Food and Agriculture
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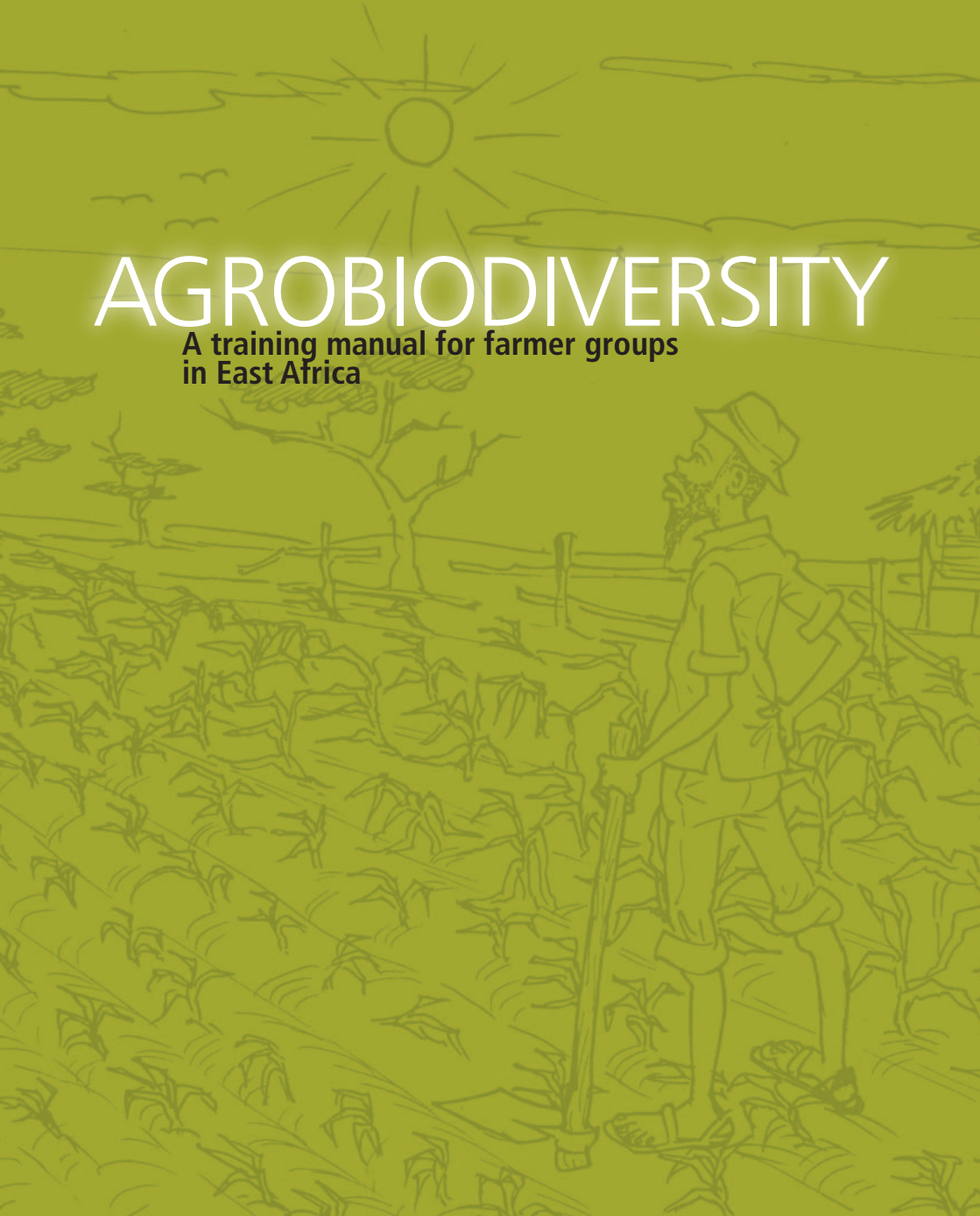
AGROBIODIVERSITY

A training manual for farmer groups in East Africa



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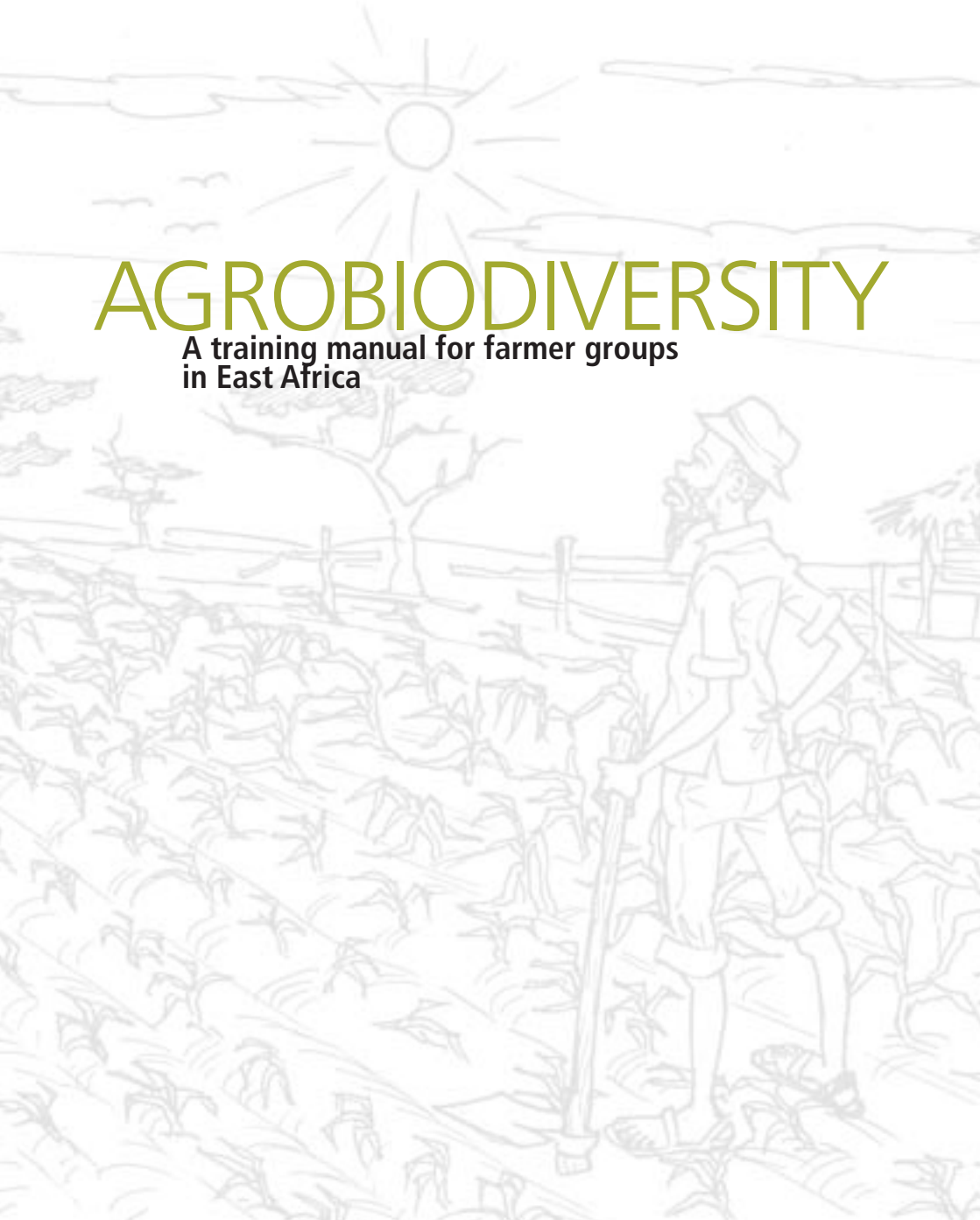

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FOREWORD

Agricultural biodiversity (or agro-biodiversity) includes all the animal, plant and micro-organism species that sustain agricultural ecosystems, and the variety between and within them, and is essential to food and nutrition security.

