay</td>
<td></td>
<td>which includes the soils’ biological communities and the plant and animal residues at different levels of decomposition (from fresh active residues to the more degraded and stable humus)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Being able to identify the different soil components - and their diversity - is critical to:

<table>
<thead>
<tr>
<th>i</th>
<th>understand how different soils have different effects on crop growth (for example, texture on water and nutrient dynamics)</th>
<th>ii</th>
<th>realize and picture the large amount of water and air contained in soils</th>
<th>iii</th>
<th>and recognize the heterogeneity of soils – even in a small area - when considering the implementation of soil-specific management practices.</th>
</tr>
</thead>
</table>

2.2 Improving soils is a 5 percent deal: the importance of soil organic matter

Despite only accounting for about 5 percent - much less in many soils around the world - organic matter in soil brings several agronomic benefits and is key for different ecosystem functions such as water retention, nutrient cycling, soil aeration and increased biological activity. Increasing and maintaining high levels of organic matter is the main strategy to maintain soil health and to help guarantee crop production for future generations. It is therefore important that farmers are able to test and adapt management practices that increase soil organic matter while at the same time improve crop performance and provide broader ecosystem-level benefits.

2.3 Soil and water

The role of water in agricultural production and landscape ecology is simply crucial. Water is an essential element for plant growth and in many cases a limiting factor for agriculture and crop production. Soils ultimately mediate the nutrients and water uptake of crops through their different properties, such as its structure which determines the size and arrangements of pore spaces through which water and nutrients move or are retained. The structure of the soil is in turn highly influenced by management decisions such as tillage operations and organic matter additions.
2.4 Principle of soil health

Soil health is “the continued capacity of soil to function as a living system. Healthy soils maintain a diverse community of soil organisms that help to control plant disease, insect and weed pests, form beneficial symbiotic associations with plant roots, recycle essential plant nutrients, improve soil structure with positive repercussions for soil water and nutrient holding capacity, and ultimately improve crop production” (FAO, 2011).

When we consider all aspects of the soil including its structure, the nutrients and other chemicals contained within it, and the organisms that live within it, this means that:

- soil is a diverse, dynamic and balanced system regulated by ecological processes that are essential for its continued capacity to function
- soil health encompasses three categories: chemical, physical and biological soil health
- all three aspects are equally important, and it is their interaction that ultimately defines soil health (Figure 3)
- and therefore, soil management is sustainable only if improves all the three domains of soil health.

![Figure 3](image-url)
2.5 Soil health in practice

In combination with local knowledge, the concept of “soil health” is an **important framework under which the critical analysis and problems solving skills of farmers could be strengthened**. Practically speaking such a framework would be useful to:

- assess current soil conditions according to physical, biological and chemical observations/parameters
- understand the reason behind soil degradation or enrichment in time and space
- study the impact of management practices on the three domains of soil health (for example, impact of tillage on soil biological communities, impacts of organic amendments on nutrient availability and soil structure)
- understand that improving soil takes time, and therefore the need to use long-term strategies to foster soil health
- develop site-specific management plans to improve soil health
- understand the role of healthy soils at a landscape level.

To achieve this within a FFS, a structured and comprehensive process is required. This would start with the introductory FFS activities, for example, analysis of the local soil problems, followed by the design of an experiment to address the problem. It would then be necessary to build on the AESA to assess the effectiveness of the intervention and finally use all the information from the experimentations and other activities to plan follow up activities. Hopefully this manual will help you to facilitate this process.
3. INTRODUCTORY ACTIVITIES AND BASELINE SURVEY

3.1 Why do introductory activities and baseline surveys?

Before starting a FFS facilitators need to spend some time with the group to prepare the activity. This is important to:

- stimulate interest and build trust of the community
- compose a village profile including soil health considerations
- understand the community’s perception about production (crop-livestock-aquaculture-homestead garden), its constraints and opportunities for improvement, giving special attention to soil management aspects
- discuss the programme of the FFSs to the community
- receive community’s decision to participate in a programme for FFS.

3.2 How to do introductory activities and baseline surveys?

Over four sessions, the team of local facilitators and members of the community – for example, farmers, local leaders and resource persons – conducts the following activities:

1. transect walk and informal interviews with farmers and community leaders
2. participatory mapping
3. focus group discussion (FGD)
4. community feedbacking meeting

3.2.1 Transect walk and informal interviews

GOALS:
- to get acquainted with the physical and functional structure of the village
- to collect information about the local farming system management including resources, constraints and opportunities with special attention to soils and soil health
- invite people to the FGD and/or the community feedbacking meeting.

MATERIALS: notebook, pencil, field observation form (Annex I.a) for recording general information, and the interview guide for individual families form for recording farm-level information (Annex I.b).

PROCEDURE: The team of local facilitators and members of the community walks through the village (built-up and agricultural areas) preferably accompanied by at least 1-2 key respondents of various age groups (farmers, community leaders, etc.). The idea is to collect info from the key informants and direct field observations in order to get a first grasp of the area and data for mapping:

- main crops and livestock
- main areas (for example, in terms of crop, soils, homogenous landscape characteristics)
- main soil type
- average size of the farm
• land tenure – is the farm owned? Is land leased? Sharecropping?
• livelihoods (how do people make a living)
• who is working in the farm (men, women, young and old people)
• roles of women, men, young and old people
• farm management practices
• main problems
• FFS or other farming training previously conducted.

Observations and information from respondents are recorded in a notebook. Photographs may also be taken to show the conditions. You may find the form provided in Annex I.a useful for specific field observations (make photocopies for multiple observations and recording).

During the transect walk you will talk to farmers and other people you meet on the way in an informal manner. The idea is to collect information as small “case studies” to get a more detailed picture on farm management in the area. The forms in Annex I could be used or adapted for this purpose.

3.2.2 Participatory resource mapping

GOAL: to produce a map describing the physical aspects and the resources in the area (Figure 5).

MATERIALS: large sheets of paper (for example, newsprint), markers or crayons, notebook and pencil, tape.

PROCEDURE: Following the Transect Walk (same day or the following visit), the team meets again to draw the map of the village including the information collected. Other community members may want to join. Ask the group to map the village.

1. Participants draw an outline map of the village. Attach the outline map to the wall.

2. Summarize the information collected during the Transect Walk. Participants can be divided into two or more groups, if the group is too big. Groups can be divided to focus on sections of the village.
3. The information collected from the Transect walk could include:

- agricultural land using various production criteria, including crops, soil types and fertility, soil problems and water supply, both at individual and community level
- built-up areas using criteria for off-farm enterprises or social structures
- non-agricultural and non-residential land using utilization criteria (for example, forest, water reservoirs, etc.)
- Aquaculture and livestock production areas and criteria such as source of feed, water supply, etc.
- Location of houses in relation to crop-livestock-aquaculture-homestead garden production areas
- Farmer Field Schools or other training for farmers previously conducted in the area.

4. When the list of resources is exhaustive enough to be useful for planning purposes, have the participants determine what symbols will be used for each kind of resource. In determining these symbols, try to make them associative, that is the symbols should look as much like the thing that they are meant to represent. For example houses to show residential areas, trees to show where trees are in the field, a pineapple would represent an area where pineapples are grown, a hose with water emerging from it for an area that is irrigated.

5. Once symbols have been prepared, have the participants attach or draw the symbols on the map in accordance with how these resources are actually distributed throughout the area. Do this until all the resources identified in step three have been located on the map with their appropriate symbols.

6. Have the participants check again to make sure that they have located on the map everything that they think is relevant.

7. The activity finishes with a brief discussion around the following question: How can we use the existing resources to improve production and benefits for the community – particularly for soil health and management?
3.2.3 Focus group discussions

GOAL:

i. to discuss the village resource map

ii. to understand the perception of the community members with regard to their main problems in farming (crop-livestock-aquaculture-homestead garden) with a special attention to soil management.

PROCEDURE: starting by presenting the village resource map (max. 15 minutes), guide the discussion towards the following topics:

- linking different areas with different production levels
- current status of local soils
- main problems in farming (special attention to soils)
- how to tackle these issues together through collective experimentation.

Annex I.c presents some questions you might find useful to stimulate discussion around these topics.

You can use the following exercise to discuss the main problems in farming.

1. Ask participants the most important problems they face throughout the cropping season with a special attention to soil management.

2. Write the most important problems identified on cards and fix the cards to the board using a pin or adhesive tape. Ask the group if they all agree and if they want to remove or add something.

3. Ask participants how they assess those problems. Table 1 can help you and the participants to recognize some soil issues. If possible, you may want to see those problems in the field. Write the indicators on the cards and stick them next to the problems.
<table>
<thead>
<tr>
<th>Soil management problem</th>
<th>Observable indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil erosion by water</td>
<td>Exposed plant roots</td>
</tr>
<tr>
<td></td>
<td>Pedestals, rills, gullies, accumulations of soil</td>
</tr>
<tr>
<td></td>
<td>Reduced topsoil depth (seen in the side of gullies, or by digging or auguring)</td>
</tr>
<tr>
<td></td>
<td>Variations or changes in soil color and/or texture indicating subsoil exposure</td>
</tr>
<tr>
<td>Soil erosion by wind</td>
<td>Signs of wind scouring and exposure of plant roots</td>
</tr>
<tr>
<td></td>
<td>Wind-blown deposits accumulating at field margins or areas where the wind is obstructed</td>
</tr>
<tr>
<td>Nutrient level - deficiency/toxicity/availability (pH)</td>
<td>Relative nutrient levels (using a field soil testing kit)</td>
</tr>
<tr>
<td></td>
<td>Leaf color as an indicator of nutrient deficiencies</td>
</tr>
<tr>
<td></td>
<td>Crop growth and vigor</td>
</tr>
<tr>
<td>Salinization/Alkalinity</td>
<td>pH (using a field pH meter or test kit)</td>
</tr>
<tr>
<td></td>
<td>Salt on soil surface</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>Presence of indicator plants (for example, sedges)</td>
</tr>
<tr>
<td></td>
<td>Stunted or dying crops</td>
</tr>
<tr>
<td></td>
<td>Twisted or dropping leaves</td>
</tr>
<tr>
<td></td>
<td>Dark and/or rotting roots</td>
</tr>
<tr>
<td></td>
<td>Lack of flowers or fruits</td>
</tr>
<tr>
<td></td>
<td>High water table</td>
</tr>
<tr>
<td></td>
<td>Mottling within the topsoil and upper subsoil</td>
</tr>
<tr>
<td>Surface compaction/crusting</td>
<td>Thickness and strength of a soil crust</td>
</tr>
<tr>
<td></td>
<td>Excessive surface runoff</td>
</tr>
<tr>
<td></td>
<td>Uprooting and observation of the shape &amp; distribution of the tap roots of indicator plants</td>
</tr>
<tr>
<td></td>
<td>Number, size and distribution of roots per soil horizon as seen on the side of a profile soil pit</td>
</tr>
<tr>
<td>Lowering of the groundwater table</td>
<td>Drying of wells</td>
</tr>
<tr>
<td></td>
<td>Deepening of boreholes</td>
</tr>
<tr>
<td></td>
<td>Dying trees</td>
</tr>
<tr>
<td>Declining water quality</td>
<td>Presence of sediments in, or discoloration of the water</td>
</tr>
<tr>
<td></td>
<td>Algae</td>
</tr>
<tr>
<td></td>
<td>Bad smell</td>
</tr>
<tr>
<td>Sedimentation of water reservoirs</td>
<td>Discoloration of the water by sediment</td>
</tr>
<tr>
<td></td>
<td>Sediment deposits visible as water level drops</td>
</tr>
<tr>
<td>Degradation of grazing areas</td>
<td>Gullying of livestock trails</td>
</tr>
<tr>
<td></td>
<td>Poor ground cover (estimation in %)</td>
</tr>
<tr>
<td></td>
<td>Signs of bush encroachment</td>
</tr>
<tr>
<td></td>
<td>Relative proportion of palatable to non-palatable pasture species</td>
</tr>
<tr>
<td></td>
<td>Poor condition of grazing animals</td>
</tr>
</tbody>
</table>
4. Divide the participants into groups according to the main problems and request each group to identify the cause of one selected problem and make a problem-cause tree.

5. Each group should identify and discuss the causes and effects of the problem, the causes of the causes, and so on, until they are able to answer to a couple of “whys”. Questions starting with “Why” and “Because of what” work really well for this exercise.

6. Ask each group to write on single cards all the causes identified and stick them next to the problems linking them with arrows.

7. At the end of the exercise open a general discussion to confirm or modify each group's problem-cause tree and come up with a combined list of problems;

8. If there are too many problems prioritize the problems that FFS members want to tackle/experiment throughout the FFS process. Each participant will assign a priority score to each problem ranging from 1 to 5. Facilitators will guide the prioritization process in order to select a feasible number of problems to tackle using the scheme reported in Figure 6.

Figure 6
Scheme to prioritize the number of problems to be tackle/studies during the FFS.

Do not forget that your role is to help the group to participate in a lively and natural discussion and not to decide what to do. The meeting should be open to everyone who wishes to attend and try to have a balanced representation of the people in the community (for example, men and women, leaders, and farmers, as well as young and old people). It should be scheduled at a time that is convenient for the villagers. If the group is too big (more than 15 people), it should be decided on a case-by-case basis whether separate meetings should be organized for different groups (for example, men and women, community leaders and community members). The meeting(s) should not be longer than 2 hours.

