SECTION 5

Appropiate management of the soil will ensure sustainable use of this valuable resource for present and future generations.

Section 5: Integrated Soil Management Strategies

5.1 Introduction

In Section 4 local and technical indicators of soil quality were integrated to form a technical-local soil classification system. In addition, these indicators of soil quality were classified into two groups, permanent and modifiable properties.

Such a classification system takes into consideration the abundant knowledge farmers have on their soils and hence can be used as a tool to devise appropriate management strategies of identified constraints. Having involved the users and main beneficiaries of the soil in the identification and classification of the indicators of soil quality it is possible to devise management strategies that can easily be adopted by them. In this section we shall learn integrated soil management strategies that can be applied by farmers to address identified soil constraints with the overall aim of enabling them to choose between different options depending on their resource endowment. We shall differentiate between short, medium and long term modifiable soil properties as well as identifying short, medium and long-term management strategies for identified constraints.

5.1.1 Objectives

At the end of this section the trainees will be able to:

- ✓ Differentiate between short, medium and long term modifiable soil properties.
- ✓ Identify short, medium and long term management strategies for identified constraints.
- ✓ Devise soil management strategies to address identified constraints.

5.1.2 Section Structure

The section structure is given in Figure 1.

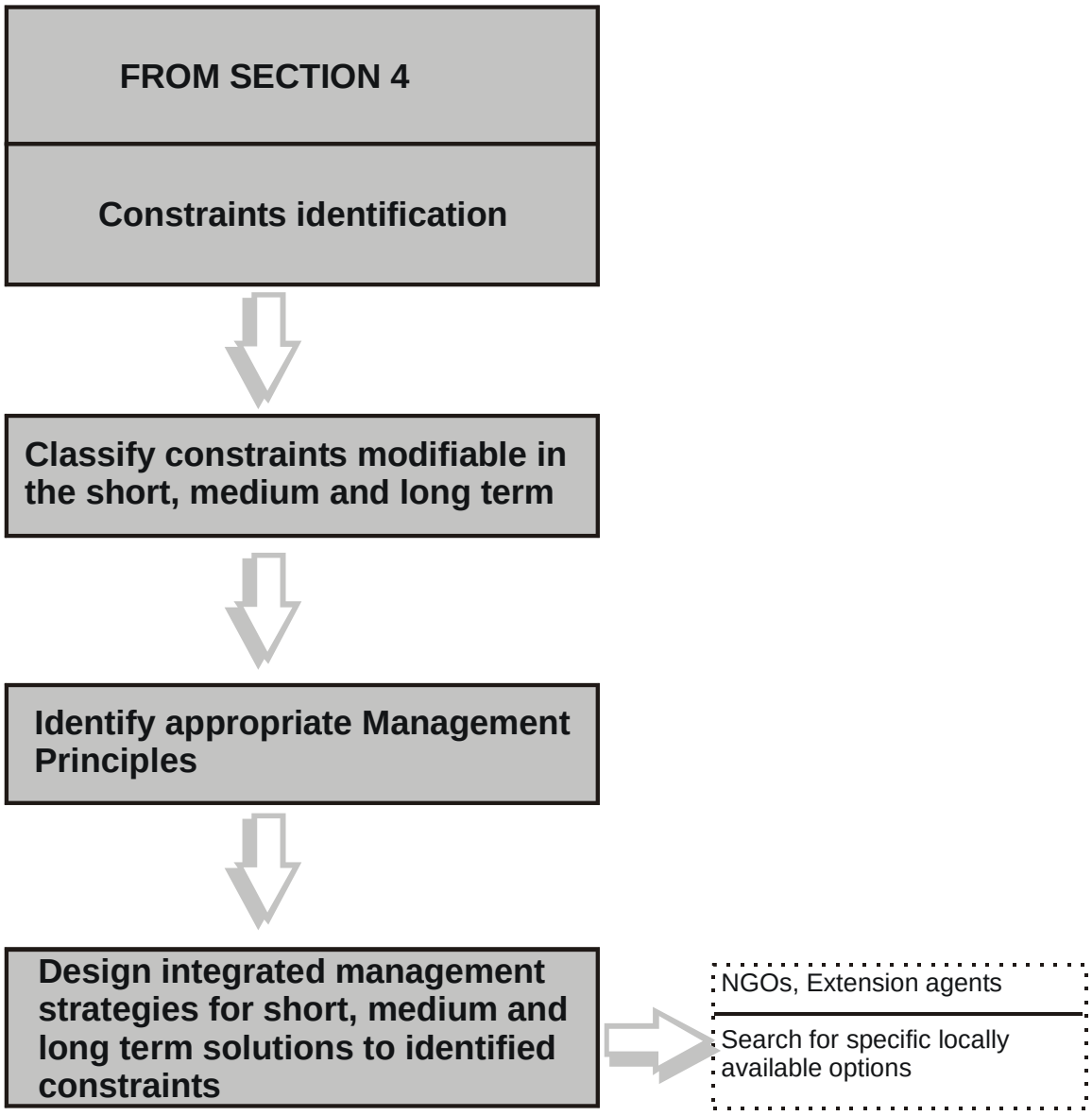

Figure 1 Outline structure of Section 5

5.1.3 Opening Questions

· Do you know any soil properties that can be modified through management.

· How do you know when you have a soil management problem?

· Once you know there is a soil management problem in a farm/plot what do you do?

· Do you know of any traditional soil management strategies (successful and unsuccessful) applied by farmers in your area?

· Do you know of any technical soil management strategies (successful and unsuccessful) applied by farmers in your area?

· Do you know three short-term soil management strategies?

· Do you know three medium-term soil management strategies?

· Do you know three long-term soil management strategies?

· Why is it important that farmers participate in the design of soil management practices?

5.2 Classifying Modifiable Soil Constraints

Modifiable soil constraints are those that can be overcome through management. Examples include low nutrient and water availability, low and high pH, soil compaction and low soil organic matter content. We distinguish between constraints that can be modified in the short, medium and long term depending