There is increasing recognition that agriculture is a key driver of biodiversity loss. Expansion of agricultural production to new land drives deforestation, which in turn results in loss of natural habitats and the species these host. Overexploitation of land resources, including through the overuse of agro-chemicals, leads to degradation of land and water bodies, and consequently to the loss of precious biodiversity resources such as beneficial insects – including pollinators – that help sustaining agroecosystems and agricultural production.

While agriculture poses threat to biodiversity, it can also play a role in supporting its conservation. Agricultural production occupies at least one third of the land in most countries throughout the world. If managed through practices that enhance, rather than deplete, natural ecosystems, agriculture can protect biodiversity, while at the same time enabling its sustainable use to support livelihoods, food and nutrition security.

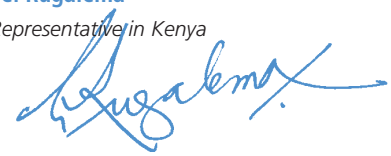
Farmers play a crucial role in conserving and managing agrobiodiversity. In fact, the diversity of species that support agricultural production systems has been carefully managed and shaped, by farming communities, over the course of the history of humankind. For example, species were selected that could adapt easily to the local environmental conditions, or that had desired characteristics, such as specific taste or higher yields. Farmers act as custodian of the Earth's agrobiodiversity resources, and play a big part in preserving traditional plant and animal varieties, as well as traditional local knowledge on agricultural and food-related practices. Women farmers, in particular, play a central role in agrobiodiversity conservation. It is often women who select and save seeds, tend to home gardens where landrace crop varieties and indigenous animal breeds are preserved, and maintain local knowledge on the medicinal properties of wild plants.

Farmers do not have control of all the processes that relate, directly or indirectly, to food production and supply – for example, agricultural policies, incentives or market functioning. However, they can shape the ways in which food is sourced, by shifting to, or expanding the use of production practices that are less or not harmful to natural ecosystems and biodiversity.

This manual aims to introduce the concept of agricultural biodiversity, and its relevance to different aspects of agricultural production and farm management for smallholder farmers in East Africa. It includes eight different training modules, each covering a specific aspect related to agrobiodiversity. The modules draw on FAO's long-standing experience in training farmers in the region, and particularly on the work carried out through the Farmer Field Schools (FFS) network in Kenya. Each module is standalone and can be used independently from the others, based on the user's or project's aim.

While the manual is not intended as a comprehensive handbook on agrobiodiversity conservation and management, it is our hope that it will be of help, in the context of FFS or other farmer training settings, to introduce key concepts related to agrobiodiversity, stimulate discussion and, ultimately, raise awareness of its importance to agricultural production and of the need for its conservation and sustainable use.

Gabriel Rugalema
FAO Representative in Kenya



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The original materials were updated following an extensive expert review between May 2017 and January 2018. Over the same time period, Module 8 was developed by the editors to cover the themes of natural pest control and pollination services, that were previously not included in the manual.

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The manual was revised, updated and edited by David Colozza, Francesca Mancini and Stefano Mondovi.

Additionally, the following experts have contributed as reviewers for the different chapters: Arshiya Noorani (FAO) contributed to the introductory module and the sections related to crop diversity in Module 2; Shawn McGuire provided numerous inputs to Module 2 on crop diversity and seed systems; N'Danikou Sognigbe (Bioversity) and Paola de Santis (Bioversity) reviewed Module 3 on traditional crops and nutrition; Giacomo de Besi (FAO), Gregoire Leroy (FAO) and Gregorio Velasco- Gil (FAO) reviewed Module 4 on livestock; Marcela Portocarrero-Aya (FAO) contributed to Module 5 on fisheries and aquatic biodiversity; Simone Borelli (FAO) provided comments on Module 6 on agroforestry; Dylan Warren Raffa (FAO) reviewed Module 7 on soil and water.

Suggestions for further edits and feedback are welcome, and should be communicated to David.Colozza@fao.org

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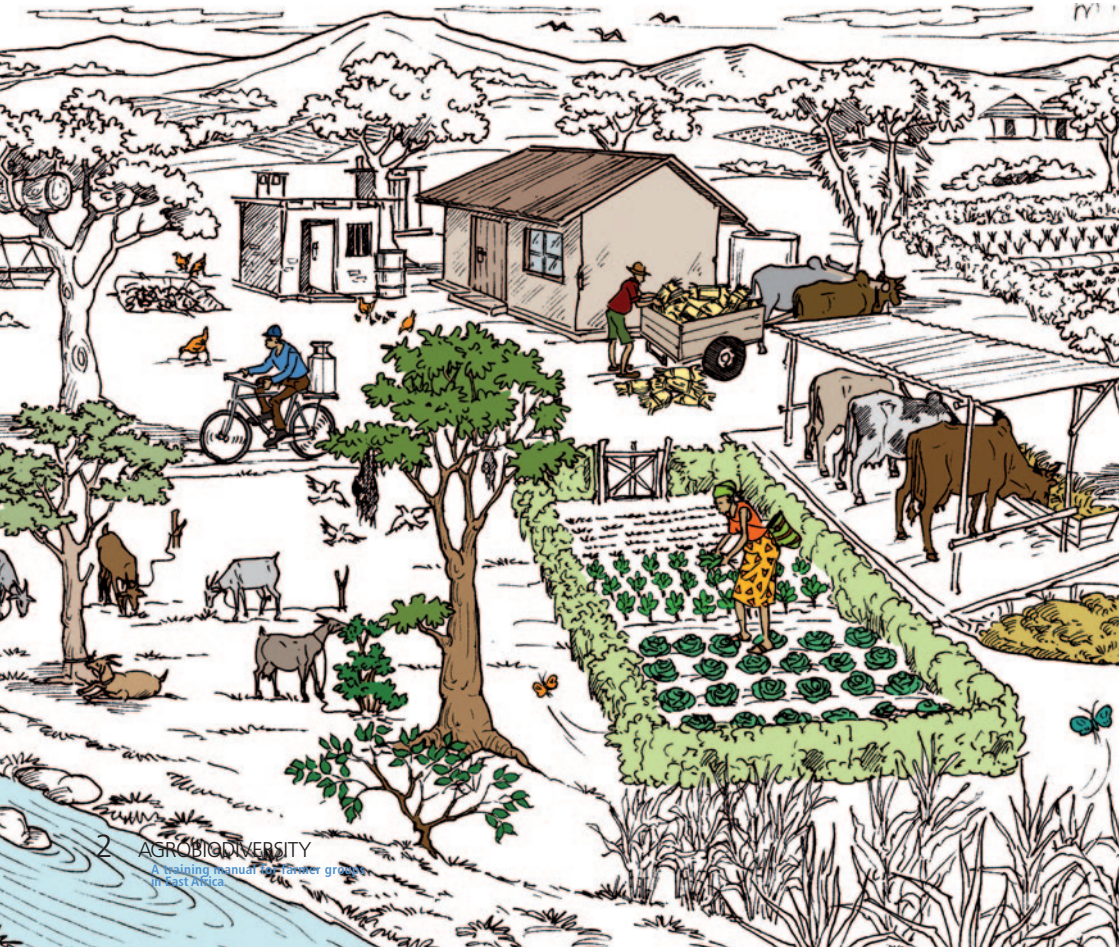
MODULE 1
introduction to agrobiodiversity

This module:

- **Introduces the concepts of biodiversity and agrobiodiversity**
- **Reviews some of the benefits associated with agrobiodiversity**
- **Considers impact of changes in agrobiodiversity**



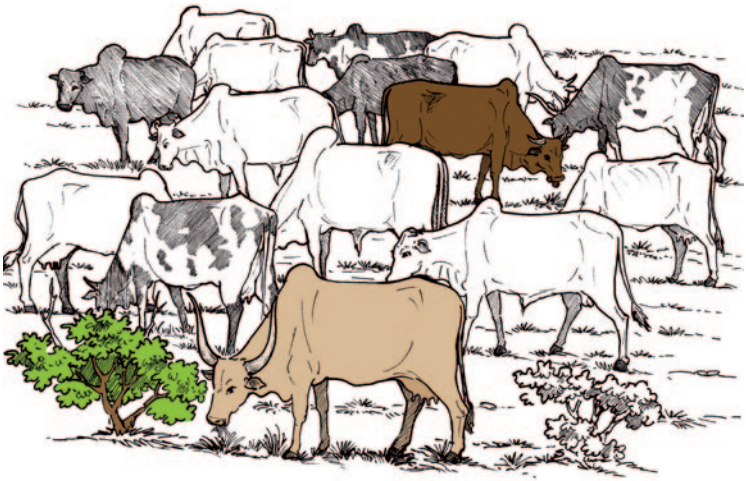
Biodiversity

Everyone depends on agricultural biodiversity: it provides a wide variety of food, fibre, fuel and other products that are essential to the present and future survival and wellbeing of all people on Earth. But what is biodiversity?