MATERIALS: Pens, newsprint, cards of different colors (one for problems, one for causes one for indicators), tape.
3.2.4 Community feedbacking meeting

GOAL: to collect feedback on the FFS, the topics to be included in the curriculum and select ideas for the PTDs.

PROCEDURE: Present briefly what an FFS is. Spend some time in explaining that you do not have the solutions for the problems identified. Rather the FFS will offer a space to learn and experiment solutions together.

Briefly discuss the problems identified in the Focus Group Discussion. You may want to ask a participant to take the lead role in this. Find out what the participants would like to experiment with and learn about. Ask for proposals on topics for the curriculum. Discuss what topics they believe could be important and why.

Allow the participants to discuss any topics relevant to the focus of the meeting at any moment that seems appropriate.

These questions and pointers could help you to facilitate the discussion:

- What are farmers doing to solve these issues?
- What is the community doing to solve these issues?
- What else could be done to solve these issues?
- Is there something that we need to learn to solve these issues?
- Is there something that we don’t know?
- What practices would you like to field test together to assess their effect?
- People may have different ideas which are all valid. Highlight the importance of field testing these ideas and the opportunity given by the FFS as a space to do it together. Stress the importance of doing it in a collective way.

You may want to look at Exercise 10 to discuss what to experiment concerning soils in the PTDs.
PARTICIPATORY TECHNOLOGY DEVELOPMENT (FIELD STUDIES)

4.1 What are and why do we do participatory technology developments (field studies)?

- PTDs are season-long studies where a farmer’s practice is compared with an innovative/improved practice, for example, spray pesticides vs IPM management, or, use of inorganic fertilizer vs a combination of organic matter and inorganic fertilizer.
- PTDs provide farmers with the chance to study and discover the effect of certain practices on the crop and the agroecosystem, for example, the effect of adding organic matter on the soil structure, the health and productivity of the crop, as well as on the insects and weeds.

STRUCTURE OF THE PTDs:

- **Objectives**: describe what we want to achieve by the experiment.
- **Experimental design**: include the factor (for example, fertilization), the level or treatments (for example, fertilizer’s doses) and the allocation in the experimental plot.
- **Hypothesis**: describe what results we expect to obtain/find in the different plots included in the PTD.
- **Monitor indicators**: these are the variables (for example, yield, crop growth) that are used to measure the impact of the different/new practices. These are usually measured during AESA and at the end of the season.
- **Records**: it is important to document any relevant baseline information, the weekly AESA observations, as well as the final results of the study, such as the yields, cost and return analysis and other observations such as the condition of the soil and crop in general.

ADDITIONAL CONSIDERATIONS:

- **PTDs are NOT demonstration plots** in which farmers have a passive role and only observe the results of a comparison study decided and performed by somebody else. They are designed and done by the farmers themselves with the assistance of a FFS facilitator.
- The PTD site should have a minimum area of 1,000 square meters.
- PTDs usually only consider one or two alternative practices (factors) in the experiment (for example, different type of fertilizers). Also make sure that the varying factors are clear from any other differences that may occur in the plots you are studying. For example, if studying combined inorganic fertilizer and organic matter additions compared to inorganic fertilizers alone, make sure that the soils in both plots are the same, or at least comparable, and have had similar management in the recent past.
- **PTDs are NOT set up as formal research plots with proper block design and replication. PTDs do not aim at answering a specific research question (e.g. Does N fertilizers influence crop yield?), rather they aim at fostering farmers’ understanding on how practices/factors influence crops and agroecosystem dynamics.**
• **Practices** to be included in the PTDs should be **feasible** in terms of cost, labor requirements and availability of resources. For example, if using organic fertilizers they must be available, affordable and/or able to be managed with the available manpower.

• Practices should be **functional** to study a particular problem that the community is facing.

• Practices should be **decided in a participatory way** (See Chapter 1 and Exercise 11).

**POINTS TO EMPHASIZE WHEN DOING PTDS ON SOIL HEALTH:**

• The FFS on soil health aim at **challenging the current perception of soils as an inert medium to which to add N-P-K**. Facilitators should therefore reflect on how to best use the PTDs in order to discover with farmers the complexity of soils and foster a holistic approach to their management.

• This does not necessary mean that very complex experiment or very detailed indicators should be tested/measured. It might happen that more basic exercises on increasing the efficiency of fertilizers could be valid entry points (not the goal!). In other contexts where farmers are more advanced or prone to study and experiment on soils, more innovative experiments could be designed.

• **"Keep it simple!"** The tendency is always to try and test too many factors at one time. The more factors varied in an experiment, the more difficult it is to interpret the results.

• If the experiment involves putting organic matter back into the soil and evaluating the outcome, realize that effects may not be easy to see after the first season. For paddy fields to show a strong response in yield and soil quality to recycling rice straw or using cover crops, you usually need to wait until the second or third season.

• Look to evaluate a wide range of effects. If farmers wish to test a new method that has an effect on their soil system, **look at a full range of effects**, not just on the yield. For example, look at the physical, chemical and biological health of the soil, general appearance of the crop, the incidence of diseases, pests and natural enemies.

• Plan a time to go over **the next step in carrying out the research plans** (usually a couple of weeks pre-planting or pre-harvest)” (FAO, 2000).
4.2 Examples of field studies for soil health

This section reports a selection of example season-long PTDs or field studies. The structure should be followed, however treatments and indicators can and should be modified according to the specific needs of your FFS. We would recommend not to use these example studies mechanically or as a recipe, but always let the FFSs select what to experiment as a result of the analysis of the problems they are facing, the resources available and the selection of meaningful indicators according to their needs.

4.2.1 Example 1. Integrating organic and inorganic fertilizer use in paddy rice

OBJECTIVE: To study the impact of different proportions of organic and inorganic fertilizer applications on soils, yield and gross margin.

EXPERIMENTAL DESIGN: The levels or treatments are the different shares of organic and inorganic fertilizers applied to the field. In this case the experiment consists of 4 treatments:

- **Treatment 1**: farmer’s’ usual fertilizer practice in terms of fertilizer type, the dose (amount of nutrients) applied, as well as the number of applications. This serves as the control. Note, in this example the farmers’ practice is assumed to be 100 percent inorganic fertilizer. Refer to Box 1 for more details.
- **Treatment 2**: 75 percent of farmers’ practice fertilizer dose (amount of nutrients) as inorganic fertilizer + 25 percent as organic fertilizer such as manures, vermicast, composts or other organic material.
- **Treatment 3**: 50 percent inorganic fertilizer + 50 percent organic fertilizer.
- **Treatment 4**: 25 percent inorganic fertilizer and 75 percent organic fertilizer.

HYPOTHESIS:

- **i** the plot receiving the largest amount of organic fertilizer will be the one showing the largest improvement in soil condition.
- **ii** improved soil characteristics will improve plant development, for example, root growth, tillering and yield.
- **iii** the cost return analysis will be driven by the cost of organic fertilizers and treatment 3 is expected to be the most advantageous.
CONTEXTS WHERE IT COULD BE USEFUL: farmers solely relying on inorganic fertilizers (note that the exercise does not challenge total fertilizer rate!!), soils lacking organic matter, compacted soils, low/decreased yield response to inorganic, high availability of manure and organic fertilizers, increased cost of inorganic fertilizers.

MONITOR INDICATORS:

- number of tillers
- plant height
- root length
- spread of the roots
- mud depth
- color of the roots
- color of the soil
- crop vigor variability and related soil variability
- costs for different treatments and benefits

RECORDS:

- Spot map of the FFS site
- Record of weekly AESA
- Crop cut yield
- Actual yield
- Cost and return analysis

QUESTIONS FOR DISCUSSION

- What treatment gave the best plant development and yields? Why?
- What treatment is economically best? Why?
- Did you observe differences in other factors, like insects, natural enemies during the season? Why or why not?
- Is it easy to have access to organic manure? What are constraints to get it?
- If you do not own your land, what do you think about adding organic manure? Why?
- What are plans for next season? Do you think that what was done this season will influence soil health and quality next season? Why or why not? How to find out?
Box 1. Calculating the amount of organic fertilizers

If we want to compare the effects of organic vs inorganic fertilizer we need to make sure we apply the same amount of nutrients in each case. However, a perfect match with each nutrient is not often feasible and would require mixes of different organic fertilizers and knowing the exact composition of the organic material. It is therefore advisable to base the computation of the amount of organic fertilizer required on the nitrogen doses.

• Calculating total kg of N/ha in Farmer’s practice:

3 bags 14-14-14 N-P-K
1 bag 46-0-0 N-P-K
1 bag = 50 kg
Total kg N/ha = 3*(50*0.14)+1*(50*0.46) = 44

• Calculating equivalent in organic fertilizers (e.g. vermicast)

N percent content =1.5 percent
Dry matter = (1- water content) = 55 percent
Kg of N in 1 kg of vermicast = 1*0.55*0.015 = 0.00825
Kg/ha of vermicast needed to apply 44 kg of N/ha= 44/0.00825 = 5,333

• Calculating treatments:

75 percent Inorganic = 3*0.75*(50*0.14) + 1*0.75*(50*0.46) = 33 kg N ➔ which means 2 bags and a quarter of 14-14-14 + ¼ bag of 46-0-0
25 percent organic (11kg N) = 5,333*0.25 = 1,333 kg of vermicast

50 percent Inorganic = 3*0.5*(50*0.14) + 1*0.5*(50*0.46) = 22 kg N ➔ which means 1.5 bags of 14-14-14 and half bag of 46-0-0
50 percent organic (22kg N) = 5,333*0.5 = 2,666 kg of vermicast

25 percent Inorganic = 3*0.25*(50*0.14) + 1*0.25*(50*0.46) = 11 kg N ➔ which means 3/4 bags of 14-14-14 and ¼ bag of 46-0-0

4.2.2 Example 2. Amounts and timing of fertilizers to improve the use of nutrients

OBJECTIVE: To study split fertilizer applications as a practice to spread the nutrient availability over the growing season and thereby increase crop nutrient uptake and yield.

EXPERIMENTAL DESIGN: The factors are different nutrient doses and split application. The experiment consists of 3 treatments:

Treatment 1. farmer’s practice, in fertilizer dose and number of applications.

Treatment 2. farmer’s practice in terms of dose (=same amount of fertilizer applied within the season) but with increased number of applications. For example, three application times: last harrowing, active tillering, panicle initiation.

Treatment 3. recommended doses and number of applications by the local NARS.
HYPOTHESIS:

i. Treatment 1 will yield less than Treatment 2 as an additional split application will increase nutrients' uptake by the crop.

ii. Treatment 3 and Treatment 2 will be comparable in terms of yield as the increased nutrients' uptake in treatment 2 will compensate the higher fertilizer doses applied in Treatment 3.

iii. Treatment 2 will show the best results in term of cost and return analysis.

TREATMENT 1

Farmers’ practice in dose and number of application (Location specific)

TREATMENT 2

Same amount of fertilizer of T1
More applications than T1

TREATMENT 3

Recommended doses and number of application by local NARS

CONTEXTS WHERE IT COULD BE USEFUL: soils with high content of organic matter, farmers relying on high doses of inorganic fertilizers, low/decreased yield response to inorganic fertilizers, very limited availability of manure and organic fertilizers, increased cost of inorganic fertilizers.

Monitor Indicators and Records as Example 1.

NOTE: Improving nutrient recovery efficiency is certain a pillar of sustainable crop production but not the ultimate goal!! This exercise does not include the use of organic matter input and therefore does not directly challenge the current vision of soil as an inert medium. If you want to use this experiment make sure you build a curriculum which strengthens the biological and physical dimensions of soil health across the special topics and AESA and thoroughly discusses nutrient recycling at the farm level.

Questions for discussion

- What treatment gave best yields? And which treatment gave the best economic results? Why?
- Is it easy to apply fertilizer more often? Why or why not? What about labor requirements?
- What do you think about the total amount of chemical fertilizers you use and efficiency? Is it possible to reduce the amount of chemical fertilizer and get similar yields? How? How come? What will you do next season?
- Did you observe differences in other factors, like insects, natural enemies during the season? Why or why not?
- What other things can you do to improve long term soil health? What about organic matter? Crop rotations with legumes?
4.2.3 Example 3. Using Azolla to reduce fertilizer application and improve soils

OBJECTIVE: To (i) explore synthetic nitrogen input reduction through the use of Azolla and (ii) assess the impact of Azolla on soil health and crop production.

EXPERIMENTAL DESIGN: The experiment consists of 3 treatments:

Treatment 1. Farmer’s practice, in fertilizer dose and number of applications.

Treatment 2. Azolla incorporation before land preparation + 1 fertilizer application at panicle initiation.

Treatment 3. Azolla incorporation before land preparation and intercropped Azolla during the season and no nitrogen fertilizer application. Terminate Azolla at active tillering stage.

HYPOTHESIS:

i  Yields will be comparable across the three treatments.

ii  Soil indicators will be better in Treatment 3.

iii  Labor requirement will be the highest in Treatment 3 so that Treatment 2 will show the most interesting results in terms of cost return analysis.

CONTEXTS WHERE IT COULD BE USEFUL: low yield, low access to fertilizers, low/decreased yield response to inorganic fertilizers, increased cost of inorganic fertilizers, availability of an organic market.

Monitor Indicators and Records as Example 1.

Questions for discussion


• Did you observe differences in other factors, like insects, natural enemies during the season? Why or why not?

• Is it easy to obtain or use Azolla? How to improve use and access?

• What are plans for studies for next season to improve soil health?