on the time span required for an appreciable change to take place. Some constraints are not easily modifiable, like rooting depth which can be modified depending on the cause of that constraint such as chemical barrier and compaction. Further, all proposed solutions depend on resource endowment, mainly cash availability. Social and cultural factors can also limit or determine the duration in which a constraint can be overcome, for example, labour availability, distribution of resources, taboos attached to certain crops or consideration of manure as dirt. For the purpose of this manual the time span has been set as follows:

Short term = less than 2 years,
Medium term = between 2 and 6 years,
Long term = more than 6 years.

The separation between short, medium and long term is necessary to enable prioritization of management strategies, which are mainly dictated by resource endowment. A summary of soil constraints modifiable in the short term, medium and long terms and the soil management principles and strategies to overcome the identifiable constraints in the short, medium and long terms are given in Tables 5.1a, 5.1b and 5.1c respectively.

Table 5.1a Soil constraints, management principles and management strategies.

Table 5.1a Soil constraints, management principles and management strategies.

Soil constraints	Management principles	Management strategies
Constraints modifiable in the short term		
Low or limited nutrient availability	Replenish nutrients in depleted soils	Apply fertilizers. Soluble inorganic fertilizers like N and K applied each season offer short-term solution. Soluble P fertilizer offers both short and medium term solution (residual effect).
Low soil pH	Maintain soil pH between 5 and 7	Liming offers short, medium and long-term solution while phosphate rock apart from supplying P (Semoka, 1989; Mnkeni et al, 1991), modifies soil pH and hence offering short, medium and long-term solution. Adopt crops tolerant to low pH.
Some soil borne diseases and pests	Preserve soil biological integrity	Diversify cropping systems in time and space Application of pesticides directly into the soil
Weeds	Suppress weeds	Frequent weeding and the use of herbicides.
Low or limited water availability	Conserve soil moisture	In the short-term irrigation and rainwater harvesting and minimizing evaporation loss through mulching will address the problem.
Poor water infiltration	Avoid soil compaction	Deep tillage and avoiding using heavy machinery will address the problem.
Soil compaction	Avoid soil compaction	Breaking the compact layer using appropriate tillage machinery e.g. chisel plough will offer short-term solution.

Figure 1: Weeds: A short-term constraint that can be modified in the short term. Here bracken ferns are suffocating maize in Kwalei, Lushoto, Tanzania.