Let us start by explaining what **biological diversity** (also known as **biodiversity**) is: **Biodiversity** is the variety of living organisms – animals, plants and micro-organisms – from all sources, such as terrestrial, marine and other aquatic ecosystems.

Biodiversity can be considered at several different levels, including:

- **Within species (intraspecific) variation:** the differences within a species that affect the physical characteristics and appearance and qualities of the individuals such as productivity, ability to withstand stress and adapt to change. For example, not all zebu cattle are the same: they may vary in size, colour of coat, presence or absence of horns, milk yield and degree of susceptibility to tick-borne diseases – these different traits are, to some extent at least, due to variation in the individual's genetic make up: they were passed down from its parents.



- **Among species (interspecific) variation:** a species is a distinct type of animal, plant or micro-organism that shares common characteristics and can breed only with other similar individuals. Examples include: animals such as elephants, ostriches, crocodiles, tree frogs, catfish, locusts; plants such as mango trees, aloes, mosses; and micro-organisms such as the bacterium that causes tuberculosis in cattle and the yeast that allows bread to rise.
- **Ecosystems:** the interaction of different species with each other and the physical environment that sustains ecological functions and services. Ecosystems can be identified and studied at various scales, for example
  - small scale: looking at interactions amongst a single plant, the soil and the atmosphere, e.g. root form and depth, root nodules and activity of rhizobium bacteria and plant health indicators (leaves, colour etc.)
  - medium scale: the interactions in a farm (crop-trees-livestock-humans) or a pond (plants-fish-ducks) and the efficiency of resource use (e.g. inflow and outflow of nutrients, use of crop residues/livestock waste etc)
  - large scale: the interactions within a watershed or catchment, a rangeland area or a high altitude/ mountain region (land use, soil erosion, water flows, inputs, outputs).

Agrobiodiversity

Agricultural biodiversity, also called agrobiodiversity, is an important sub-set of biodiversity. Agrobiodiversity is that part of biodiversity related to agriculture and the production of food and non-food natural resources.

A definition from FAO[1] states that agrobiodiversity is:

> *"The variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, including crops, livestock, forestry and fisheries. It comprises the diversity of genetic resources (varieties, breeds) and species used for food, fodder, fibre, fuel and pharmaceuticals. It also includes the diversity of non-harvested species that support production (soil micro-organisms, predators, pollinators), and those in the wider environment that support agro-ecosystems (agricultural, pastoral, forest and aquatic) as well as the diversity of the agro-ecosystems."*

[1] FAO. 2004. *"What is agrobiodiversity?"*.
Available at:
http://www.fao.org/tempref/docrep/fao/007/y5609e/y5609e00.pdf

Agro-ecosystems are ecosystems that are used for agriculture and the production of food and non-food products. They are made up of biological resources and its diversity, the physical environment and human management practices.

Agrobiodiversity includes:

- domesticated crops and wild plants including trees (used for food and other products such as timber, fibre, fuel, medicine), domestic and wild animals (used for food, fibre, hides, furs, power, manure) and wild and cultivated fish and other aquatic animals (used for food or feed), within field, forest, rangeland and aquatic ecosystems
- non-harvested (associated) species within agro-ecosystems that support agricultural production and food provision, including soil micro-organisms, pollinators (bees and other insects) and beneficial predators
- non-harvested species and features in the wider environment that support the functioning of agro-ecosystems (agricultural, pastoral, forest and aquatic ecosystems) such as trees, field borders and fallow lands that sustain functions such as the water, soil nutrient and carbon cycles, provide shade and windbreaks, watershed and wildlife protection.

Agrobiodiversity helps to ensure:

- sustainable and resilient production of food and other natural resource-based products
- the continuation of biological processes that support sustainable production systems, provided by soil micro-organisms, pollinators and predators
- the maintenance of ecological and social services provided by agro-ecosystems: examples include landscape and wildlife conservation, soil protection and health (prevention of erosion, maintenance of fertility and structure), sequestration of carbon and functioning of the water cycle.

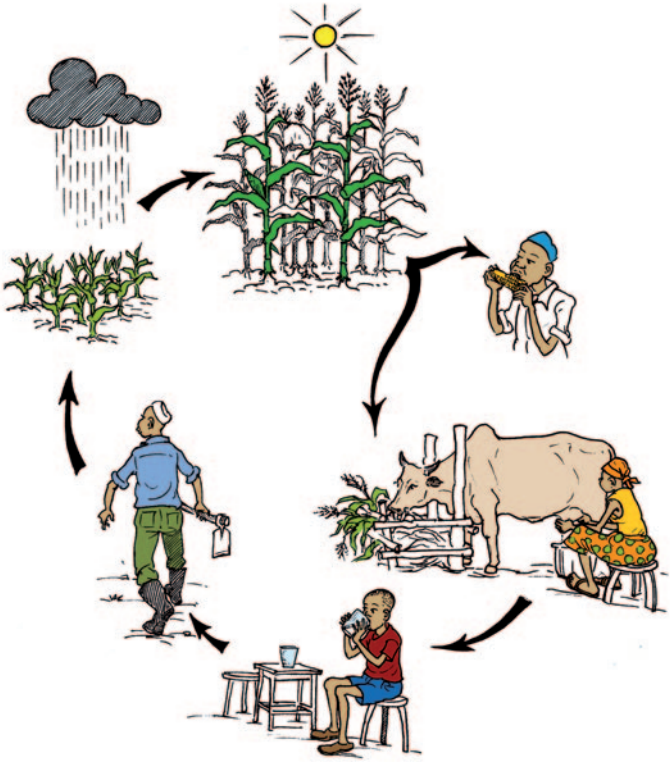
So, agrobiodiversity provides economic, social and ecological benefits which are realized at different levels, including farm/household, community, nationally and globally.

Food webs: the relationship between different species within an ecosystem

The different animals that can be found in an ecosystem depend upon other species in the ecosystem for food: this relationship can be summarized in a **food web.**

Food webs are made up of a number of different levels, each including several different species: usually these include one or more levels of predators, a number of herbivores and a variety of

green plants. For example, on a farm maize is grown. Maize is a green plant that uses energy from the sun to convert carbon dioxide from the atmosphere, water from rain and minerals from the soil to form its stems, leaves, roots and maize cobs. Stems and leaves are often fed to cattle and other farm animals, which use the energy and nutrients contained in them to maintain themselves and to produce milk. People consume both maize grains and milk from cows. So, in this case energy and nutrients flow along the food web, from plants to people.



Typically, in an ecosystem, energy and nutrients flow along the food web, across populations of individual organisms of different sizes, which depend one on the other, in a circular relationship. For example, a small number of lions will hunt a population of several hundred gazelles, which in turn graze on thousands of plants. If the number of gazelles decreases – due to disease, or if drought reduces the amount of grazing and browse available – the number of lions will also decrease, reflecting the circular relationships between elements of the food web, where each component is dependent on the other. If the gazelles disappear all together, then the lions which depend on them will also disappear.