NOTE: If growing Azolla before the FFS begins is a problem, you could consider to:

(i) Treatment 2: apply fertilizers during last harrowing instead of panicle initiation and introduce Azolla after transplanting; (ii) Treatment 3: apply manure or vermicast at land preparation (the amount should be equivalent to the nitrogen you apply through fertilizers in Treatment 1 - See Box 1) and introduce Azolla after transplanting.

Also you can play around with number of Azolla termination (once, twice, three times), type of Azolla termination (trumpling, incorporation, draining the paddy).

Discuss the results and make sure to highlight that Azolla can be managed in many different ways which are worthy to try and experiment further beyond FFS in order to maximize benefit and reduces costs (especially labor).

Phosphorus fertilization could be considered as Azolla is not able to uptake P from the soil.
4.2.4 Example 4. Management of rice straw

OBJECTIVE: To study the effects of rice straw retention on soil, yield and gross and the interactions with fertilizers.

EXPERIMENTAL DESIGN: The factors are straw management and fertilizers. In this case the experiment consists of 3 treatments:

Treatment 1: farmer’s practice in terms of fertilizer applications (doses and timing) without rice straw retention.

Treatment 2: farmer’s practice in terms of fertilizer applications (doses and timing) + straw incorporation right after harvest (30 days minimum between the two crops are needed).

Treatment 3: farmer’s practice in terms of fertilizer applications (doses and timing) + 10 percent of nutrients applied through organic fertilizers + straw incorporation right after harvest (30 days minimum between the two crops are needed).

Clearly, this experiment needs to be organized at the end of the previous period to allow for the planting of the green manure crop.

HYPOTHESIS:

i. Straw retention will decrease initial growth and leaf “greenness” if not additional fertilizers is added.

ii. Straw retention will improve soil health.

iii. Straw retention combined with the addition of extra organic fertilizers will improve soils and yield.

iv. The increased cost of production due to straw retention + extra organic fertilizer will be compensated by higher yields.

Contexts where it could be useful: straw represent a critical C input in soils so this exercise is relevant everywhere but critical (i) where straw burning or displacement is a common practice and (ii) in areas characterized by low soil organic matter and widespread soil degradation.

Monitor Indicators and Records as Example 1.

Questions for discussion

• What give best results for yields? For economics? Why?
• How do you compare soil properties in the different treatments? Any differences? Do you think that all differences can be seen after only one season? Is it interesting to continue experimentation?
• Did you observe differences in other factors, like insects, natural enemies during the season? Why or why not?
• How is straw normally used in the farm? Is it burned? Used for cooking? For animals? Any other uses? Can incorporating straw bring improvements to the soil? How – think about nutrients, structure, etc
Participatory technology development (field studies)

- What is the best way to incorporate straw? What do you prefer? Why?
- What are your ideas for next season?

4.2.5 Example 5. Green manure and/or crop rotation with legumes

OBJECTIVE: To study the effect of green manuring and crop rotation on soil, yield and gross margin in irrigated rice.

EXPERIMENTAL DESIGN: The factor is green manure or crop rotation. In both cases the experiment consists of 2 treatments:

Treatment 1: fallow period before rice.
Treatment 2: green manure before rice. Green manure, often mung bean (Monggo), is incorporated into the soil at land preparation when the green manure crop is at flowering or early pod-forming stage.

And/or,
Treatment 3: crop rotation, where the legume residues are incorporated into the soil at land preparation.

Clearly, this experiment needs to be organized at the beginning of the fallow period to allow for the planting of the green manure crop.

HYPOTHESIS:

i. Green manure/crop rotation will improve soils as compared to fallow.

ii. Rice following green manure/crop rotation will be more productive.

iii. Green manure will increase costs of production.

iv. Crop rotation with legume will be the most remunerative option as the legume harvest can be marketed or consumed by farmers.

CONTEXTS WHERE IT COULD BE USEFUL: no specific contexts, the innovation would benefit from the availability of a “legume season” and a market for the legume crop.

Monitor indicators and records as Example 1.

Questions for discussion

- What gave best results? Why?
- Did you observe differences in other factors, like insects, natural enemies during the season? Why or why not?
- Is it common to have crop rotation with rice? Why or why not?
- What are advantages and disadvantages of rotation: for land preparation, seeding, and agricultural operations. What about livelihoods?
- Is it interesting to have different crops in the system for family use, or for marketing?
- What are ideas for next season?
NOTE: Green manure has been shown to be a good practice to improve soils, and break the rice monoculture cycle with positive effects on reducing pests and diseases. However, it also sensibly increases the cost of production. If you are working in places where you can have a “legume season” (for example, in rainfed rice) it would be preferable to experiment with a crop rotation which provides an additional market output or source of food in addition to the agricultural and environmental benefits mentioned before.

If the FFS is operating before the harvest or termination of the legume, it would be a very interesting exercise to analyze the legume root nodules.

Nodules are small, round or irregular knobs attached to the root. They are produced by the interaction between the rhizobia bacteria and the legumes. These bacteria are responsible for nitrogen-fixation. To analyze the nodules use the following exercise taken from FAO (2017b) and pictured in Figure 7.

Steps

1. Put the roots of the legume plants in the water and leave for 10 minutes for the soil to soak and soften. Gently wash the soil from the roots and lay the plants on a sheet of paper.
2. Identify the main root and root branches. Check if there are any nodules.
3. Count the total number of nodules on the roots of one plant. In general, each plant needs more than 10 active nodules to fix a lot of nitrogen.
4. Separate 10 nodules at random for each plant. Cut them in half using a sharp knife.
5. Look at the color inside the nodules. Those that are whitish or beige are not fixing nitrogen. Brown or reddish nodules are active.

Questions to stimulate discussion

Are these plants fixing nitrogen effectively?
Are there a lot of nodules?
What color are they inside?
In which treatments/condition have you found more active nodules?
How could you explain this difference?
How can we optimize nitrogen fixation?
NOTES:

- A ground cover legume can add as much nitrogen as 125 kg of urea per hectare!! However, peas, beans and groundnuts put much of the nitrogen they fix into their stems, leaves and beans. Harvesting the yield takes a lot of this nitrogen out of the field. If the farmer does not return the crop residues to the field, the soil may actually lose rather than gain nitrogen.

- Nitrogen fixation has a high energy cost for the plant. Therefore, if there is a lot of mineral nitrogen in the soil (for example, due to a high fertilizer application) you will usually find less active nodules and therefore a very low amount of nitrogen fixed.

4.2.6 Example 6. Crop rotation and fertilizers

OBJECTIVE: To study the effects of crop rotation with legumes on soil, yield and gross margin and the interactions with fertilizers.

EXPERIMENTAL DESIGN: The factors are crop rotation with legume and fertilizers. In this case the experiment consists of 4 treatments:

Treatment 1: farmer’s practice in terms of fertilizer applications (doses and timing) in a field where no legumes were planted.

Treatment 2: legume residues incorporated into the soil prior to planting followed by farmer’s practice for fertilizer applications.

Treatment 3: recommended doses and number of applications by the local NARS in a plot with no legume residue incorporation.

Treatment 4: recommended doses and number of applications by the local NARS in a plot with legumes residues incorporated.

HYPOTHESIS:

\[ \text{Legume residues will improve soil conditions and provide additional nitrogen to plants resulting in higher yields.} \]

\[ \text{Recommended fertilizers doses will improve yield but also cost of production with little improvement in soil.} \]

CONTEXTS WHERE IT COULD BE USEFUL: no specific context, the innovation would benefit from the availability of a “legume season” and a market for the legume crop.

Monitor Indicators and Records as Example 1.

Questions for discussion: can be similar to previous study....

NOTE: If the FFS is operating before the harvest or termination of the legume, it would be a very interesting exercise to analyze the legume root nodules presented in the previous exercise.
5 AGROECOSYSTEM ANALYSIS (AGRO-ECOSYSTEM ANALYSIS)

5.1 Why do we do the agro-ecosystem analysis?

- Agroecosystem Analysis (AESA) is the process of examining the different components of the agroecosystem and studying how they interact, affect and/or could affect the growth and development of the plant.

- The components of the agroecosystem include the plant itself, the soil and its health, water, weeds, herbivores and rats, natural enemies, vegetation of the field margins, pests, diseases or other factors.

- The process of analyzing the different components and their interactions helps to make an informed decision about what to do or how to manage the situation so that the crop will develop better and eventually give good yields.

- AESA is carried out on a weekly basis throughout the season to develop skills in accurate estimation and informed decision making that comes with the repeated practice of the process, i.e., collecting information and critically judging how the other components of the agroecosystem affect the crop and what management actions should be done.

- When working on soils it is during AESA that farmers can practically use the three soil health spheres as a framework to assess their soils and think about how to improve. The idea is that the integration of this framework into AESA is key to develop farmers’ critical and problem solving skills on soil management.

- AESA is a core activity in farmer field schools. The information below focuses on soil health aspects mostly, assuming that experiences facilitators know how to conduct AESA of all elements of the cropping system. Consult other manuals and field guides for more background on AESA, including process and questions of relevance for discussion during different development stages of the crop.

5.2 How do we do the agro-ecosystem analysis?

In small groups, farmers go out to their PTD studies to collect information about the crop and field situation. Assign one area to each group permanently (that is, at least weekly for the entire season) to collect data for the AESA – for both the local package/farmer’s practice plot and the improved practices plot.

1. Walk diagonally across the field and randomly choose 4 hills on the diagonal. This would be a total of 20 hills for all 5 groups (for the farmer’s practice and the improved practices plots). All groups must ensure that the entire plot assigned to them is represented by the 5 hills that they will select. For each hill, examine the plant and its surroundings and record your observations. This should be done for each plot.

2. The group should look at: insects, disease, rats, natural enemies, soil and plants, and weather conditions. Detailed guidelines and observation are provided in Annex IIa.

3. When back in the session area, each group should process its observations through discussions and by drawing the field ecosystem (Figure 7). Everyone should be involved in the drawing. The drawings of the field ecosystem from the previous week – for both the farmer’s practice and improved practices plots - should be compared with the drawings of the current week. The guidelines for drawing are provided in Annex IIb.
4. Keep your drawings for comparison with drawings from weeks later in the season.

5. Now it’s time to discuss! You can find useful questions concerning soils in chapter 5.3.2. As an experienced facilitator, make sure that you also ask questions that cover other components of the agroecosystem. You can also check field guides for rice IPM for general questions to be asked. In both sections the questions are reported per each crop stage. One person in the group is designated as the questioner (change the person each week). Write your answers on the paper and add a summary.

6. Each group should make a presentation of their field observations, drawing, discussions, and summary. A different person should make the presentation each week.

7. At the end of the presentations and discussions between all groups, the big group makes a decision on the management actions that need to be taken on the crop. Since it is only one field – all the groups need to reach a consensus, i.e., one decision on what management action to implement.

Figure 8
Graphical representation of the AESA
©FAO/Alma Linda Abubakar
5.3 Enhancing the study of soil and soil health in the agro-ecosystem analysis

Integrating soil health concepts through weekly observations of the AESA is critical to discuss with farmers more holistic approaches to soil and its management. However, little material is available to support facilitators in this task as (i) most of material available on AESA focuses on IPM and (ii) also the soil-specific FFS publications focus on special topics. Filling this gap emerged therefore as a critical need in the 1st workshop which was addressed in the following meetings. Specifically the groups worked on:

- A new AESA procedure to discuss soil health starting from investigating the links between soil, roots and plants
- Questions and observations on soil health per stage.

5.3.1. Exploring the links between soil, roots and plants: destructive sampling at 3 crop stages

GOALS:
- link soil conditions with roots growth, crop development and production
- demonstrate that nutrient availability is not enough to guarantee crop health and production.

PROCEDURE:
Each group carries out a destructive sampling of a few rice plants at three crop stages (vegetative, reproductive and maturity), at most four per group (Figure 8). Each group should identify two different areas of the plot, one with high and one with low plant vigor, and uproot two rice plants from each area. By examining the four plants and the soils under them, the group try to understand if soil conditions are behind the variability in plants’ vigor.

**TRANSPLANTED RICE**

*Growth Duration*

<table>
<thead>
<tr>
<th>FIELD</th>
<th>NURSERY</th>
<th>FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vegetative Phase</td>
<td>Reproductive Phase</td>
</tr>
</tbody>
</table>

- **Fallow to land preparation/ before transplanting**
- **Sowing and early vegetative phase (germination to seeding stage)**
- **Mid to late vegetative phase (tillering to stem elongation)**
- **Early reproductive phase (panicle initiation to booting)**
- **Mid to late reproductive phase (heading to flowering)**
- **Ripening phase/filling stage (milky and doughy stage)**
- **Ready for harvest (mature grain stage)**
- **After harvest (seed/storage stage)**

**Figure 9**
Crop calendar, rice phases and suggested time interval for the three destructive samples.
SPECIFICALLY, TAKE OBSERVATIONS ON THE FOLLOWING:

**Tillers:** count the number of tillers of the two plants (high vigor vs low vigor) and roughly estimate production.

**Roots:** measure the root length of the vertical roots originating from the tiller node to the top of the longest root, i.e., primary root, lateral roots and root hairs as well as observe the root color and general condition. Discuss the differences and relate this with the number of tillers.