Figure 2: Application of fertilizer will address low or limited availability of nutrients. Bean treated with Minjingu rock phosphate + organics (farmyard manure or Venonia subligera shrub) (Right), versus untreated plot (Left) in Kwalei, Lushoto. Note that the treated plot has almost attained maturity.

Table 5.1b

Soil constraints	**Management principles**	**Management strategies**
Constraints modifiable in the medium term		
Low organic matter content	Optimize soil organic matter content	The use of organic residue, use of green manure and practicing no till systems.
Poor soil structure	Maintain optimum soil structure	Use organic manure, maintain improved fallow systems and practice minimum tillage.
Stoniness	Ensure stone free seedbed	Remove stones

Figure 3: Application of mulch will conserve soil moisture. Here the Venonia subligera shrub has been applied as a mulch on a bench terrace in Kwalei, Lushoto, Tanzania.

Table 5.1c

Soil constraints	Management principles	Management strategies
Constraints modifiable in the long term		
Nutrient depleted soils	Replenish nutrients in depleted soils	Use integrated management strategies aiming at reclaiming the soils. Apply fertilizers to restore soil nutrient reserve (e.g. for P recapitalization by applying phosphate rock), use organic manure/residue, integrate N fixing crops in the cropping system, institute improved fallows, appropriate rotation, use of crops not sharing the same niche in time and space (e.g. short and deep rooted crops, short duration and long duration crops) will ensure better distribution of nutrient exploitation.
High pH/Salinity	Maintain suitable soil pH (Between 5 and 7)	Improve drainage, flush salts with good quality water and use good quality water for irrigation.
Low effective rooting Depth	Protect soil against erosion	Construct soil conservation measures e.g. contour bunds, cut ditches, bench terraces and incorporate trees and grasses to ensure soil build up.
Culture of uncontrolled burning	Apply judicious burning practices	Create awareness among farmers on the negative effects of uncontrolled burning as well as enlightening them on the importance of practicing efficient organic residue management.

Figure 4: Soil conservation through use of appropriate structures can improve productivity. The maize in front of the woman was planted on an un-terraced plot 4 days Earlier than the maize behind the woman who is on a bench terrace.

Exercises in Identifying Soil Constraints and Devising Integrated Soil Management Strategies

Objectives

After completing the exercise the trainees will be able to:

Identify constraints to soil productivity
Devise soil management strategies to address these constraints

Orientation for the Instructor

Using the case studies work with the trainees to answer the questions, encourage the trainees to answer the questions before they see the answers. The answers are given in Appendix 1.

Guidelines for the trainee

Read carefully the information given for each case study and answer the questions that follow.

Resources necessary

A pen and a sheet of paper

Suggested time: 20 minutes for each case study

5.3.1 Case Studies

Tanzania. Kwalei catchment (Lushoto AHI benchmark site).

Kwalei catchment is located in Lushoto District, Tanga Region Northeast Tanzania. Lushoto District lies between 4 22' and 5 08' South and between 38 5' and 38 38' East in the Usambara mountain ranges. With an area of 3500 km2 and a population of about 471240, based on the 1988 census and a growth rate of 2.8 % (Lyamchai, 1998), it is the most populated district in the country.

Kwalei village is in Mamba ward in Soni division in the southern part of the district about 12 km south of Soni Township. The average altitude is 1300 m.a.s.l. with hilly steep slopes and medium tall mountains and narrow valley bottoms. Annual rainfall varies from 800 to 1700 mm. The area occupied by the catchment is about 5 km2 while the population is about 5274.

Major activity in the catchment is farming. The main crops are tea, coffee, maize (intercropped with beans or banana), vegetables and fruit trees. Livestock population is low and poorly kept and mainly comprises of cattle, goats and sheep.

Land ownership is restricted to men because they are the ones who can inherit it from their parents according to customary law. About 90 % of the land is acquired this way while the remaining 10 % is acquired through buying. Although women cannot inherit land they can own it as long as they can afford to buy but this is rarely done.

The household contributes about 90 % of the labour requirement while the remaining 10 % comes from hired labour. Almost all operations are done by all members of the family except pruning and spraying coffee, which is done by men and threshing and shelling of maize, which is done by women.