Exercise **Introduction to agrobiodiversity** Part 1

Learning objective	Timing	Time	Materials
To introduce the concept of agrobiodiversity and to appreciate the benefits and potentially detrimental features associated with it. The exercise will also help the farmer group to select and prioritize the aspects of agrobiodiversity on which they should focus during the training cycle	By repeating the exercise at the beginning and end of the training cycle, and keeping the outputs produced, it will also be possible to track any changes in agrobiodiversity and related knowledge that have occurred during this period	2 hours for Part 1. For Part 2, 2 hours for farm surveys and an additional 1 hour for groups to present their findings and for a facilitated discussion	Marker pens, cards, flip-chart paper

Steps

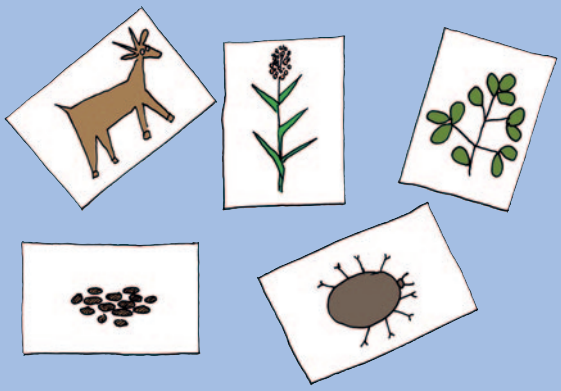
1 The facilitator asks the group members to form groups of around 6 people. Ideally, each group will include men and women and also members covering a range of ages.

2 Each group is asked to draw around 20 examples of living and non-living things that are found on their farms, from the smallest to the largest, one drawing per card: for example, a goat, sorghum, soil, ticks, etc.

3 Using the cards, the groups then explore how the different living and non-living things interact with one another, and whether these interactions are beneficial, detrimental or have no impact on their farming activities: e.g. goats eat sorghum stovers; goat manure can be used to improve soil fertility; ticks suck goat blood and transmit diseases, etc.

4 The groups then reconvene in plenary and describe some of the interactions they have identified using the cards, including positive and negative ones, and discuss what would be the impact if one or more of the things disappeared from the farm.

5 During the discussion, the facilitator could also introduce the concept of a food web with an example of wild or domesticated species: it might be possible to use the cards prepared earlier (perhaps adding a few more to fill any gaps) to develop one or more food webs on the farm.



Exercise **Introduction to agrobiodiversity** Part 2

At the next FFS session:

1 The facilitator builds on Part 1 to introduce the concept of agro-biodiversity and to illustrate some of the benefits associated with it.

2 FFS members are then asked to form working groups of around 6 people per group. If possible, this should include groups made up of only women, younger members and older members. Each group visits one of the members' farms.

3 At the farm, the group is asked to perform a rapid survey of agrobiodiversity including:
- crops
- livestock
- wild plants
- trees and shrubs
- insects and other small animals
- wild birds and other medium and large-sized animals (including those that they know visit occasionally but are not present during the visit, such as leopards, elephants or duikers)
- aquatic animals and plants
- life found in the soil
- examples of agrobiodiversity that cannot be seen but they are aware is present.

4 The range of agrobiodiversity found on the farm should be described and captured in the form of a sketch map, which can be enriched with drawings, lists, tables, physical samples, etc. Each group should label their map with the date and the farmer's names for future reference.

5 The groups consider what benefits are obtained from the various species found on the farm, including direct (food, timber, honey, etc) as well as indirect benefits (pollination, soil fertility, etc). Are there some components of agrobiodiversity that are harmful, such as destroying crops, causing disease, etc? Are the effects of these pests, diseases, weeds more serious in monocultures (where a single crop is grown) or in diverse systems (where different crops are grown together) and why might this be?

6 What opportunities can the group see to increase agrobiodiversity and the benefits associated with it? How can potentially detrimental aspects be managed?

7 At the next group training session, the groups present their findings back in plenary and the facilitator leads a discussion:
- How did agrobiodiversity vary on the farms?
- Why did it vary?
- What impact might this variation in agrobiodiversity have?
- Which farms are likely to support households better during drought years or other shocks, such as outbreaks of crop or livestock diseases, floods, etc.?
- Do men and women, younger and older members value aspects of agrobiodiversity differently? If so, what are these differences and what impact might this have?
- Are any impacts of agrobiodiversity enjoyed beyond the farm? If so, what are they and who benefits?
- Which aspects of agrobiodiversity does the group want to focus on during the coming training cycle?

8 The groups' drawings, maps and lists should be kept. This exercise can then be repeated towards the end of the training cycle by the same groups visiting the same farms: what changes have occurred – has agrobiodiversity increased or decreased? Why has this occurred – have farmers adopted new approaches, crops, etc as a result of what they have experienced during the training process? What benefits have they experienced as a result and what problems have arisen?

What impact can loss of agrobiodiversity have?

Livestock include both modern and traditional breeds. Modern breeds, such as Friesian dairy cows, can be very high yielding under certain conditions (high-input systems - using bought-in feeds, veterinary supervision, high levels of management, housing - in high-potential areas) whereas traditional breeds, such as the Small East African zebu, though well adapted to the environment in which they were developed, are less productive than modern breeds under more favourable conditions. Modern breeds have a high degree of genetic uniformity (they are all very similar) whereas traditional breeds have much more genetic diversity (individuals vary in physical appearance and characteristics).

Crops include both modern varieties and farmers' or traditional varieties of cultivated plants. Modern crop varieties are the outcome of scientific breeding programmes. They give high yields under certain conditions (often high-input systems in high-potential areas) and have a high degree of genetic uniformity (that is all the individual plants are the same). Development agencies have in the past, and some still do, promote the use of high-yielding hybrid varieties of crops, such as maize along with extension packages of seeds, fertilizers and pesticides.

Traditional varieties of crops (also called landraces) are the product of selection carried out by local farmers over long periods in their fields and through exchange with other farmers. They are very well adapted to the local conditions under which they were developed (marginal areas with low and variable rainfall and poor soils) but, under more favourable conditions (higher, more dependable rainfall and fertile soils), will tend to have lower yields than modern varieties. They are also well suited to traditional local socio-cultural needs. They have high levels of genetic diversity: not all plants are identical - some will be taller, faster maturing or more disease- or pest-resistant or are rich in micronutrients. Farmers growing traditional varieties will usually grow many different crops, which further reduces risk and enhances food security.

When a number of local, traditional varieties are replaced in farming systems with just one modern, high-yielding variety or species (such as when an improved variety of maize replaces local varieties of maize, cowpeas and vegetables) there will likely be a significant loss of agrobiodiversity, especially in terms of genetic diversity of crops. When traditional crops cease to be cultivated they can easily be lost forever: along with them go unique local knowledge, culture and skills, such as how they were grown and utilized.

Local knowledge and culture are integral parts of agrobiodiversity. Over recent years, changing ideas, attitudes and preferences have tended to make the value of traditional crops less appreciated than previously, as younger farmers and consumer increasingly favour modern varieties: traditional crops are now often regarded as 'poor man's food' and are avoided.

Exercise **Changes in agrobiodiversity over time**

Learning objective	Timing	Time	Materials
To find out what changes in agrobiodiversity have occurred in the area over the lifetime of the oldest group members or elderly members of the community	At beginning of the training cycle	1 hour for interviews with elderly members of community and an additional 1 hour in the next session for groups to present their findings and for a facilitated discussion	Marker pens, flip-chart paper, farm agrobiodiversi ty maps from earlier session

Steps

1 The facilitator asks members to remind each other what is meant by agrobiodiversity: the maps prepared during a previous session can be reused for this purpose.