**Soil:** Measure soil depth (soft mud) and relate this to roots characteristics and thus tillers. Also, observe the amount of soil that sticks to the root when the plant is pulled up. The idea of these measurements is twofold: (i) to visualize how soil conditions improve roots growth which translates into more tillers and likely higher production. In brief, why do plants growing in softer mud have more and denser roots? And, what is the impact on crop production? (ii) to demonstrate that nutrient availability - and in general chemical soil health alone - is not enough to guarantee crop health and production. Usually fertilizers are applied in a homogeneous way especially in paddy fields. Reflect on why we have differences in crop vigor and production, or nutrient deficiency among different areas? What is behind such a variability? How can we improve low vigor areas? Important: discuss options analyzing all the three domains of soil health (physical, biological, chemical).

8. Old roots are brown in color and more thick whereas new roots are white in color and less thick originating from the tiller node.
5.3.2. Agro-ecosystem analysis questions on soil per stage

NOTE: This section only reports the observations and questions concerning soil. As an experienced facilitator, make sure you address all the other elements in the agro-ecosystem as well (like plant development, water management, pests and natural enemies, etc), to come to a good management decision.

Early vegetative stage (4 to 10 days after transplanting)

- Start with evaluating the texture of your soil (refer to Exercise 2). Discuss how this texture affects water and nutrients dynamics and thus plant growth and development. Check the color of the soil and discuss how it is related to soil quality and production. See if you can spot different kinds of organic matter (for example, residues at different stages of decomposition). Discuss the reasons behind those differences and how organic matter benefits your crop. Smell the soil and brainstorm on what a bad smell could indicate and what is considered a good smell for a healthy soil.
- Consider soil water condition: Measure the depth of the water. Is the soil too dry? How do you know if the soil is too dry? When was the water released into the field? Too wet? What happens if the field is constantly flooded at this stage of the plant?
- Discuss what could be done differently: What could you have done differently? What would be the advantages? What could be the disadvantages?

Mid-vegetative stage (2 to 4 weeks after transplanting)

- Consider the effect of soil preparation: Walk around your field. Consider how soil was prepared and discuss the impact of soil preparation on the soil chemical, physical and biological health. Analyze the field giving particular attention to the heterogeneity of the soil and/or plant vigor. Can you see areas where plants are developing better? What could be the reason? If you have applied basal fertilizer, why have you applied this (these) kind(s) of fertilizer(s)? How much nutrient do plants need now? What kind of nutrients? What else do they need? If you have applied organic fertilizers or incorporate Azolla what do you see? What is the difference with the plot where only inorganic fertilizers were applied? How does the current condition of the soil affect plant development? Measure the depth of the soil (soft mud) in the different areas. Discuss how this could impact plant development. Discuss what to do to improve this particular soil in order to improve crop growth.
- Consider soil water condition: Measure the depth of the water. Is the soil too dry? How do you know if the soil is too dry? When was the water released into the field? Too wet? What happens to the crop if the field is constantly flooded at this stage of the plant? At this stage, what can be done to improve the soil condition?

Late vegetative and maximum tillering (5 to 7 weeks after transplanting)

The rice plants should be reaching its maximum tiller number at this stage. New leaves are not emerging as often, and the top leaves will have to survive until the end of the season. A few more leaves will emerge, and they will be the most important leaves for a good yield. Healthy and abundant tillers at this stage are a good sign of a good harvest.

- It’s time for your first destructive sampling!!! See chapter 5.3.1 for details.
- Consider soil water condition: How is the water situation? Is the soil moist or flooded?
• Consider weeds: Are there too many weeds in the field? Are there any differences in weeds species across your experiment? If so what could be the reason? What is an action threshold for weeds according to your opinion? Why? How would you manage weeds and why do you prefer that method? What are the advantages? What are the disadvantages?

Panicle differentiation

Panicle differentiation (or panicle initiation) refers to the stage where the panicle starts to form in the base of the same, is 1 to 2 mm in length and the branching of the panicle is visible. This is a critical stage during rice plant development. At this stage, the environment can have a major effect on rice plant development. The second yield component, number of potential grains per panicle, is set by the time this development stage occurs” (Moldenhauer and Slaton, 2001).

NOTE: Panicle differentiation stage in most modern varieties occurs 65-70 days before maturity. For a 125-130 day variety, panicle differentiation is expected at 65 days after seeding.

• Discuss the use and kind of fertilizers: Chemical fertilizers are usually applied now. Why nutrients are usually applied at panicle initiation? What is the effect of chemical fertilizers on soil health (consider the three dimensions)? What is the effect of organic fertilizers? How can you maximize crop nutrient uptake? What happen if you applied less nutrient? What does nutrient efficiency means? How can be improved? What happen if we mix organic and inorganic fertilizers? How can we recycle nutrients? What are the advantages and disadvantages of these practices?

• Consider soil water condition: How is the water situation? Is there sufficient water available to flood the field? Is the soil moist or flooded? Why should there be water in the field?

Booting stage

“Booting stage is loosely defined as that period characterized by a swelling of the flag leaf sheath which is caused by an increase in the size of the panicle as it grows up the leaf sheath. Full or late boot occurs when the flag leaf has completely extended” (Moldenhauer and Slaton, 2001).

Developing panicles should be visible in the tillers. Most tillers should have passed panicle initiation stage and developing panicles. Water is very important. Coordination of water management will be crucial for everyone in the area to achieve a good yield. Water is necessary to develop the panicle, to allow the panicle to expand, and finally for the flowers to develop completely. Water management should be considered daily.

• Is there any evidence of disease or fertilizer deficiency on the plant? Is there any plant yellowing? Old leaves or young leaves? What could be the reason behind that?

• How do nutrients (and fertilizers) affect disease development?

• Consider soil water condition: How is the water situation? Is the soil moist or flooded? Why is water important for panicle development? What else is important at this stage?

• Do you see differences among the treatments?

Flowering and milky stage (35 to 30 days before harvest)

• It’s time for your second destructive sampling!!! See chapter 5.3.1 for details. Take out the AESA drawing of the first destructive sampling. Have the roots grown? How much? What would you do to improve root development? Has the
situation improved/worsen in terms of root health? Has the situation improved in terms of crop vigor? Why? What could you do differently next year?

- Consider soil water condition: How is the water situation? Is the soil moist or flooded? Why should there be water in the field? Why is water important for pollen formation and complete germination? What else is important in this stage? What happens if the pollen germination is very poor?

- Try to think as a farmer. Are you happy with your results in your field so far in terms of soil? What would you do different in terms of soil and fertilizer management next season up to this point?

- Is there a management practice that you can apply at this time to improve soil health? What do you know about green manure? What could be the advantages and disadvantages?

Dough stage

- What will happen in the next weeks? How will you control water to make the grain ripen more evenly? Can the field be drained? Why does draining the field improve yields and grain drying? How easy is to manage water on this soil? If you could choose another soil what kind of soil would you choose? Why? How can you change your soil in order to give your son/daughter a better soil to farm in the future?

- What do you know about crop rotation? What is the advantage of practicing crop rotation? How can this practice improve soil health (consider the three dimensions)? Are there other advantages? And disadvantages? What other practices could you think about to improve soil health? Are they feasible?

Maturity and harvest

- It’s time for your third and last destructive sampling!!! See chapter 5.3.1 for details. Take out the AESA drawings of the first and second destructive samplings. What has changed? Have the roots grown? How much? And the plant? Has the situation improved/worsen in terms of root health? Has the situation improved in terms of crop vigor? Why? What could you do differently next year to improve soil and roots development? How did soil, root and plant conditions evolved throughout the season?

- What do you do with the rice straw after harvesting? What are the (feasible) options? What are the advantages and disadvantages of each option? What are the problem associated with straw burning? How can we optimize straw management to avoid burning? Describe the soil that your son/daughter will find in 20 years’ time if you burn the residues compared to if you incorporate them. What is the impact of rice straw on chemical, physical and biological soil health? What will the differences be if straw is left on the soil (as mulch or incorporated)? What other practices could be used to improve organic matter? How does organic matter improve soil health? How does soil health improve crop production?

- What could you do differently to improve yields for next season? What could you do different to improve profits for the next season?

- From your ecosystem analysis, can you do an economic analysis? How about an environmental impact analysis? How would you consider soil health?
SPECIAL TOPICS

Each FFS session includes a special topic of interest for the group in that particular moment. Special topics can take the form of short-term experiments, demonstrations or simply group discussions. Special topics can be a response to what happened in the previous FFS session or an opportunity to deepen the knowledge on a particular process/dynamic or topic concerning the agroecosystem. It can also be about social concerns that affect the community (FAO, 2016).

NOTE: This section presents the special topics that were identified as the most appropriate to learn about the concepts that farmers need to know to improve their soils. If you are looking for other ideas for your FFS, do not hesitate to have a look at Annex III and to other reference material.

6.1 Special topics for soil composition

Exercise 1. Soil composition

GOAL: To visualize the different soil components and observe the air in the soil, the relative amounts of the mineral particles and soil organic matter.

TIME: 1 hour

MATERIALS: Manila paper, three different kind of soils, three 1 or 1.5 liter plastic bottles (wide mouth to get the soil in) or clear glass jars, pens, markers, bucket.

PROCEDURE:
This exercise could be run the same day as Exercise 2. The following part could be prepared by the facilitator the day before or while the group is describing the sample.

1. Take three buckets and gather samples of soil from three separate locations (ideally it would be great to have contrasting soils, for example, a poor sandy soil, an average field soil, and a rich soil with added organic matter such as manure, compost or vermicast)
2. Dry part of the three soil samples overnight under a fan, or for several hours spread out under the sun
3. If possible weight out 500 g of each of the three soil types so that you can analyze the samples quantitatively
4. Add soil and from each location to a separate plastic bottle and close it tightly
5. Pour water and shake until all the soil has been loosened up in the solution (destroy the soil structure), then set aside overnight. Let the contents settle out in order to have the samples ready for the session (this can take several hours).

DURING THE SESSION:
1. Brainstorm with farmers about the soil composition starting asking them what is the soil made of?
2. Write each answer in a large paper sheet;
3. Place a soil sample in the jar or bottle, add some water and ask what they immediately see (some bubbles should come up proving the existence of oxygen). Repeat the experiment if needed;
4. Explain the soil composition experiment and ask three farmers to do that;

5. Divide the farmers in groups, provide a sample per group, ask them to discuss what they see and try to interpret it. Suggest to pay close attention to differences in the layers of soil. The larger, heavier materials will fall down first, followed by the intermediate and then the finest particles. Very fine clay particles may stay suspended in the water for a very long time (due to the negative charges on the surface of the clay particles causing them to repel each other). Observe the surface of the water for any materials to be found floating (organic matter).

6. If you have dried and weighed the samples you can observe the differences in volume of the three soils.

7. Ask the groups to briefly present the result of the experiment.

QUESTIONS TO FACILITATE DISCUSSION:

• Water bucket exercise
  • What did you observe when the soil was soaked?
  • What is this?
  • Why is important for crop production?
  • What are the effects on crop?

• Soil composition exercise
  • What do you observe?
  • What are the component of soils?
  • What could be the relative share of each component (See Figure 12)?
  • Why do some solutions become clear while others remain cloudy after several hours? (only if you wait for sedimentation)?
  • What is the soil organic matter made of?
  • What can we change in the soil composition through management (discuss how the share of water, air and organic matter can change)?
  • What cannot be changed through management?
  • Would you provide some examples (for example, tillage, manure application)?
  • So the soil consists of?
  • How these can vary? If for instance a soil get flooded? Or if dries up? And if the soil get compacted?
Exercise 2. Soil texture

BACKGROUND: Soil texture is a rather formal academic distinction to characterize the mineral soil fraction based only on particle size distribution:

- Sand refers to the biggest soil particles with diameters from 0.05 to 2.0 mm.
- Silt to the soil particles with diameters from 0.002 to 0.05 mm.
- Clay to the soil particles with diameters < 0.002 mm (See Figure 13).

To make it easier to compare the relative sizes of the particles: if a clay particle has the size of a pea, then a silt particle would be as big as ping pong ball and a grain of sand would be the size of a basketball or even bigger.

NOTE THAT:
- Texture only refers to the mineral particles, and not the organic matter in the soil
- Texture does not change quickly over the time, unlike organic matter
- Texture refers only to the share (ratio) of different sized soil particles and should not be confused with soil structure (which refers to the aggregation, or the way the different soil components are arranged).

The texture of a soil is directly related to many important aspects of fertility: for example, the ability of a soil to absorb and retain water, to hold plant nutrients. It also directly affects the ability of roots to develop and move through the soil. Soils containing a lot of clay are said to be “heavy” soils and tend to hold a lot of water that moves relatively slowly. Soils composed of a lot of sand are considered “light” soils and tend to hold very little water as the water is able to drain through the large pores easily, unless they also contain a lot of organic matter that makes the soil more “spongelike” and able to retain the water. Water infiltration (movement) in sandy soils tends to be very rapid.

Optimally, this exercise can be done on the same day as Exercise 1 so that farmers can look at the soil composition jars from Exercise 1 while manually examining the soil samples outlined here.

GOAL: To observe and characterize soils according to their texture.

TIME: 1 hour

MATERIALS: Water, soil samples from different areas identified during the community soil mapping (ideally it would helpful to have soils of different textures, they do not necessary need to be taken from paddies)
PROCEDURE:

1. If you are planning to compare this exercise with Exercise 1, you need to use the same soil samples. Otherwise take two or more contrasting soils. Ask all participants to take a sample so that everyone can run the exercise.