The major crop production constraints are low soil fertility, loss of topsoil through erosion, non-use or limited use of both organic and inorganic fertilizers, lack of opportunities for fallow, and pests and diseases. During a PRA conducted in 1998 (Lyamchai et al, 1998), farmers reported that there was virtually no soil erosion up to 1950's. Uncontrolled human activities including deforestation, cultivation of marginal areas and free livestock grazing are among factors responsible for increased soil erosion in the village. Others include lack of soil erosion control structures and cultivation along riverbanks and steep slopes. Pfeiffer (1990) reported a loss of about 100 tones per hectare in some steep areas of Lushoto, carrying with it about 370 kg N per hectare per year among other nutrients.

The use of inorganic fertilizers is limited by their high prices and unavailability while the limited use of organic manure is due to the low amounts produced because of the low livestock population. Due to poor storage of the organic manure its quality is also low. Farmers traditionally use a local shrub called "tughutu" (Venonia subligera) believed to enrich the soil. In a study by Wickama and Mowo (1999) the shrub was found to contain relatively high amounts of N, P and K. However, the amounts of the shrub produced are low..

Questions:

1. Mention the major soil constraints at Kwalei catchment.

2. How would you go about solving each of these constraints with the aim of rendering the soil more productive.

3. Given that land is limited suggest ways of improving soil productivity within the land and other resources available to Kwalei farmers.

Tanzania Lowlands of Masama division

Masama division is located in the central part of Hai district in Kilimanjaro region North of Tanzania. The area of the Division is about 418 km2. The foothills of Mt. Kilimanjaro to the north dominate the topography of the division. It stretches southwards to the lowlands of Sanya plains. Three divisions, the uplands, midlands and lowlands based on altitude, can be identified.

The lowlands covers an area approximately 312 km2 and maximum altitude if 900 m.a.s.l. Annual rainfall is about 580 mm. It is the least populated of the three altitude zones with a population density of 50 persons km2 against 250 and 650 in the mid and uplands respectively. The high population pressure as you go upward has forced out-migration to the lower slopes. There is a high risk of increased land fragmentation, overexploitation of soils due to absence of opportunities for fallow and bringing of marginal lands to arable agriculture.

Soils.

Predominant soils include Lithosols , Regosols and Fluvisols (USDA :Entisols) . The weakly developed Lithosols are shallow and stony and consists of black

sandy loam's and sandy clays. They are mainly used for extensive grazing and recently for maize and beans. The Regosols are brown and reddish brown in colour, clay in texture and are shallow and stony. Extensive grazing is the most suitable land use although maize and beans are grown during the wet seasons. Irrigation is necessary to supplement the low rainfall. The Fluvisols are dark reddish-to-reddish brown alluvial soils occurring along rivers Sanya and Kikuletwa. They are deep, loam to clay loam in texture and highly fertile. They are mainly used for irrigation agriculture.

Socio-economics

The major enterprise is farming. There are limited opportunities for off-farm activities in the form of small rural trading centres, selling of vegetables along the main roads etc. There are two types of land tenure: the 'Kihamba' and 'Shamba'. 'Kihamba' is clan land to which the occupants have permanent freehold rights and are found in the uplands. In the lowlands, are 'shambas' and traditionally they used to be held on a yearly basis at the discretion of the chief. Today 'shamba' tenure is obtained by registering land with the local authorities through the village committee. This type of tenure is increasingly secure and can therefore be traded privately.

The household is composed of the core family (man, wife and children) and extended family and is mainly headed by men. Members of the family form the bulk of the labour and there is no strict gender division of labour. In some cases farmers hire tractors and/or labour. Decision making on land and livestock disposal is vested on men in male headed families while both men and women play role in deciding on land use issues.

The major production constraints include high prices and/or unavailability of inputs, recurrent drought, low quality of feeds, poor husbandry, predominance of stones, poor fertilizer application methods, limited use of manure due to lack of transport facilities and land shortage leading to frequent clashes between livestock keepers and crop producers.

Questions.