2 The group members now break down in smaller groups of around 6 people, each including at least one elder member. [Alternatively, if the group does not have elderly members, elderly men and women from the local community could be interviewed].

3 The objective is to find out what changes in agrobiodiversity have occurred over time by comparing the situation, landscape, farm and wild diversity, infrastructure and services when the elderly person was young with the situation today.

4 The groups go through the different aspects of agrobiodiversity, asking the interviewee what changes they can remember from when they were young:

- Have the types or varieties of crops grown changed?
- Have the types of livestock (species and breeds) kept changed?
- Is there a difference in the plants and trees growing on uncultivated land?
- Are there more or less trees growing on the farm?
- Have the types and numbers of wild animals which live on or visit the farm changed: small animals, birds, larger animals?
- Has farm size, layout or farming methods changed?
- When did any major changes occur – related to key events (such as the 'big flood') if dates cannot be recalled?
- What impact do the interviewees think are associated with these changes?
- What impact have changes in management practices had on the conservation and sustainable use of agrobiodiversity, including crop and livestock and associated biodiversity, and effects on related ecosystem functions, including:
  - clearing of natural vegetation and burning
  - soil tillage
  - crop or livestock specialization
  - biological pest control or use of agrochemicals
  - farmer seed selection and multiplication
  - maintenance of diverse habitats: land

uses, field borders, forest and wetland areas, etc.
- private sector support (seed, markets etc.).

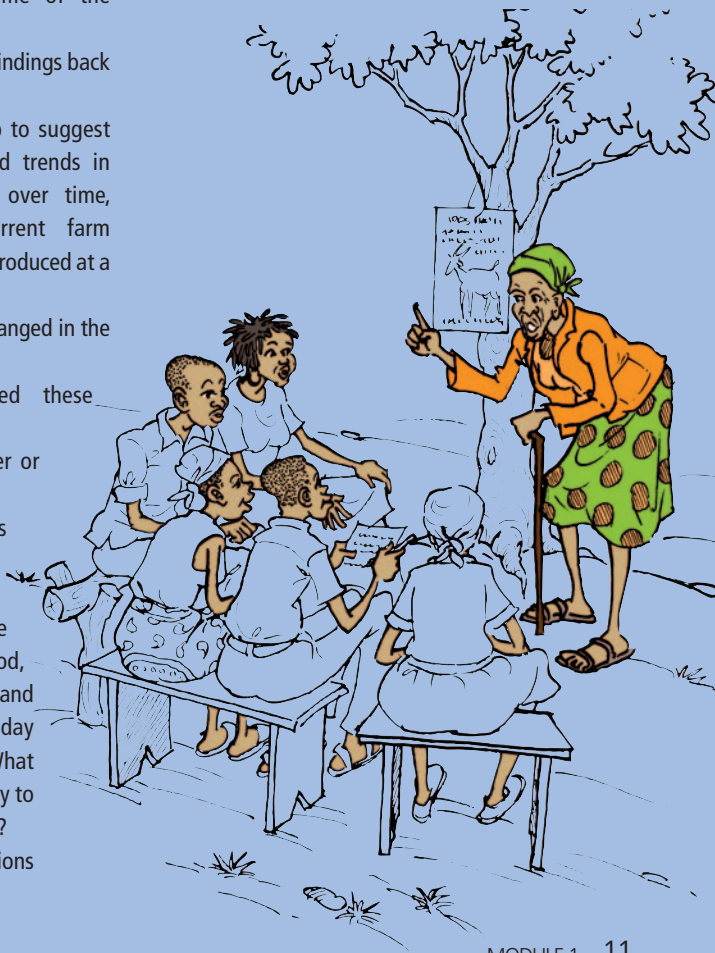
• What other social and environmental changes have they noticed, such as in the climate, poverty, food security, population size, markets and so forth.

5 The groups should record the information obtained by producing a map enriched with drawings, lists and notes showing the situation in the past, labelling their map with the date and the name of the interviewee.

6 The groups then present their findings back in plenary.

7 The facilitator asks the group to suggest what the major changes and trends in agrobiodiversity have been over time, referring back to the current farm agrobiodiversity survey maps produced at a previous session.

• How has agrobiodiversity changed in the area over time?
• What might have caused these changes?
• Is the trend towards greater or less agrobiodiversity?
• What impact might this change in agrobiodiversity have had?
• Are households likely to be better-off in terms of food, income and ability to withstand shocks, such as drought, today compared with in the past? What impacts are the changes likely to have at the community level?
• What are the gender implications of any changes? Do men and women judge the changes differently?
• How can farmers be encouraged to maintain biodiversity? What benefits can be provided such as:
  - monetary
  - training
  - self reliance
  - food and livelihood security.



All components of agrobiodiversity and the human management practices are interlinked

This manual was originally developed for farmer training within Farmer Field School (FFS) contexts, but it is not limited to FFS and can be relevant for other group training settings. For convenience, the volume is organised into a series of modules; each module covers a specific topic, such as crop diversification, traditional crops and nutrition, aquatic and livestock biodiversity, and natural resource management (see Table of contents).

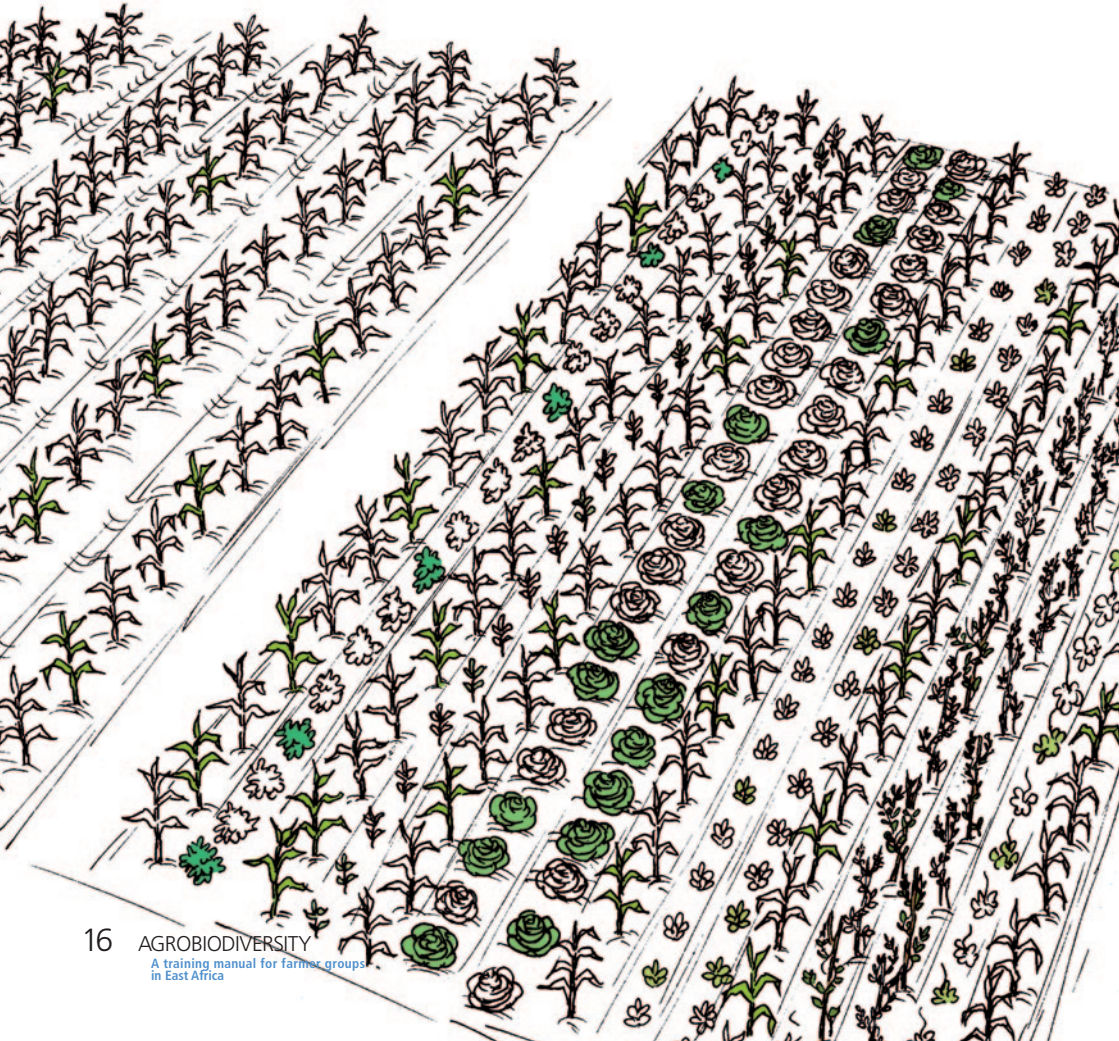
But in fact, these topics are all interlinked and complement one another; there are many opportunities for the different themes to be introduced together, to present a more complete overview of the relevance of agrobiodiversity for agricultural production and food and nutrition security. For example:

- cattle, sheep and goats can convert low-value crop residues, such as sorghum stovers, into valuable products such as milk or meat
- soil fertility can be maintained or improved through the incorporation of manure and the growing of nitrogen-fixing legumes, such as cowpeas
- draught animals can reduce the amount of hard work needed to prepare land for planting and, with the appropriate tools, for other labour-intensive operations such as weeding
- growing fodder legume trees on farms produces leaves and stems which provide high-quality supplementary feed for livestock and also provides fodder for bees, shade for people and livestock and stabilizes and enriches soils.

MODULE 2
crop diversity and food security

This module:

- **Shows the link between crop diversification and food security**
- **Introduces a selection of traditional crops**
- **Explains the value of home gardens**
- **Shows how loss of agrobiodiversity threatens food production**
- **Reviews different cropping systems, especially intercropping**
- **Compares formal and informal seed systems**



Crop diversification

Crop diversification simply means the growing of a wider selection of different crops.

Crop diversification, including the growing of traditional crops (see below), is particularly important in low-potential areas where modern varieties and types of crops do not thrive unless higher inputs (such as fertilizer, pesticides and irrigation) are used.

Crop diversification has a number of advantages:

- it reduces risk and increases food security: if one crop fails because of an unusually dry period or infestation of pests, the others might not suffer
- it can help ensure stable yields even under extreme weather conditions, such as drought or flooding
- it can make more effective use of limited resources in marginal lands
- it spreads demand for labour more evenly, when different crops demand labour at different times
- it can help reduce the need for weeding
- it increases associated agrobiodiversity – that is, the number of different non-crop species that an agro-ecosystem supports – and helps ensure the conservation of traditional crops
- it can be more environmentally friendly: it can provide more soil cover for longer periods, require less fertilizer and pesticides and support sustainable production.

However, crops can also compete for resources or not be compatible. Careful selection and proper management of crops in diversified systems is therefore critical to ensure these benefits.

Crop diversification is an important part of the solution to achieving food security, particularly for smallholders depending primarily on their agricultural produce for their livelihood. Growing a number of crops – traditional and modern – rather than relying on one or just a few modern varieties of staple crops decreases risk. If a farmer relies on just one major crop, he or she is highly vulnerable to the impact of pests and diseases, adverse weather conditions or collapsing markets that affect that crop.

Crop diversification is an integral part of agrobiodiversity, which helps to improve food security for small-scale farmers. But it also has impacts on other aspects of agrobiodiversity and enhances the health and functioning of the agro-ecosystem:

- a range of crops can provide niches for many associated species – such as beneficial predators which control pests and various pollinator species – and helps to prevent the rapid spread of crop diseases

- different crops have different types of roots and different nutrient needs: if grown together or in sequence through rotations, the different crops make better use of the soil and its nutrients, provided that they are compatible, and that their arrangement and management are designed to maximise complementarity and minimise competition
- some crops, such as garlic or marigolds, may repel some types of pest
- tall perennial crops can provide shade for more delicate crops.

Food security

To achieve food security there must be:

- ***availability* of food: enough food that is available at the right time and in the right place**
- ***access to* food: people need to be able to afford to buy the food that is available and of high nutritional quality**
- **correct *utilization* of food: available, accessible food needs to be stored, processed and used appropriately.**

Traditional crops

Traditional crops are those crops that have been grown by local farmers over a long period of time. Over tens or even hundreds of years, local farmers have selected varieties (also called landraces) from amongst the traditional crops which are well adapted to their local conditions (often marginal areas with low and variable rainfall and poor soils. These crops are also well suited to local socio-cultural needs.

In addition, most traditional crops have high levels of genetic diversity: not all plants are identical – some will be taller, faster maturing or more disease- or pest-resistant. Farmers growing traditional crops may decide to grow a number of different varieties, to further spread risk and enhance food security. To derive the most benefit from growing traditional crops, systems are needed to support their marketing and processing: usually marketing systems and processing activities are currently focused on modern crops and varieties, such as improved varieties of maize.

Some examples of traditional crops grown in Kenya include: cereals such as sorghum and millets; grain legumes (pigeon pea, cowpea, *Dolichos lablab*, green grams); tuber crops (cassava, sweet

Top row:
sorghum, millet,
pigeon pea, cowpea

Middle row:
green grams, groundnut,
cassava tuber,
sweet potato plant

Bottom row:
yam, amaranth,
black nightshade,
cassava

potatoes, yams); oil crops (sesame, groundnuts) and African leafy vegetables (amaranth and black nightshade). For more detailed descriptions of traditional crops see Appendix 1.

with a high level of inputs, such as pesticides and fertilizers) traditional varieties and crops will tend to have lower yields than modern varieties. But under less favourable conditions, locally adapted crops will usually still produce a reasonable yield.

Crop diversity and nutrition

To be healthy, people need to eat balanced diets that provide all the nutrients they require. Although staple crops (such as cereals, pulses and tubers) can provide most of the energy and protein needed, they are often deficient in essential vitamins and minerals. Leafy green vegetables, including traditional vegetables, are rich sources of these micro-nutrients, such as iron and vitamin A and C, and are valuable dietary supplements. **(See Module 3 "Utilization and nutritional value of traditional crops").**

Loss of crop diversity

This can occur when farmers stop growing traditional crops and varieties in favour of one or a few introduced crops and modern varieties - such as just growing one improved variety of maize and beans.

Effects of loss of crop diversity can be felt at various levels.

At the *household* level these can include:

- dependence on one or a few major food crops will increase risk of total crop failure, for example when there is lower than usual rainfall or problems with pests and diseases
- less nutritionally balanced diets leading to malnutrition and greater susceptibility to certain diseases, such as diabetes
- reduced soil fertility due to nutrient overexploitation from the same crop
- increased susceptibility to pests and diseases, which may lead to greater dependence on use of pesticides
- decreased genetic diversity among key crops, which limits adaptation to changing contexts.

At the *community* level, loss of crop diversity can destabilize beneficial agro-ecosystem processes, such as pollination of crops and varieties by insects and birds or predator-prey relationships that help keep insect crop pests under control.

At the *global* level, institutional and commercial plant breeders depend on the genetic diversity present in traditional crops, as well as wild relatives of domesticated crops growing naturally around fields, for future breeding programmes.

To avoid loss of crop diversity, farmers may need help in obtaining seeds of traditional crops and varieties, in choosing the most appropriate combination of crops and varieties and in selecting seed to keep for the next season **(see "Seed systems", below)**.