2. Hold approximately about half a fistful of dry soil in your palm. Look at it carefully to see if it is very loose and single-grained (probably sandy), or if it has numerous hard lumps or clods that are difficult to break when dry (probably clay), or something in-between;

3. Add water drop-by-drop and knead the soil in your hand, breaking down any lumps, until the soil is plastic and moldable. Next, squeeze the soil tightly in your hand, then open your hand. If the soil fails to form a ball when you do this, but instead falls apart when released, then it is a sandy soil (If you think you may have added too much water, add a little dry soil and try again);

4. Rub some of the soil around with the forefinger of your other hand and determine whether the feeling is one mostly of grittiness, or mostly of smoothness. There will almost always be some grittiness to the soil, but try to identify the predominate feeling;

5. If the soil forms a ball, roll the ball between your hands or on a clean flat surface to form a cylinder, then try to bend the cylinder in a circle to form a ring.

   Note the following characteristics:

   a) if the soil is SANDY (more than 70 percent sand) you will not be able to form a cylinder more than 5 cm long and 1.5 cm in diameter, it will not form a ring, and it will have many cracks in it and fall apart;

   b) if the soil is HEAVY CLAY (more than 40 percent clay), your sample will form easily into a smooth cylinder around 10 - 15 cm long and about 0.5 cm in diameter, with no cracks or fissions in the side; and

   c) if the soil is a type of LOAM OR SILTY, you will be able to form a cylinder 10-15 cm in diameter and to form a ring, but the ring will have many cracks in the outer edge;

6. If possible, check the dry form of the soil: silt, when dry, is easy to break with your fingers.

---

Figure 14 offers a pictorial representation of the exercise. Adapted from: FAO, 2000
QUESTIONS TO FACILITATE DISCUSSION:
How does soil texture affect crop growth?
What is the texture of the good and bad local soil?
What are the advantages and disadvantages of growing crops on clay soils?
What are the advantages and disadvantages of growing crops on sandy soils?
Can soils with same texture and organic matter content look different? Why (introduce the concept of soil structure)

Exercise 3. Mineral fraction and water

GOAL: This special topic exercise could also be used as a fun team exercise or energizer as it simulates water dynamics in soils of different textures where the group participants are the soil particles and the water!!!

TIME: 30 minutes

PROCEDURE:
1. Divide the participants in four groups. Assign each group one of the following role: sand, silt, clay and water
2. Each of the group should position the arms as shown in Figure 15
3. Group the sand people together so that everyone touch another with his/her fingers
4. Ask the water people to pass through them
5. Repeat the same exercise with the other particles groups
6. Repeat the exercise mixing sand, silt and clay people.

QUESTIONS TO FACILITATE DISCUSSION:
In case of high rainfall what would happen in a heavy clay soil?
What would happen in a sandy soil?
Thinking about the soil composition, what are the other factor/s that can influence the soil water dynamics? Introduce two or three additional people to be organic matter, that is the “glue” that helps fill the gaps and trap water and nutrients between sand particles, or that create extra space between clay particles. In sandy soils they could “hug” the water people and not let them pass through and in the clay soils they could “wiggle” in between clay particles and again “hug” the water people.

Figure 15
Graphical representation of sand, silt and clay role
© FAO/Alma Linda Morales-Abubakar

Figure 16
Performing the water and mineral fraction exercise with farmers during the 2nd workshop
6.2 Special topics for importance of organic matter

Exercise 4. Observing soil organic matter

BACKGROUND: The amount of soil organic matter varies from soil to soil. It depends in part on the past land use and on the soil texture. For example, clay helps protect organic matter from degradation and it is more common to find organic matter in soils rich in clay compared to sandy soils. This exercise shows a simple way to assess the health and productivity of a soil by observing its organic matter content. This exercise can also be used to compare the topsoil (the top 5 cm layer) and the subsoil (that below 20 cm). Note that this exercise could be done in conjunction with Exercise 6.

GOAL: To compare organic matter in different soils, understand the importance of organic matter in soils, and how organic matter builds up.

TIME: 1 hour.

MATERIAL: Spade or hoe, kitchen knife, magnifying glass, contrasting soil samples from different areas and/or different depths.

PROCEDURE:
1. Ask the participants to choose two soils they think will differ in organic matter content: for example, forest or fallow versus a cropped field.
2. Use the spade or hoe to cut out a block of each soil, about 15 cm square and 20-30 cm deep. You can do this by first digging a hole, then carefully cutting out a block of soil from next to it.
3. Check the following (use the magnifying glass to see details if you have one and if it helps):
   - The leaf litter on the surface
   - The different layers in the soil
   - The soil color and how it differs from layer to layer
   - The distribution of humus (the dark organic material)
   - The number and size of pores, and the amount of compaction
   - The density and depth of roots
   - Signs of earthworms (burrows) and other living organisms
   - The structure of the soil and the presence and shape of soil crumbs
     - usually round crumbs indicated an high biological activity
   - Discuss the importance of pores in soils. Everything that happens in soils happens in pores (water flow, air diffusion, nutrient movement and uptake).
4. Compare the two soils and invite the participants to discuss the differences between the two soils in terms of physical, biological and chemical attributes and their impact on crops.

QUESTIONS TO FACILITATE DISCUSSION:
Why is there more litter at the forest/fallow site than in the field?
Why are there more soil animals in the forest/fallow soil?
Why is the topsoil darker?
How does soil biodiversity affect soil organic matter?
What happens to leaves and dried grasses in the forest/fallow soil?
Why are there more and larger pores in the forest/fallow soil than in the cropped soil?
Why are large pores important?
How do the pores affect the movement of rainwater or irrigation, both into and through the soil?
Does this have an effect on erosion?
How do the pores affect the movement, cycling and loss of nutrients and fertilizers?
What do roots do for a plant?
What happens to water taken up by roots?
What happens to nutrients they absorb?
What happens to nutrients in dead leaves on the soil surface?
What would be the impact of higher soil organic matter on crop growth (discuss advantages and disadvantages)?
How can a cropped soil be transformed so it looks like the one from the fallow/forest?

Exercise 5. Study of the decomposition of organic materials in soils

BACKGROUND: Although many of them are invisible to the human eye, the soil biological communities mediate several ecosystem processes such as nutrient cycling, the breakdown and decomposition of organic matter, soil structure maintenance and others. This series of exercises/studies help participants to visualize the effect of those communities on organic matter decomposition and to reflect on the consequence for soil health and crop development.

GOAL: to understand how different soils have different decomposition rate and understand why.

MATERIAL: Small mesh bags, pieces of mosquito net or large-mesh cloth (with holes big enough for earthworms and small beetles to get through); string (not degradable!), notepaper, pencils.

PROCEDURE: Ask the group to choose three places with different types of soil: one should be high in organic matter (darker in color), one should be low in organic matter (lighter), and a third soil, if possible, should be in a paddock where there is old manure.

1. Take several armfuls of leaves from a garden
2. Divide the leaves according to number of soils and replicates you have
3. Put the leaves into the bags or cloths, and tie each bag or cloth into a bundle with string
4. Bury the bags, one in each of the three places
5. After 4 weeks dig up the bundles. Open them and look at their contents
6. Bury them again in the same place
7. Dig them up again at regular interval during AESA to examine them (every 2 weeks).

If you want to study **how different organic materials decompose at different rates, then put different plant material in each soil**. For instance compare rice straw (very resistant to decomposition) to legume leaves or dry leaves from a tree. **This would be a great introductory study to the next exercise.**

QUESTION TO FACILITATE DISCUSSION:
Are there any obvious differences between the bags in the different places? Where have the leaves decomposed fastest? Where is slowest? Why?
What has happened to the leaves in the bags? Have they been attacked? By what? Fungi? Bacteria? Rats?
Why is the breakdown of organic matter important for the soil and crops? Whose job is it to start the breakdown?
IN CASE YOU HAVE BURIED DIFFERENT PLANT MATERIAL IN THE SAME SOIL/S:
Are there any obvious differences between the organic material? Which material decomposed fastest? Where is slowest? Why?

How does this process contribute to physical soil health, chemical soil health and biological soil health?

NOTES: Instead of burying the bags in three places, you could bring soil from three places and put it into three big pots. You can then bury the bundles in each of the pots to save time during the AESA.

Exercise 6. Sources of organic material

BACKGROUND: We often neglect to utilize or make the most of valuable organic materials. We think of them as rubbish and so throw them away or burn them. This exercise helps participants identify the major types of organic materials available in the area and check their value for use in cropping.

GOAL: To discuss ways to increase the supply of organic materials, and how to valorize them on the farm.

TIME: 1 hour

MATERIAL: Large sheets of paper, marker pens and different organic material if available

PROCEDURE:
1. Divide the participants into groups of 3–5;
2. Ask each group to list possible sources of organic materials in and around the village. How are they normally used?
3. Ask each group to think of how they could get more organic materials for the farm and what would be required to do so. For example, would it require labour, transport?
4. How might they reduce the use of crop residues for fuel and fodder, so they stay in the field?
5. If local people burn crop residues when preparing the land, what nutrients might be lost?
6. What kind of soil would you leave to your son and daughter in 20 years if you keep burning residues for 20 years? And if there was no burning? What would be the differences?
7. Give the groups enough time (1 hour or more) to discuss as this might be a sensible issue. They can use the markers and paper to take notes;
8. Ask one member from each group to present the group's findings to everyone.

OPTIONAL EXTRA:
If there is interest and time, this additional exercise helps recognize residue characteristics and link them to decomposition potential, therefore improving decision making on residue management (See Figure 17).

The exercise compares two kinds of crop residues usually one from a cereal crop and another from a legume;

1. Ask the group to look at the color of the residues, see how it shreds, and try to chew them. The color is usually related to nitrogen content, shredding to lignin, therefore carbon content, and an astringent taste to recalcitrant compounds which slowdown decomposition. For instance, rice straw is yellow as it contains little nitrogen, is hard to shred and chew therefore has a lot of carbon. Conversely mungbean is green, easy to shred and chew and has no astringent taste so is high in nitrogen and not so high in carbon.
2. Discuss how to use this assessment to target residue management. Hint - Rice straw will degrade slowly, bring a lot of organic matter, could be used for erosion control, but is low in nutrients and therefore increases the risk for nitrogen immobilization as microbes need
nitrogen to help breakdown carbon material. Conversely, mungbean residues are easy to degrade and therefore to provide nitrogen in the short run.

QUESTIONS TO STIMULATE DISCUSSION:
- What organic materials are available on the farm?
- How are they used at the moment? As fuel, fodder, thatch, or other purposes? Does this mean they cannot be used as an organic fertilizer?
- Are there other sources of fuel or fodder that could be used instead of crop residues?
- Are there organic materials on the farm that are not currently used?
- Are there any food industries nearby (for example, sugar or cereal mills, coffee processors)? Do they have any by-products farmers could get?
- Are there any other materials the farmers could get from outside (grasses, leaves and pruning from the forest, or other crops with lots of “waste” material such as bananas)?
- What happens to the different organic materials when applied to soils? Should they/can they be treated first such as by composting?
- Is it possible to organize recycling and reuse of materials on different scales from the farm level to a community level?
6.3 Special topics for principles of soil health

Exercise 7. What is a healthy and fully functional soil? Dig a little, learn a lot

BACKGROUND: This is a quick and easy exercise which aims at synthesizing the participant’s knowledge up to this point. Participants may still not be clear on just what constitutes a good soil, or what can be done if you have a poor soil.

Bear in mind - a healthy, fully functioning soil is balanced to provide an environment that sustains and nourishes plants, soil microbes and beneficial insects. Soil is a living system, and healthy soil should look, smell, and feel alive. Healthy soil can increase production, increase profits, and protect natural resources, such as air and water.

ACTIVITY:
Participants are required to break into groups and go to different fields and dig up some soil to discover what the soil looks like, how it smells and what the texture feels like so as to assess its health and production potential. Make sure that they have notebooks and pens with them for proper documentation of observations.

Understanding how healthy soils like, smell and feel are the first steps toward achieving soil health.

After this activity, allow the all the groups to get together to discuss their soils and any differences in their observations and the possible reasons for them.

GOAL: To synthesize the participants existing knowledge and to introduce several new ideas regarding the positive qualities of soil components.

TIME REQUIRED: 45 minutes

MATERIALS NEEDED: Manila paper, pens, tape.

PROCEDURE:
- Dig into and look at the soil – Healthy soil is typically darker in color, crumbly, and porous. It is home to worms and organisms that squirm, creep, hop, or crawl. Healthy soil provides the right amount of air, water, and organic matter for microorganisms to thrive and for plants to grow. Soil that is functioning at its full potential is full of the roots of the healthy and strong plants. On the other side of the coin, an unhealthy, poor functioning soil typically appears lighter in color, can be compacted or have poor structure, and contains few roots and/or living things.
- Dig in and smell the soil – Healthy soil has a sweet and earthy aroma. This is the scent of geosmin, a byproduct of soil microbes called actinomycetes. These microbes decompose the tough plant and animal residues in and on the soil and bring nitrogen from the air into the soil to feed plants. An unhealthy, out of balance soil smells sour or metallic, or like kitchen cleaner.
- Dig in and feel the soil – Healthy soil is easy to dig into. It is soft, moist, and crumbly, and allows plants to grow their roots more freely and unimpeded. This crumbly or granular structure is ideal because healthy porous soil is able to retain water for plants to use when they need it. This is particularly important in times of water shortage or drought when the difference between a dead and surviving crop can be a healthy soil! Its increased water holding capacity and permeability also reduce runoff that can cause flooding and other damage such as soil erosion.
- An unhealthy, poor soil can feel overly-dry or waterlogged, crusty, and/or cloddy. It doesn’t crumble readily into nicely sized aggregates when pulled apart but rather either sticks together or shatters.
Exercise 8. What is soil health?