1. What are the major constraints limiting optimum soil productivity in Masama division?

2. How would you address each of these constraints in order to improve agricultural production in the Division?

Madagascar Fianarantsoa AHI site

The Fianarantsoa AHI site in Madagascar is located at an altitude of between 1100 and 1500 m.a.s.l. and 21 south. The site fall into what geographers call rejuvenated surfaces. There has been a general geomorphological action during the quaternary cycle, where erosion cycle restarted. This natural action was speeded up by human activities, such as deforestation, bush fires and cultivation. Slopes vary from gentle to steep. But the erodible soil material was washed away

as soon as the protective cover disappeared. There are a lot of rocky areas in the site. The effects on water infiltration and surface water flows are tremendous.

Rainfall is uni-modal. The rainy season lasts from November to March. During the last few years, there has been a noticeable change in rainfall pattern, rains coming either late or stopping early. Rainfall averages 1100mm annually with maximum of 1500 mm and a minimum of 800 mm.

Major cropping systems are lowland rice practiced by all farmers except migrants who do not own paddy fields, upland crops such as cassava, grain legumes, maize (in the more fertile niches only) while at higher altitudes sweet potato replaces cassava. Rice is the staple food and the major cash earner.
Cattle keeping used to be an integral part of the farming system but the number of zebu cattle has diminished substantially since 1985 when organized banditry hit the area.

The major farming systems are:

·Traditional rice-cassava-grain legume system
·Intensified rice-sweet potato-grain legume system
Soils
The two farming systems have developed in different pedological environments.

Cassava: Oxisols (FAO: Ferralsols), rhodic (reddish)or ochric (yellowish) with medium to low fertility levels. The pH varies from 5.0 to 5.5.

Sweet potato: Ultisols (FAO: Acrisols), ochric with low fertility levels. pH varies from 4.5 to 5.0

In the valleys, there are waterlogged soils or alluvial soils. In some areas the soils are shallow where the organic matter enriched layer is less than 10 cm deep. Some soils are compacted hence experience lowered porosity and impaired infiltration. The average organic matter content is low to medium, soil pH is low, and especially in the ultisols, aluminium toxicity is frequent. The CEC is low because of the kaolinitic character of the clay and because of the iron coating on the clay. Most soils are deficient in N and P. Other soils may be deficient in Ca and K while micronutrient deficiencies (Bo, Zn and Mo) have been found in different places. Poorly drained paddy soils are mostly deficient in N and P and show Fe toxicity.

Questions:

1. Mention two soil chemical and two physical constraints of the soils at the Fianarantsoa AHI site.

2.How would you go about rejuvenating the soils at this site?

3. The change in rainfall pattern at Fianarantsoa was mainly caused by human activities. Explain.

4. How would you address the problems of low pH, low organic matter and low contents of N, P and K at Fianarantsoa in the short, medium and long term.

5.4 Summary

This chapter dealt with management strategies of soil constraints after both local and technical soil constraints were integrated in the previous chapters to give a common nomenclature that does not only reflect the real situation at the level of the farmer taking into account the enormous indigenous technical knowledge they have but also in a language that can be understood by both extension staff and researchers.