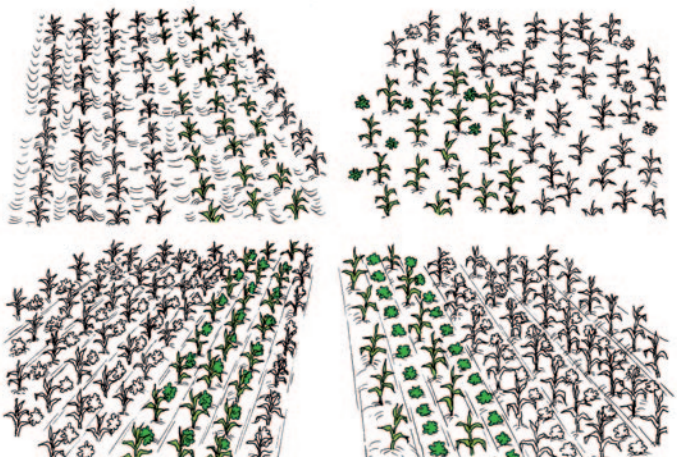
Cropping systems

Cropping systems can vary and be diversified according to:

- which crops are grown
- the distribution and arrangement of crops in the fields (and around field borders)
- level of management and inputs required
- how this changes in successive seasons.

A cropping system which is especially useful where a number of different crops are grown together is intercropping.

What is intercropping? Intercropping is when two or more crops are grown at the same time on the same field. Intercropping will often be beneficial to small-scale farmers: the yield of the two crops combined will usually be more than if either one had been grown alone.



Top row:
monocropping (left),
mixed cropping (right)

Bottom row:
relay intercropping (left),
row intercropping (right)

(For advantages and disadvantages of different cropping systems see Appendix 2)

There are different kinds of intercropping systems, which vary according to how the crops are combined and arranged:

- *row intercropping:* the different crops are grown in separate, usually alternate rows
- *patch intercropping:* the different crops are grown in one or more patches spread over the field
- *mixed cropping:* the different crops are grown intermingled over the field
- *relay intercropping:* a second crop is sown between the stands of an existing crop, just before the first crop is harvested. In relay intercropping the first and the second crops spend most of their time in the field as sole crops, growing together for only a brief period.

Besides intercropping, there are other ways to increase diversity in cropping systems:

- planting of trees and other plants in field borders: e.g. alley cropping and other forms of agroforestry for fruits, livestock fodder, organic materials for mulch etc.
- features such as hedgerows or grassed strips or borders, that provide habitats for other species and help reduce runoff and soil erosion
- home gardens that may combine different plant types, including those that grow on the ground, that form shrubs and higher tree layers
- intercropping varieties of the same species as this can promote higher yields, greater resistance to pests and diseases as well as increase options for home consumption and markets.

Exercise **Introduction to crop diversity**

Learning objective	Timing	Preparations by the group	Time	Materials
To understand and appreciate the importance of crop diversification	Towards beginning of training cycle, when crops are growing	None	Total of 4 hours: 30 minutes introduction in plenary, 2.5 hours for farm survey, 1 hour for group presentations and discussion in plenary	Marker pens, flip-chart paper

Steps

1 The facilitator first introduces the concept of crop diversity; that is the range of different types of crops and of varieties of crops grown, as well as useful wild plants and trees, and all the different direct and indirect benefits they provide.

2 Participants are then asked to form groups of around six people and each group visits one of their members' farms where they carry out a rapid survey of crops grown:
- What crops are being grown – staples, pulses, vegetables, fruits, herbs, trees, fodders, others?
- For each crop specify were these traditional crops, or crops introduced by researchers, extension officers or from other farming systems in Kenya?
- What cropping systems are being used? Is intercropping being used? If so, which types?
- What useful wild plants are present?
- What direct benefits (produce) do the crops, wild plants and trees provide (including less obvious and secondary ones)?
- What indirect benefits (services) might the crops, wild plants and trees also provide?

3 The crops and other useful plants and trees found on the farm should be recorded as a sketch map on a sheet of flip-chart paper. For each crop or wild plant or tree, the direct and indirect benefits they provide are also recorded, either as drawings or as lists.

4 The group members then reassemble for plenary discussion. The facilitator leads the discussion to share results from the groups. It may be helpful to prepare summary tables of findings, as shown below:

Plant diversity
- What crops (species/varieties) used to be grown but are no longer found; are still grown but only by very few elderly persons; and those that are being grown widely today?
- What wild plants and trees were used in the past but are no longer found, what were they used for?
- List the crops and wild plants in a table (see below) with local names (and scientific names if known) and their uses
- For each crop/variety, indicate properties (specific advantages/disadvantages), such as ease of cultivation, storage, taste and use characteristics, and marketability.

Farm diversity
- How did the different farms vary in terms of farm size, cropping systems, diversity and types of crops grown or useful wild plants present?

Traditional crops no longer grown	Uses (properties)	Crops grown by few /elderly	Uses (properties)	Crops grown widely	Uses (properties)

Wild plants/trees no longer found	Uses (properties)	Wild plants/trees still found	Uses (properties)

Farm types /cropping system	Plant diversity (crops/wild plants)	Influencing factors

- What factors influenced which crops were grown, e.g. farm size, presence/absence of livestock, age of household members, proximity of markets etc.

Other points

- Are there any negative aspects to diverse cropping systems?
- How can farmers obtain good yields and income and ensure reliable and sustainable food production?
- Good seed and information to improve yields is often not available for local crops. How can seed supply and knowledge be improved for local/ traditional crops?

If time is running short, arrange to discuss the issues below during the following group meeting:

- For which crop/plant products is there no market? How could the group help to develop or improve markets?
- Are there opportunities to enhance food security, for example by increasing the diversity of crops grown or modifying the cropping systems used?
- As a result of this exercise, would members like to make any changes on their own farms? If so, what changes and why?
- What challenges will they face in doing this? How could the group help overcome these challenges?
- Develop a plan of action for enhancing crop diversity.

Facilitators' notes:

The growing of commodities and market-driven farming is associated with maximum yields for maximum income. Farmers opt for monocultures in striving for higher incomes. But are the combined risks of crop failure in the short term and the longer-term effects of soil fertility decline and detrimental effects on the ecosystem adequately taken into account?

Access to seed and extension is easier for improved varieties, as there is more public and private sector support, although nowadays farmers also buy seeds for other crops through local markets (e.g. pigeonpea, sorghum, other legumes). Can farmer groups be more involved in participatory plant breeding and improved management of local crops to obtain better yields?

Difficulties may arise with diverse cropping systems: it can be difficult to use oxen or tractor-drawn tools for weeding or ridging in mixed cropping systems. Also, when small amounts of several products are marketed, farmers may get lower prices than producing larger quantities of just one crop.

Seed systems

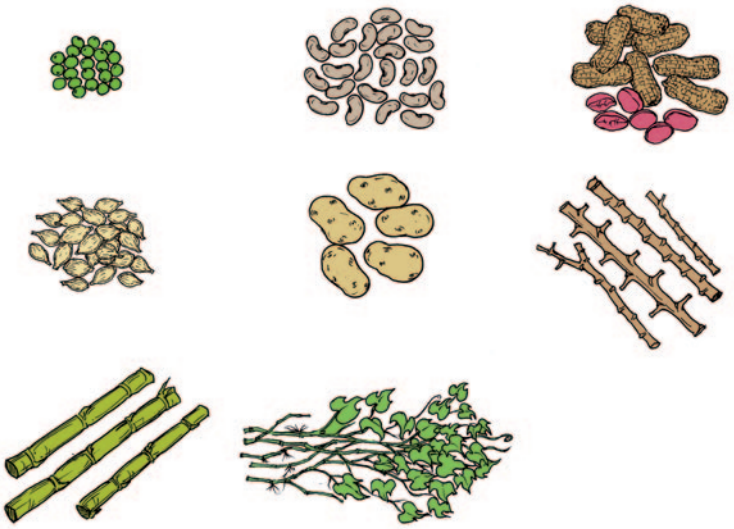
The objective of this section is to enable farmers to develop a clear understanding of formal and informal seed systems and the contribution the two systems make to crop diversity and food security.