GOAL: To discuss the concept of soil health.

TIME: 1 hour

MATERIAL: Large paper sheets, Markers.

PROCEDURE:
1. The exercise starts with the question what does a plant need for healthy growth? (Hint: light, water, nutrients, oxygen for roots as well as leaves).
2. Followed by which of these “inputs” come from the soil?
3. Form 3 groups and assign them as water, oxygen, and nutrients. Have the groups brainstorm and write up on a large sheet of paper (i) what soil properties are needed to make sure these inputs are provided to a plant and (ii) what would be the indicators they can identify to ensure the soils have these properties.
4. Ask each group to pin up their paper/poster and present their findings.
5. There is something that should always be mentioned (hint - organic matter), why? Spend time on this! (See Table 2)

<table>
<thead>
<tr>
<th>Crop inputs from the soil</th>
<th>Soil properties</th>
<th>What do we need to ensure those properties?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>High water holding capacity/Good drainage pattern</td>
<td>Good content of Organic matter</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Good aeration through soil pores</td>
<td>High biological activity</td>
</tr>
<tr>
<td>Nutrients</td>
<td>Nutrient content and recycling</td>
<td>Good content of Organic matter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optimal pH</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Balanced nutrients availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Optimal chemical characteristics to retain nutrients</td>
</tr>
</tbody>
</table>

6. The exercise started with the question about what the crop needs for healthy growth and we have seen that soil is at the basis. Now let's try to use an analogy to better understand what soil health is. When we discuss human health we can easily see that it consists of several aspects….? Mental health, physical health and good nutrition. What happens if one is missing?

7. The facilitator can ask to the participants to mimic what happens if one of those health-related aspects is missing. This can be done through a quick game to make the session more alive where facilitators calls the “health” that is missing and farmers mimic accordingly.

8. Now let’s go back to the soil. Look at the input and the soil characteristics you have considered in the table. What would happen to the crop if the soil is well endowed in nutrients but lacks structure? Or if the soils lacks soil organisms?

9. So how is human health similar to soil health? Can we identify three spheres of soil health? Insist on the concept that they are all important and it is their interaction that ultimately define soil health! If one is missing the soil is not healthy.

QUESTIONS TO FACILITATE DISCUSSION:
What would be the characteristics of a healthy soil?
What similarities do you see between soil health and your local soil assessment?
What aspects are important?
What would you add to the definition of soil health?

Table 2
Example of list of inputs that crop receive from the soil, soil properties and elements needed to ensure those properties
What the local classification add to the soil health concept?

What does the soil health concept add to the local classification?

Why similar soils in terms of soil composition (mineral fraction) can have different production level? (Reflect on the three aspects of soil health)

Imagine a soil perfectly endowed of nutrients and with high nutrient retention which get flooded at each minimal rainfall event. What will the standing crops miss in terms of input from the soil?

Imagine now another soil with no worms, bacteria and fungi. What kind of problem would this soil have?

6.4 Special topics for soils and water

Exercise 9. Water holding capacity

BACKGROUND: A clearly important characteristic of a soil is its ability to hold water. One problem with a coarse sandy soil is that water (and nutrients) are rapidly lost from the soil. One of the important qualities of soil organic matter is that it helps a soil to retain water. This is a simple exercise to demonstrate how soil texture and structure affects its water holding capacity and that should help promote the use of compost and mulch.

Soil pores play a major role in water and air movement. Also, soil microorganisms reside in pores. Coarse-textured (sandy) soils have less total pore space (higher “bulk density”) than do fine-textured (clay) soils. A sandy soil is typically 35 percent to 50 percent “pore space”, while a clay soil is 40 percent to 60 percent “pore space”. The size of the pores, however, is just as important as the total quantity of pore space. Two classes of pore sizes are recognized: macropores and micropores. The minimum diameter of a macropore is considered to be between 0.03 and 0.1 mm). Pores smaller than this are considered micropores.

Macropores characteristically allow the rapid movement of soil gases and soil water. Sandy soils have less total pore space, but those spaces are mostly macropores; thus, sandy soils usually drain rapidly. In contrast, clayey soils have more total pore space, but these spaces are mostly micropores and drain more slowly. Thus, sandy soils have a relatively low water-holding capacity and clayey soils relatively high water-holding capacity.

When a soil is saturated with water and the water is allowed to drain freely, the water drains only from the soil macropores. This is “gravitational water” and while in the soil it can be harmful to plants because it reduces soil aeration. When the macropores have drained, the soil is said to be at “field capacity”. At field capacity, most soil micropores are still full of water, which is available for plants. However a plant cannot use all of this water, because when the micropores are close to empty it is bound too tightly to the soil solids for plants to use (imagine yourself trying to drink through a very thin straw). At this point, plants permanently wilt and do not recover, even when water is added. This is the “permanent wilting point”.

GOAL: To learn how to measure the differences in the capacity of different soils to retain moisture.

TIME REQUIRED: 1 hour

MATERIALS: For each small group: 4 plastic 1 liter water bottles, 4 pieces of cheese cloth or loose-weave organdy (8 cm x 8 cm), 4 rubber bands, twine, sharp knife, colored permanent marking pen, 4 clear plastic cups or glasses, balance scale.

PROCEDURE:

1. Take a quantity of soil which could fill a plastic water bottle and spread it out on a plastic sheet in the sun to let it air dry for a day or two. Choose soils from three locations so that you have: a) poor and sandy soil, b) local farm soil c) compost or soil rich in organic matter;
2. Cut the bottom off each plastic water bottle. Turn bottles upside-down and put the cloth into the neck area of the bottle from the inside.

3. Weigh out a fixed amount of each soil for each bottle (somewhere between 300 to 600 g) and place it in the inverted bottles;

4. Put a good amount (30 percent of the total soil) compost/manure in one of the sample and mark the sample;

5. Suspend the inverted bottles above the clear plastic cups by hang them with twine from a horizontal pole (see picture below);

6. Take another plastic cup and fill it with water; then add it to each bottle. Do some other activity and return when the water has passed completely through all samples. If the soil in any of the bottles has absorbed all the water, and none has passed through into the cup underneath, you will need to add more water. You will need to add the same amount of water to each sample in order to be able to compare the results at the end (Careful – make sure that the cups underneath can hold all the water that will pass through);

7. After all samples have drained completely, line up the cups side-by-side and compare the results.

QUESTIONS TO FACILITATE DISCUSSION:
Which of the soils holds (retains) the most water?
What factors do you think are responsible for holding more or less water?
Why is water-holding capacity important?
Is there a relationship between water-holding capacity and structure?
Are there any differences in the color of the water? What does this indicate?
How can you best improve the water-holding capacity of your soil?
What was the effect, or role, of the added organic matter?
Why has it had such effect?
Exercise 10. Run off and soil erosion

BACKGROUND: Run off is the flow of superficial water, usually due to excessive rainfall, and may contain soil and/or nutrients. This poses a serious issue for soil health and is a major concern for many soils around the world.

Soil erosion results in the displacement of topsoils which are the most important soil layers this is where the organic matter, soil biodiversity and nutrients are concentrated. Run off and soil losses due to erosion are particularly evident on steep soils where sediments are transported downhill by the water.

This process has had major consequences at a landscape level. For instance, fine fertile soils are often located in the valleys as a result of the continuous topsoils from hills washing down. By contrast, soils uphill are often shallower and characterized by coarser texture and visible parent material.

Overgrazing, downhill ploughing, leaving soils bare, and removal of residues are all inappropriate management practices which favor soil erosion.

GOAL: To demonstrate what soil erosion and understand the crucial role of soil cover to reduce soil losses.

TIME: 1 hour

MATERIALS: 3 large plastic bottles, 3 small plastic bottles or cups (something to catch water in), 3 intact/undisturbed soil samples (approximately 10 cm deep and wide and long enough to fit into your cut-off bottle – see picture below), 2 from a bare field and 1 from a grassland sward (with grass still attached), a few handfuls of crop/forest residues, twine, water.

PROCEDURE:
1. Have a brainstorming session with farmers on soil erosion, how and why it happens, and if there are examples of it in the area?
2. Divide the farmers in 3 groups and assign one soil sample per group
3. Prepare the bottles. Place the large bottles on their sides and slice cut off away the top third from just above the neck all the way down to its base (see picture below). Place the undisturbed soils into the bottles as illustrated in the picture.
4. Put the three bottles on a gentle slope and gently pour in water over the soils so as to simulate heavy rainfall. Note, put in the same amount of water to each and depending on the size of the bottles you use.

QUESTION TO FACILITATE DISCUSSION:
What is the difference between the amount of water in the three cups?
Are there color differences?
Why the bare soil bottle is darker?
What makes it cloudy?
Why might be the reasons for the differences between the three samples?
Imagine we leave the soil bare for 10 years. What would happen to the soil?
What would happen if we leave residues?
What does this mean for the crop?
What might be practices that favor run off and therefore soil loss?
What might be other practice to avoid run off?
Imagine a steep hill divided in 5 areas owned by different farmers (See Figure 20). Farmers in Area 5 have invested in terrace and other soil conservation practices in order to mitigate run off. However when rainfall occurs they are still experiencing excessive water flows which damage their crops. How can they solve the problem? (Hint: clearly, they cannot do it alone).

What solutions can farmers put in place collectively?

In this situation what would be the result of group actions compared with individual interventions?

Do you have other examples of interventions that should be taken by the community (for example, pest regulation, wind erosion)?

You may want to demonstrate this exercise by making a soil heap representing a hill, then simulate rainfall over the hill with a watering can or plastic container with small holes in the bottom (Figure 21). Some management practices could also be reproduced like terracing or mulching parts of the hill.
6.5 Special topic for soil health in practice

Exercise 11. Tackling soil problems to foster soil health at the local level

BACKGROUND: There are basically two “groups” of interventions to maintain and improve soil health: short term investments (agronomic practices to tackle specific issues for example, ridge tillage, raised bed) and long term investments (for example, increasing and protecting soil organic matter, rotation with legumes, cover crops).

The challenge is to implement soil management strategies which strike a balance between expensive long term investments (often not affordable by farmers) and short term interventions which maximize economic benefits in the short run. This has to be done by taking into account the biophysical and socio economic constrains in which farmers act. These strategies are strongly site-specific and that is why they should be adapted at the local level.

This exercise could be done during the introductory analysis when deciding what to experiment or at the end of the FFS when discussing the way forward on in both period.

GOAL: To (i) identify strategies/practices to tackle the soil health problems and understand long and short term interventions, (ii) analyze those strategies through the soil health framework (iii) discuss the trade-offs that may arise between production and soil health (iii) discuss strategies able to bring both short and long term benefits.

TIME: 1 hour

MATERIALS REQUIRED: Copies of the problem-cause trees/causal diagrams already produced, a large board, cards, markers, pins or adhesive.

PROCEDURE:

1. Pin up the problem-cause tree. Ask each member of the group to write down what he/she considers to be possible strategies/practices to address the cause of the problem, using a separate card for each practice. Participants should also indicate the time frame in which they expect to see results of the possible strategies (for example with a, L or S, or a clock with a time range between 1 and 12 o’clock). Here the facilitators should discuss the need to improve or maintain production while at the same time improve soils.

2. Ask for each strategy/practice to discuss the expected impact on biological, physical, chemical soil health.

3. The facilitator will stick the cards under the causes of the problems identified on the problem-cause tree;

4. Form different groups according to the problem previously identified and request each group to evaluate the resources needed to implement the possible strategies. In this process the group should consider, available resources (for example, manure, residues, legumes, trees), labor and land requirements, costs and other aspects they consider important;

5. At the end of the exercise group representatives present to the whole assembly the possible long and short term solutions to each of the causes in their problem-cause trees/causal diagrams for discussion;

6. The discussion will rank the possible strategies from the most to the least promising and feasible;

7. Request the farmers to decide which of the most promising strategies they identified and they would be willing to test in the PTDs.
QUESTION TO FACILITATE DISCUSSION:
What is the time frame for which expect the innovation/strategy to be successful?
What other solutions might there be?
Would you be able to implement this practice for more than one cropping season?
What problem could you face?
What would be the impact of the new practice on family labor? (men and women may have different views)
What external inputs would be required?
Are they available locally? How much would they cost?
What kind of organic material is available locally? Are there any competing uses (for example, crop residue fed to livestock)?
What would you expect to be the short term results of this solution?
What would you expect to be the long term results if you repeat this solution for 10 years?
The previous chapters presented a number of observations and special topics which were mainly taken from two publications. Such a selection might not suit the specific needs of the farmers’ communities and facilitators. In this case we highly recommend to have a look at the whole publications where you can retrieve several exercises. Both publications are available on line.

7.1 The living soil

AUTHOR: FAO | DATE: 2000 | PAGES: 80 | STATUS: Published in 2000

LINK: https://www.share4dev.info/ffsnet/documents/3144.pdf

BRIEF DESCRIPTION: The manual presents 31 discovery based learning exercise on soils which form a 4 days FFS training on soils. It represents the first effort to compile discovery based learning exercises on soil to be included in FFS curricula. All the exercises were tested with farmers in Indonesia, Thailand, Cambodia and Bangladesh. It also gives detailed recommendations on group dynamics.