5.5 Bibliography

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Originals for Overheads

Structure of the Section

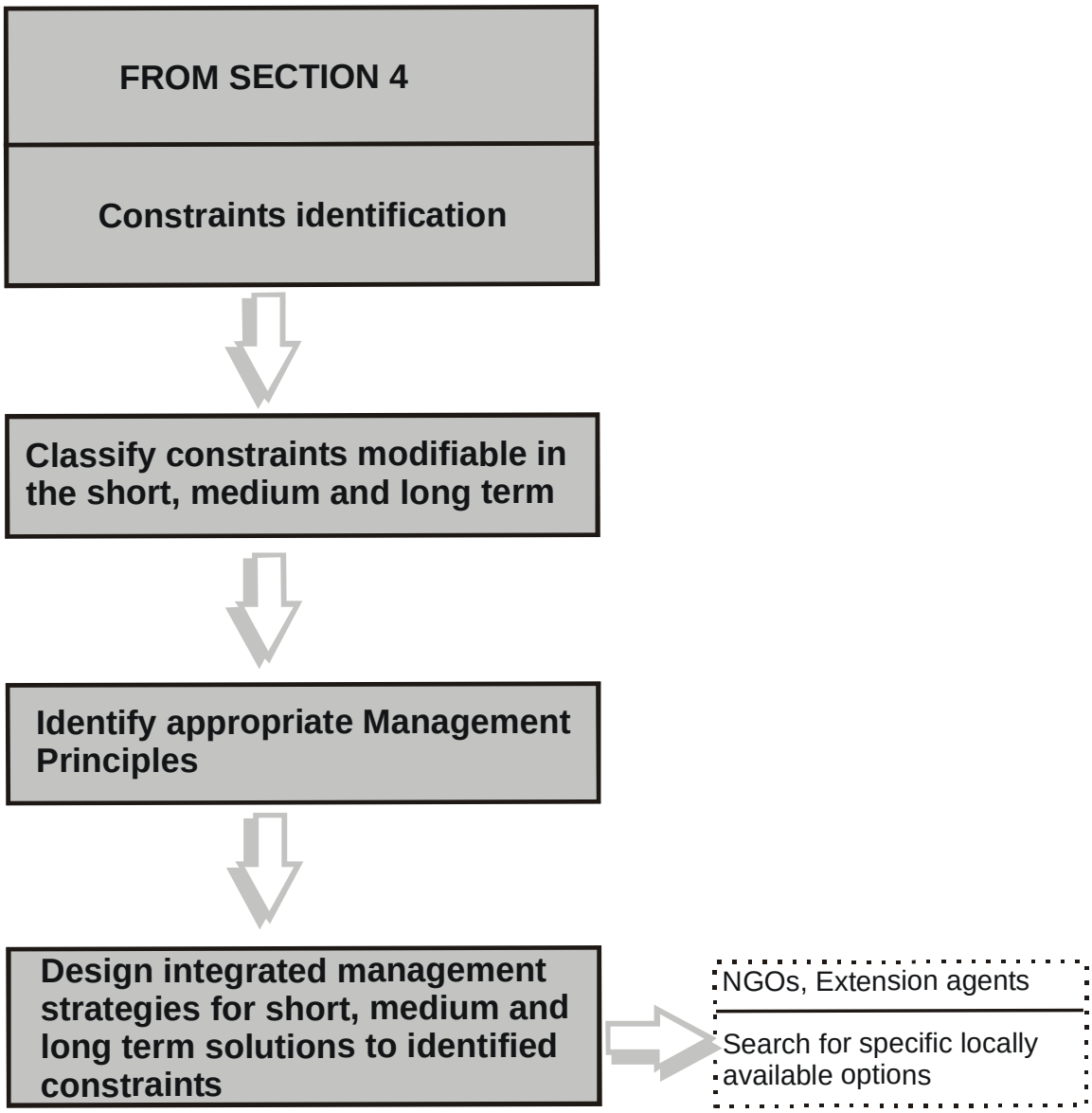

Figure 1 Outline structure of Section 5

Objectives

To enable trainees to:

- Differentiate between short, medium and long term modifiable soil properties.

- Identify short, medium and long term management strategies for identified constraints.

- Propose short, medium and long term management strategies for identified constraints.

Opening Questions

Aims at establishing how much do the trainees know about soil manageement

Examples:

- Do you know any soil properties that can be modified through management.
- How do you know when you have a soil management problem?
- Once you know there is a soil management problem in a farm/plot what do you do?

Modifiable Soil Constraints

'Those that can be overcome through management'

Examples: Low nutrient and water availability
Low and high pH
Soil compaction
Low soil organic matter content
etc.

We differentiate between:

Short term = less than 2 years,
Medium term = between 2 and 6 years,
Long term = more than 6 years.

This differentiation enables prioritization of management strategies according to resource endowment

Soil constraints, management principles and management strategies.