7.2 Discovery-based learning in land and water management: a practical guide for farmer field school

AUTHOR: FAO, 42 FFS experts from Africa and Asia

DATE: First Draft 2006; Publication 2018 | PAGES: 407

LINK: http://www.fao.org/3/a-i6897e.pdf

BRIEF DESCRIPTION: This practical guide is a result of intensive “write shop” sessions were forty-two FFS, soil, water and land management experts got together to discuss and share their experiences in order to compile a comprehensive guide for facilitators. Perhaps this work represents the most complete training material on soil and water management which also includes exercises and contributions from other material such as: the Living soil and Guidelines and reference material on integrated soil and nutrient management and conservation for farmer field schools. All the 14 modules presents an initial technical background section followed by a set of discovery-based practical exercises:

- Module one presents an introduction on the FFS approach
- Module two aims at identifying problems and feasible solutions to be tested during the FFS as well as opportunities for farmers
- Module three focuses on innovations and guide facilitators in the process of introducing experimental learning (for example, AESA)
- Module four provides theoretical and practical material to learn the different soil characteristics, functions and how soils have been formed
- Module five to eleven are the core technical modules which deals with: efficient use of organic resources, importance of soil biodiversity, improve management of nutrients, reduced tillage, crop rotations, how to harvest and retain water in soils, weeds management
- Module twelve highlights the concept of ecosystem and presents the agroecological approach. This module guides facilitators through the evaluation of the farm diversity and how to use it to improve nutrition and optimize on-farm and off-farm resources use efficiency
- Module thirteen is the economic and marketing module while module fourteen provides elements to evaluate the FFS.
BUILDING A FARMER FIELD SCHOOL CURRICULUM

The table below shows an example of a curriculum where some of the exercises presented in this manual are integrated. The curriculum does not include them all but only a selection of those that the facilitator and participants considered instrumental to improve their soils (the rest can be found in Annex II). If farmers are facing specific soil issues then dedicated sections should be included. In other words, by following the problem tree analysis, the group will consider different exercises and topics to include in their curricula in order to experiment with innovative practices suited to their specific context. If during the introductory activities the exercises reported in this manual don’t fit your needs, consult the reference material presented in the previous chapter for more ideas.

Once again what is shown below is only an example!

### Table 3
Sample of an FFS curriculum with soil health exercises integrated

<table>
<thead>
<tr>
<th>Activities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-season</strong></td>
<td>Transect walk, interview key informants and families</td>
</tr>
<tr>
<td></td>
<td>Village Resource Map</td>
</tr>
<tr>
<td></td>
<td>Focus group discussion, Farming/Soil problem analysis</td>
</tr>
<tr>
<td></td>
<td>Community feedbacking meeting, Outline curriculum and PTDs (Ex. 11)</td>
</tr>
<tr>
<td></td>
<td>Arrange for a 1000 m² Study Field within easy reach of the FFS participants</td>
</tr>
<tr>
<td></td>
<td>Prepare seed-bed and seedlings for 1000 m² to be ready in time for the first FFS session</td>
</tr>
<tr>
<td><strong>Week 1</strong></td>
<td>Opening ceremony with introductions</td>
</tr>
<tr>
<td></td>
<td>Ballot-box pre-test and expectations</td>
</tr>
<tr>
<td></td>
<td>Planting of Study Field by FFS participants and trainers</td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td>Ice-breakers exercise (for example, Throw a ball)</td>
</tr>
<tr>
<td></td>
<td>Ecosystem</td>
</tr>
<tr>
<td></td>
<td>Special topic – Exercise 1. Soil composition</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td>Agro-Ecosystem Analysis– Soil texture (Ex. 2)</td>
</tr>
<tr>
<td></td>
<td>Mineral fraction and water (Ex. 3)</td>
</tr>
<tr>
<td></td>
<td>Roots/Vessels &amp; Pesticides</td>
</tr>
<tr>
<td><strong>Week 4</strong></td>
<td>Agro-Ecosystem Analysis</td>
</tr>
<tr>
<td></td>
<td>Team skills exercise (for example, Drawing together)</td>
</tr>
<tr>
<td></td>
<td>Special topic – Exercise 4. Observing soil organic matter</td>
</tr>
<tr>
<td><strong>Week 5</strong></td>
<td>Agro-Ecosystem Analysis</td>
</tr>
<tr>
<td></td>
<td>Team fun exercise (for example, String)</td>
</tr>
<tr>
<td></td>
<td>Special topic – Exercise 5. Study of decomposition of organic material</td>
</tr>
<tr>
<td><strong>Week 6</strong></td>
<td>Agro-Ecosystem Analysis</td>
</tr>
<tr>
<td></td>
<td>Team skills exercise (Johari’s windows)</td>
</tr>
<tr>
<td></td>
<td>Predators</td>
</tr>
<tr>
<td><strong>Week 7</strong></td>
<td>Agro-Ecosystem Analysis</td>
</tr>
<tr>
<td></td>
<td>Team fun (for example, Drama)</td>
</tr>
<tr>
<td></td>
<td>Special topic – Exercise 8. What is soil health?</td>
</tr>
</tbody>
</table>
### Activities

<table>
<thead>
<tr>
<th>Week</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Week 8</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Team fun (for example, Drama)</td>
</tr>
<tr>
<td></td>
<td>Special topic – Exercise 6 Source of Organic material (Ex. 6)</td>
</tr>
<tr>
<td>Week 9</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Team skills exercise (for example, minitower and bridge)</td>
</tr>
<tr>
<td></td>
<td>Reduced Exposure to Pesticides &amp; Pesticide Toxicity</td>
</tr>
<tr>
<td>Week 10</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Energizer exercise (for example, Ballons on leg)</td>
</tr>
<tr>
<td></td>
<td>Relevant exercise on soils and water (Special topics - Exercise. 9 or 10)</td>
</tr>
<tr>
<td>Week 11</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Being a Natural Enemy</td>
</tr>
<tr>
<td></td>
<td>Life cycles: Parasites, Stemborers, and Leaf-folders</td>
</tr>
<tr>
<td>Week 12</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Making kabob</td>
</tr>
<tr>
<td></td>
<td>Rats, Snail or other topic</td>
</tr>
<tr>
<td>Week 13</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Proposal Writing, Workplans, Budget</td>
</tr>
<tr>
<td></td>
<td>Community Self-Survey</td>
</tr>
<tr>
<td>Week 14</td>
<td><strong>Agro-Ecosystem Analysis</strong></td>
</tr>
<tr>
<td></td>
<td>Field Day Planning</td>
</tr>
<tr>
<td></td>
<td>Seed Selection or other Topic</td>
</tr>
<tr>
<td>Week 15</td>
<td><strong>Post-test</strong></td>
</tr>
<tr>
<td></td>
<td>Field Day/Harvest and Weighing of Field Trials</td>
</tr>
<tr>
<td></td>
<td>Closing Ceremony with Certificates</td>
</tr>
<tr>
<td>Post-FFS</td>
<td>Inform FFS participants of pre- and post-test scores</td>
</tr>
<tr>
<td></td>
<td>Make regular visits to follow-up activities</td>
</tr>
</tbody>
</table>

**Preseason and weeks 1-7**
REFERENCES


**FAO.** 2015. *Healthy soils are the basis for healthy food production.* Food & Agriculture Organization, Rome, Italy.


### ANNEXES

#### ANNEX I. Material for introductory activities

**a. Field observation form for transect walk**

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Name of the village</td>
</tr>
<tr>
<td>2</td>
<td>Most important crops (list from the most to the least important)</td>
</tr>
<tr>
<td>3</td>
<td>Average size of the farms (land)</td>
</tr>
<tr>
<td>4</td>
<td>Land tenure situation in the village</td>
</tr>
<tr>
<td>5</td>
<td>Households engaged in livestock/aquaculture production (estimated % of households)</td>
</tr>
<tr>
<td>6</td>
<td>Most important livestock or aquaculture production (list from the most to the least important)</td>
</tr>
<tr>
<td>7</td>
<td>Average number of animals per household</td>
</tr>
<tr>
<td>8</td>
<td>Who is mostly working in the farm (for example, men, women, young people)?</td>
</tr>
<tr>
<td>9</td>
<td>What are the role of women and man in the farm?</td>
</tr>
</tbody>
</table>
### a. Field observation form for transect walk

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Describe the main areas of the village and the surroundings (for example, crops, resources, forests, soils and info needed for the map)</td>
</tr>
<tr>
<td>11</td>
<td>How are the soils in those areas? (let the interviewee describe; for example, good bad, colour, compaction or other aspects they consider)</td>
</tr>
<tr>
<td>12</td>
<td>Describe usual farming practices (for example, soil preparation, transplanting, fertilization, crop protection, weeding, harvesting)</td>
</tr>
<tr>
<td>13</td>
<td>Describe major crop production constraints observed (for example, pests, water shortage, bad soil condition, labour shortage)</td>
</tr>
<tr>
<td>14</td>
<td>Major livestock/aquaculture production constraints observed (feed, shelter, disease, others)</td>
</tr>
<tr>
<td>15</td>
<td>Describe community efforts to improve soil health</td>
</tr>
<tr>
<td>16</td>
<td>Observe recycling of waste and by-products from livestock and agriculture production to enhance crop production (for example, How is straw from rice field used? How is cattle manure used? How are vegetable residues from homestead garden used?)</td>
</tr>
<tr>
<td>17</td>
<td>Have FFSs or other training for farmers been conducted? If so report what kind of training and what kind of support they received (for example, from local governors, private agency etc.)</td>
</tr>
</tbody>
</table>
### b. Interview guide with individual families

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Location of survey field</td>
</tr>
<tr>
<td>2</td>
<td>How many people work full time in the farm?</td>
</tr>
<tr>
<td>3</td>
<td>What is the role of each member of the family?</td>
</tr>
<tr>
<td>4</td>
<td>How big is the area you farm? Do you own the land; do you rent land, or a combination of those?</td>
</tr>
<tr>
<td>5</td>
<td>What are the main problem you are experiencing with farming?</td>
</tr>
<tr>
<td>6</td>
<td>What do you do to address those problems?</td>
</tr>
<tr>
<td>7</td>
<td>Concerning soils, how would you rate the fertility of your soil/s?</td>
</tr>
<tr>
<td>8</td>
<td>What are in your opinion the characteristics of a healthy soil for growing crops?</td>
</tr>
<tr>
<td>9</td>
<td>What do you do to improve the health of your soil? (for example, use of organic fertilizers, use of residues, cover crops and others)</td>
</tr>
<tr>
<td>10</td>
<td>What kind of organic fertilizers do you use?</td>
</tr>
<tr>
<td>11</td>
<td>What soil issues could you identify in the community?</td>
</tr>
<tr>
<td>12</td>
<td>If you would be able to choose something to experiment what would you like to do?</td>
</tr>
</tbody>
</table>
c. Guide questions for focus group discussions with community members

1. **Show the map and ask if it is ok for the group**

2. **Discuss the different areas and link with different production level**
   - What are the average yields of the crop in these areas?
   - Why some areas are more productive than others (think about soil, management practices, irrigation facilities etc.)?

3. **Current status of local soils, cause of soil differences and local indicators of soil health**
   - How do soils vary across those areas?
   - What are the reasons behind such a variation?
   - Is this variation due to inherent characteristics or due to management practices? Explain
   - What are the characteristics of a good soil? (Ask participants to list them)

4. **Discuss the common farming practices**
   - What are the common crop protection practices?
   - What are the common soil management practices?
   - What are the common fertilization practices?
   - What are the advantages and disadvantages of those practices?

5. **Main problems in farming**
   - What are the main problems farmers are facing in those areas?
   - What are the common problems among the areas?

6. **Main problems on soils**
   - What are the main soil problems in those areas?
   - What are the common soil problems among the areas?
   - What would happen if those problems are not addressed?
   - Imagine to be your niece or nephew what kind of soil and landscape you will see (in 30 years’ time)?
ANNEX II. Material for agro-ecosystem analysis

a) Agro-ecosystem analysis observations for insects, disease, rats, natural enemies

INSECTS: Before coming close to the plant, observe if there are any insects flying above the plant. Observe if there are insects on the leaves on top of the plant. Examine the base of the hill for brown planthopper and white backed planthopper. Then examine the hill from bottom to top for green leafhopper and other hoppers, stemborer egg masses, leaffolders, rice bug, and other insects. If many of the leaves are damaged by feeding, spread the tillers apart and look for caterpillars between the tillers and leaves, especially at the base of the hill. Estimate the percent defoliation of all leaves on the plant. Are larvae still present? Collect the stemborer egg masses (to be saved and reared to record number of egg masses with parasites). Count the number of deadhearts or whiteheads per hill. Record the numbers of all observation for the hill.

DISEASE: Notice the leaves and stems. Is there any discoloration due to diseases? (Ask the trainer if uncertain). Estimate the percent of the leaf/stem area infected. Record all observations.

RATS: Count the number of cut tillers per hill.