Soil constraints	Management principles	Management strategies
Constraints modifiable in the short term		
Low or limited nutrient availability	Replenish nutrients in depleted soils	**Apply fertilizers**
Low soil pH	Maintain soil pH between 5 and 7	**Liming** **Adopt crops tolerant to low pH.**
Some soil borne diseases and pests	Preserve soil biological integrity	**Diversify cropping systems in time and space** **Apply pesticides**
Weeds	Suppress weeds	**Weed frequently** **Use of herbicides**
Low or limited water availability	Conserve soil moisture	**Irrigate** **Harvest rainwater** **Minimizing evaporation**
Poor water infiltration	Avoid soil compaction	**Deep tillage** **Do not use heavy machinery**
Soil compaction	Avoid soil compaction	**Break compact layer**

Soil constraints	Management principles	Management strategies
Constraints modifiable in the medium term		
Low organic matter content	Optimize soil organic matter	**The use of organic residue, use of green manure and practicing no till systems.**
Poor soil structure	Maintain optimum structure	**Use organic manure, maintain improved fallow systems and practice minimum tillage.**
Stoniness	Ensure stone free seedbed	**Remove stones**

Soil constraints	Management principles	Management strategies
Constraints modifiable in the long term		
Nutrient depleted soils	Replenish nutrients in depleted soils	**Integrated management strategies aiming at reclaiming the soils** ***Examples:*** - Use organic and inorganic fertilizers - Integrate N fixing crops in the cropping system - Institute improved fallow - Apply appropriate rotation - Use of crops not sharing the same niche in time and space
High pH/Salinity	Maintain suitable soil pH (Between 5 and 7)	Improve drainage Flush salts with good quality water Use good quality water for irrigation
Low effective rooting Depth	Protect soil against erosion	Construct soil conservation measures Incorporate trees and grasses to ensure soil build up.
Culture of uncontrolled burning	Apply judicious burning practices	Create awareness Train farmers on efficient organic residue management

5.7 Appendix 1

Answers to the case study questions

Tanzania Lushoto Benchmark Site

Question 1

Major soil constraints at Kwalei:
- Low soil fertility coupled with limited or non-use of both organic and inorganic fertilizers.
- Loss of topsoil through erosion
- Absence of opportunity for fallow

Question 2

The problem of low soil fertility can be overcome in Kwalei through the use of both organic and inorganic fertilizers. Because inorganic fertilizers are expensive use can be made of the locally mined Minjingu PR in combination with farmyard manure or the local shrub (Venonia subligera). Since farmyard manure production and quality is low measures should be taken to increase the amount through improved feeding of livestock as well as in improving its quality by improving farmyard manure storage.

Question 3

Introduce improved fallow, judicious use of farmyard manure and the shrub Venonia subligera.

Tanzania Lowlands of Masama division

Question 1

Major soil constraints limiting optimum soil productivity in Masama division:

- Limited use or lack of farmyard manure
- Lack of simple transport facility for ferrying farmyard manure to the farms
- Lack of opportunities for fallow
- Poor fertilizer application methods
- High fertilizers price
- Stoniness

Question 2

These constraints can be addressed through:
Increase farmyard manure through improvement in livestock feeding and encouraging zero grazing to minimize wastage of farmyard manure

Local craftsmen empowered to manufacture simple transport tools using local materials

Introduce improved fallow

Extension staff demonstrates to farmers better fertilizer application methods

Encourage use of indigenous nutrient resources such as Minjingu phosphate rock

Collect stones and sell them to builders

Madagascar Fianarantsoa AHI site

Question 1

Chemical soil constraints:
Low soil pH
Micronutrient toxicity
Low CEC
Low content of major plant nutrients

Physical soil constraint:
- Shallow soils
- Soil compaction
- Poor infiltration and impaired porosity

Question 2

Use light machinery, construct soil and water conservation structures, apply manure inorganic fertilizers and crop residues, address micro-nutrient (Bo, Zn, and Mo) deficiency, apply lime to correct soil pH and correct aluminium toxicity, improve livestock management including security.

Question 3

Through deforestation and bush fires and absence or minimum planting of trees rainfall amount and pattern has been altered.

Question 4

Soil pH Lime and apply phosphate rock (if locally available or if can be imported from near-by countries). Also one can introduce crops adapted to low pH.

Low organic matter Use crop residue and farmyard manure

Low contents of N, P and K Apply inorganic fertilizers (N, P and K), introduce crop rotation or intercropping involving crops not exploiting the same niche. Intercrop with legume crops capable for fixing atmospheric N.