NATURAL ENEMIES: Count the number of each type of predator, and the number of larva with parasites per hill.

b. Guidelines for drawing

Draw the plant with the correct average number of tillers found in one hill. Write the number of tillers on the plant somewhere. If the plant is healthy, color the plant green. If the plant is diseased or lacking nutrients (low in fertilizer) then color the plant yellow;

- Draw dead or dying leaves in yellow;
- For weeds, draw the approximate density and size of weeds in relation to the size of the rice plant;
- Draw the kind of weeds in the field (broad-leaf or grass type);
- For pest population intensity, draw the insect as found in the field on the right side of the plant. Write the average number next to the insect. Also write the local name next to the insect. The data can also be summarized in a table on the right side;
- For natural enemy population intensity, draw the insects and spiders as found in the field on the left side of the plant. Write the average number of natural enemies and their local names next to the drawing;
- For rats, show the average number of tillers cut by drawing the tiller laying on the ground and cut from the side;
- For the soil, show the color of the soil and the organisms that were found in the soil. Show the depth of the soil (measure) and the max depth and spread of the roots. Highlight the differences in terms of roots and soil between the treatments and among high and low vigor areas;
- For the water, indicate the level of the water relative to the soil and the plant;
- If the week was mostly sunny, add a sun. If the week was mostly sunny and cloudy together, draw a sun but half covered with dark clouds. If the week was cloudy all day for most of the week, put just dark clouds;
- If the field was fertilized, then place a picture of a hand applying manure, straw, azolla, N’s, P’s or K’s into the field depending on the type of fertilizer used;
- If insecticides were used in the field, show sprays with a nozzle and write the type of chemical coming out of the nozzle. If granules were broadcast, show a hand with the name of pesticide being broadcast.
ANNEX III. Material for special topics

a. Special topics for soil composition and local knowledge

Describe a soil sample and local soil classification

GOAL: to critically analyse soil sample and understand the soil characteristics that are locally considered as good and bad and how they are related to crop production.

TIME: 1.5 hours

MATERIALS: Large paper sheets and markers.

PROCEDURE:

1. Divide the members in 3 groups and provide them with three different kinds of soil from areas well known to participants (for example, nearby forest, crop field, field margin);
2. Ask each group to discuss and describe the soil sample in their own way in their own words;
3. Ask the groups to list on a piece of paper or card their description of the soils sample;
4. Discuss the relationship between the soil characteristics and plant growth;
5. Then ask which of the characteristics identified belong to a good soil and which one to a bad soil;
6. Stick the two large paper sheet and ask each group presents its findings.

QUESTIONS TO FACILITATE DISCUSSION:
Why these soils have these characteristics?
Why are crops productive on soils with these characteristics?
Why are crops not productive on soils with these characteristics?
Why do you consider these aspects?
What else do you value when assessing soils?
What are the aspects you considered to say this is good or this is bad?

b. Special topics for importance of organic matter

Demonstrating soil microbes and discuss their functions

BACKGROUND: We have all seen moldy bread, and most farmers have seen bacterial diseases of plants, whether they recognize it as bacterial or not. This exercise introduces the technique of simple sterile media used to grow both fungal and bacterial cultures in order to demonstrate microbes. This method has also been used by IPM farmers in Indonesia to multiply beneficial fungi (for example, Trichoderma) at the farmer level.

GOAL: To demonstrate the existence of microorganisms in soil, to discuss their functions in soils and how they affect plant growth.

TIME REQUIRED: Initial: 30 minutes, Follow up: 5 – 7 days later 1.5 hour.

MATERIALS: Four poly-propylene bags (roughly 10-15 cm square) that strong enough they can be steamed in a rice cooker without breaking; One large rice-cook cooker (steamer); about 500 gm of cooked rice, 3 jars, hardware cloth.

PROCEDURE:

1. Add 75 – 100 gm of cooked rice to each polypropylene bag, roll the bag shut;
2. If you want to be very precise put the rice-filled bags into the rice steamer and steam for 1 hour. As long as these bags remain sealed, they should remain sterile and nothing should grow on the cooked rice;
3. In three separate cups, add a spoonful of soil of the three contrasting soil samples locations (one should be very high in organic matter), add cooled boiled water, stir and set aside to let the soil settle out;

4. While doing that save some clods of each soil sample which we will need in the second phase of the experiment;

5. Open one bag and add a tablespoon full of soil water from one sample area. Seal the bag up again quickly to avoid contamination. You might try sealing the bags shut this time by melting the plastic with a flame, or try simply tying the bags tightly shut. Do the same for each of the other two samples (when sealing up the bags this time, create an tent-like open space in order to provide some oxygen);

6. For the control (4th bag) do the same procedure of opening and sealing the bag with air space included. This will test to see if the procedure introduces contamination independently of the soil water;

7. The bags should be left sitting in a dark spot at room temperature for several days, or until you see obvious microbial growth;

8. Note: A slimy or soupy layer of many colors indicates bacterial growth whereas a fungus appears to produce “dry” “mycelia” which looks like a layer of fine cotton fibers;

9. Following some days once you see that microbes have developed;

10. Take three small jars half filled up with water and insert the three samples that you have previously saved. You may use an hardware cloth on the top of the jars to support the soil clods;

11. Pour the soil clods into the jars and observe what happen. You will see that the sample with higher organic matter will hold together. Soils low in organic matter will fall apart and disperse quickly in the water. This is a result of the presence of glomaly which is secreted by soil microbes. This is only one of the many functions that soil microbes have (for example, pest regulation, organic matter decomposition, feed for the meso-fauna);

12. Ask participants what they see, how the two experiments are related, what are the differences among samples and list the functions of soil microbes;

QUESTIONS TO STIMULATE DISCUSSION:

What type of microbes develop on the sterile rice?
Are there differences in the speed of development or the type of Microbes you can observe among the three soils?
What relationship do microbes have to organic matter?
How can you related what you see in the bag with what you see in the jars?
What are the functions of soil microbes?
What if there would be no microbes in soils? What would happen to crops?

Figure 22
Graphical representation of the step needed to perform exercise “Demonstrating soil microbes and discuss their functions.”
**Earthworm zoo**

**BACKGROUND:** Earthworms are the engineers of the soil. They fragment and decompose organic matter, improve soil aeration and aggregation. In these processes they mix organic matter, help in recycling nutrients and substances from which plants and other biological communities profit.

**GOAL:** To demonstrate how earthworms change soils and contributes to soil organic matter degradation.

**TIME:** 1 hour to set up the zoo. The exercises could be prepared at the beginning of the FFS and results analyzed when discussing the importance of organic matter and soil biota.

**MATERIAL:** 3-4 different kind of soils differing in color (plain sand could be problematic for earthworms), 2 10-30 liters transparent plastic containers with lid; 20-30 earthworms or other decomposers that can be found in flooded soils, residues and dead leaves to cover the soil surface.

**PROCEDURE:**

1. Moisten each soil type and fill up the two container by making different layers according to soil color. Do not mix the different soil layers. The two container should be compared during the experiment so at the beginning they should look almost identical;

2. Make some holes in the upper part of the containers to allow air to exchanges.

3. Place the same amount and type of organic material in the two containers;

4. In one of the two place 20-30 earthworms on top of the soil cover;

5. Close the container and store it in a cool place for up to a month. Apply water as needed. Do not let the soil dry out!!

6. If possible try to make pictures or just draw the difference you see.

**QUESTIONS TO FACILITATE DISCUSSION:**

What differences do you observe between the two jars?

What have the earthworms done?

How can this affect chemical soil health? And biological? And physical?

How can the earthworm’s work influence on water dynamics?

---

**c. Special topics for principle of soil health**

**What is a soil system?**

**GOAL:** To be able to list the principal factors, both “things” and “qualities” associated with a soil system, and be able to show how they relate to other “things”, “qualities” and the plant roots.

**TIME:** 2 hours

**MATERIALS:** Pens, Paper, Tape

**PROCEDURE:**

1. Begin with a group activity, by asking the participants to list some of the principal elements associated with a soil system. This should include both “things” (for example, sand, worms, air) and “qualities” or “characteristics” (for example, water-holding capacity, structure). Facilitator should make just a simple list;
2. Participants are asked to break into small groups and to make a drawing, including plant roots and the factors on the list divided into two columns: “things” and “qualities”. Ask them to draw arrows between those factors that have a **direct and important relationship** to each other. This should include arrows between things and qualities, but also between things and between qualities;

3. Small groups report back. The facilitator doesn’t need to worry about what is “right” or “wrong” on these lists. Let the discussion proceed as it will, hopefully with good discussion developing from the large group;

4. After each group has presented their findings, the facilitator asks them to do a second (synthetic) diagram to try and simplify and clarify the multiple relationships uncovered during the first part, into just 5 or 6 key factors and their interconnections;

5. Go to a field and observe the soil. In the field, ask the farmer students, “what is in the soil and what are the characteristics of soil?”

The facilitator should lead the discussion towards discovering at list similar to the following:

- a. Insects & worms
- b. Microbes (find a rotting piece of plant material and ask how decomposition takes place)
- c. Water (bring out idea of water-holding capacity and differences among soil types)
- d. Organic matter
- e. Nutrients (can you see nutrients?)
- f. Water holding capacity, run off, drainage
- g. Air
- h. Roots

**QUESTIONS TO FACILITATE DISCUSSION:**

All questions with What is related with and why?

e.g: What is the relationship between soil life and soil structure? Why?

What is the relationship between soil life and nutrient availability?

Why do soil communities degrades soil Organic matter?

What is the relationship between Air in the soil and root growth?

What is the relationship between water and root characteristics (for example, depth)?

---

**Is the soil a living thing?**

**GOAL:** This is a quick introductory exercise with the goal of listing the basic characteristics that define living organisms, in contrast to non-living things.

**TIME:** 45 minutes

**MATERIALS:** Colored papers/metacards, Tape, Pens

**PROCEDURE:**

6. The facilitator motivates the discussion by asking “is the soil a living or a dead thing?”

7. Participants may be given small piece of colored paper (1/8 size) and let them write to contribute to make a list of characteristics that uniquely define living organisms. They may pose their answer on the board provided;

8. The flow of the discussion on what characteristics of soils suggest that they are “alive”.

---

22. Adjusted from FAO, 2000
QUESTIONS TO FACILITATE DISCUSSION:

1. While the list may be long, the trainer should emphasize (and include, if not already listed by participants), the following:
   a. Feeding;
   b. Growth;
   c. Breathing (respiration);
   d. Reproduction;
   e. Elimination of wastes;
   f. Death.

2. Which of these characteristics can be said to be true for soils? While the soil consists of both living and non-living things, it nevertheless shares several characteristics of a living entity:
   a. it breathes;
   b. it needs to be fed;
   c. it creates waste products;
   d. and in many respects, it can “die” (ask the group if they know of any examples in which soils have been damaged and degraded to the point of being “dead”?).

3. How many living organisms in the soil?

A study done in central Europe shows just how “alive” the soil really is. The study measured the amount of living organisms in one hectare of soil, down to 20 cm in depth.

(Note that: values will be different for the tropics and depend greatly on the amount of organic matter in the soil).

Organism Kg / Ha x 20 cm deep

Insects 17 kg
Worms 600 kg
**Bacteria 1,500 kg**
**Fungi 3,500 kg**

*d. Special topics for soils and water*

**Soil as a sponge**

BACKGROUND: Excluding run off, soil hydraulic properties and water movements are not visible. However soil acts a sponge and therefore the water movement in soils can be easily represented using sponges. This is a quick introductory exercises to discuss soil water relationship. Following that the group decide if proceed with the water holding capacity or the run off exercise (or both if needed and time allows).

AIM: To experiment with some visible and “invisible” water movement.

MATERIALS: 1 dry sponge per participant, one bottle of water per person.

TIME: 45 minutes.

PROCEDURE:

1. Brainstorm with participants on what happens when the rain gets the soil (i.e., soil gets moist, soil gets saturated, once the soil is filled up the water drains in deeper layers, run-off, the soil keeps retaining water and then water evaporates and is transpired by the plant);
2. If you have more than one, distribute the sponges and ask in what they might be similar to in terms of soils;
3. Ask participants why we might use or they would not use the sponge as a model;
4. Pour some water on the sponge and observe how it gets wet;
5. Pour then more water till saturation (do not let the water "percolate);
6. Ask participants where has the water gone? How does the soil/sponge react when some water is poured (water holding capacity)?
7. Squeeze the sponge in order to dry the sponge to show how the soil retain the water;
8. Repeat the exercise adding more water in order to see percolation and drainage;
9. Divide the farmers in four groups and ask them to pile their sponges. Pour water gently in order to show how water drains from upper to deeper layer;
10. Dry up all the sponge (squeeze them), pile them again. Then pour water in order to demonstrate runoff.

QUESTIONS TO FACILITATE DISCUSSION:
What are the main water dynamics in soils?
What can happen to crops if the soil drains quickly?
What can happen to fertilizers if there is run off?
What happens to fertilizers if the soil drains quickly?
What are the results of runoff water losses?
The Soil Health for paddy rice, a manual for farmer field school facilitators, is intended for use by FFS facilitators and trainers in the implementation of a season-long FFS on paddy rice with a strengthened component on soil health. Some of the exercises presented in this manual were adapted from existing manuals, some were developed during a series of workshops on soil health for FFS facilitators, and some were developed based on activities carried out with farmers during pilot soil health FFSs in the Philippines. The content and relevant exercises can also be adapted for use in other crops and farming systems such as other cereals, pulses or vegetables, with or without livestock.

As the manual was developed together with FFS facilitators and trainers, it demonstrates the ability of trainers to adapt to the local situation and develop methods and materials accordingly. It is hoped that this output will encourage further experimentation in the field on the topic of soils, soil health and nutrient management, and for FFSs to document their experiences and exchange learnings with other FFSs, farmers and colleagues working in the field of soil health and sustainable intensification of crop production.

For more information, please contact:
Plant Production and Protection Division
Email: NSP-Director@fao.org
Food and Agriculture Organization of the United Nations
Rome, Italy

http://www.fao.org/farmer-field-schools
Illustration: Elisa Lipizzi/studio Bartoleschi