What is seed? 'Seed' in the sense used here refers to any part of a plant that is used to produce new plants. It includes both true seed, such as cereal grains, peas, beans, peanuts and pumpkin seeds, which germinate and develop into seedlings, and also vegetative material, such as tubers of potatoes, stems of cassava and sugarcane and cuttings of sweet potato vines.

Top row:
peas, beans, groundnuts

Middle row:
pumpkin seeds,
potatoes, cassava stems

Bottom row:
sugarcane stems, sweet potato cuttings



Timely and affordable access to appropriate seed (or other planting material) of acceptable quality is essential if farmers are to grow productive crops, achieve food security and produce surpluses for sale. In addition to access to the seed material, farmers also need access to information about appropriate cultivation, management and storage practices for the seed/germplasm of the crops they are cultivating.

Certified and traditional seeds

What are certified seeds? Certified seeds are produced through formal seed supply systems. These usually produce a limited number of improved varieties for a small range of crops. The production of seeds often involves a significant use of agrochemicals.

Certified seeds are sold packaged, often in large quantities suited to the needs of larger-scale farmers. Their production and distribution is controlled by government regulations: often only approved varieties are permitted to be traded and certified seed must meet specified quality standards, for example relating to purity and germination rate.

Advantages of certified seeds:

- Genetic purity: all seeds are the same and crops grown will be uniform with individual plants being very similar; for example, they will all be the same height and all will mature and be ready to harvest at the same time
- Germination rates are high and consistent under good conditions
- High economic returns in high-potential areas with good infrastructure, farming practices and market linkages
- Supply is consistent: seed is produced in different regions by contracted farmers and processed, packed and distributed by seed companies who ensure seed is available, especially in high-potential areas, ahead of the planting season.

Disadvantages of certified seeds:

- Contribute towards loss of genetic diversity and loss of associated agrobiodiversity when farmers replace their diverse traditional varieties of crops with just a few modern crops and varieties
- Adoption of modern varieties will lead to loss of culture and knowledge associated with traditional crops, such as how they are grown and utilized
- Resource-poor farmers might not be able to afford to buy certified seed each year and struggling to do so (or buying on credit) can lead to greater poverty and indebtedness
- Certified seeds are often hybrids (carefully managed crosses between different varieties) which degenerate from one generation to the next. If re-sown in the coming years losses of 20-30% in viability and performance should be expected
- Production and distribution is highly centralized, top-down and with a limited involvement of farmers
- Can be associated with environmental degradation, as they may be treated with pesticides which can lead to pesticide residues in the soil and impact on natural enemies.

What are traditional seeds? Traditional seeds (from traditional crop species and landraces) are produced and distributed, often by farmer-to-farmer exchange, at the household and community level through informal systems. Seed saving by farmers and associated traditional knowledge are integral parts of traditional production systems, which include local customs and responsibilities.

Advantages of using traditional seeds:

- Well adapted to local agro-environmental conditions under which the traditional crops and varieties were developed
- Produce yields under variable and harsh climatic conditions and in low-input systems
- Meet needs and preferences of local farmers and their families
- Less expensive than modern varieties and locally available
- Local mechanisms of quality assurance are often in place: farmers know who supplies seeds of traditional varieties that perform well
- Local seed supply is good, especially after seasons when growing conditions were favourable
- Genetic variation: not all plants are identical - farmers can select which seeds to save for the next crop based on the traits they most value. Even though this selection mechanism may not be efficient for all traits, this genetic variation provides plant breeders with genetic material which can be used to develop new, improved modern varieties.

Disadvantages of using traditional seeds:

- Give low economic returns in high-potential areas with good farming practices and infrastructure compared to improved varieties developed by researchers and seed suppliers
- Germination rates and quality of seed are variable
- Seeds may deteriorate during storage
- Genetic variation: not all plants will be identical, which can make management more difficult; for example, not all plants will be ready to harvest at same time.

Exercise **Different types and sources of seed**

Learning objective	Timing	Preparation	Materials
To enable participants to understand the difference between seeds obtained from different sources	One month before planting season	Participants are requested to bring samples of seeds obtained from various sources, such as seeds saved on-farm, bought from local markets and commercially distributed packaged seed	Pen markers, flip charts, various types of seed

Steps

1 The facilitator sets the scene by explaining that seeds can be either certified or traditional. The features of each type of seed are discussed and explored.

2 The facilitator then asks members to form groups of around six each. If possible, include one or more all male groups or all female groups as well as mixed groups.

3 Each group examines the different types of seeds they have brought:
- What are the seeds for - which crops and varieties?
- Are they certified or traditional seeds?
- Where did the seeds come from: saved on-farm, obtained from neighbours, bought in local food markets, bought from agro-vet stores or obtained from other sources?
- Are all the seeds in good condition? How have they been stored?
- Would they be expected to produce a good crop?

4 The groups record the information in a table using either words or drawings to show the type of crop and variety, source of seed, whether they are certified or traditional and any other observations they have made, such as the appearance of the seed, presence of material other than seed etc.

5 The groups reconvene in plenary and each presents their findings.

6 The facilitator then leads a discussion:
- Were the seeds mostly traditional or certified? Did this vary between crops?
- What was the source of the seeds? Did this vary between crops?
- Were there differences from where men and women obtained their seeds or in the types of seed? If so, what might be the reasons for any differences?
- Did farmers notice any differences in the appearance of any of the seeds? What might be the cause and impact of these differences?
- Do farmers have problems in obtaining the seeds they need or in other aspects of seeds, such as storage?
- Do they have a choice of seeds? If so, how do they decide which ones to sow? If not, would they like to have a wider choice? What seed types would they like to have access to?
- If farmers save their own seed, how do they select which seed to save and how do they process and store their seed?
- How could the farmer group help farmers improve the supply of seeds of the crops and varieties farmers would prefer?

Seed of crop species and variety	Type of seed (certified or traditional)	Source of seed	Observations

Local seed multiplication and bulking

Private seed companies often have little or no interest in producing and distributing seeds for traditional varieties of crops, such as sorghum, bulrush millet or local bean varieties, and yet it is important that such seeds are made available both now and in the future.

Responding to local values

Local seed and other planting materials are likely to have been selected by local farmers to produce crops that meet local needs and respond to local values. Local values include:

- *Production values*: yield potential and stability; tolerance of local conditions such as climate, soils and common pests and diseases; suited to economic and managerial capabilities (such as labour availability and cropping systems); satisfies farmers' need for secondary products (such as a good balance between grains for people and straw/stover for livestock feed or mulch)
- *Consumption values:* taste, colour and suitability for preferred methods of preparation, such as baking, boiling, frying, roasting or making into porridge
- *Economic values*: early maturity (production in the 'hungry' season); produce that matches market demand; longevity in storage; and extended harvesting period
- *Cultural values*: these are also important in some communities.

In selecting the seed to save, farmers will often balance these different values to meet their prioritized needs, for example, to respond to cooking needs (taste, cooking and storing quality) or characteristics demanded by the market. But in all cases, risk avoidance is likely to be an important objective: which seeds are likely to produce a reliable crop that meets the farmer's needs? If farmers use seeds obtained from unknown or distant sources, including modern varieties, they take the risk that these will perform poorly under their local conditions.

Advantages of local seed multiplication and bulking

Many small-scale farmers already produce most of their own seed requirements and exchange or sell seeds with friends, family and neighbours. Local seed multiplication and bulking can be an effective means of ensuring the availability and conservation of traditional crops that are well suited to local needs.

Farmers own saved seeds: Small-scale farmers often save seeds from their own crops. As long as local conditions remain unchanged, including climate, pests and diseases and market demand, this is an effective way of ensuring appropriate seeds are available for the next crop, and also

that traditional crops are conserved for the future. This might not apply to crops that have strong cash values (which may be entirely sold at harvest), or which are difficult to store (for example, most legumes).

Off-farm seed sources: Sometimes farmers will either want to or have to obtain seed from off-farm, for example when:

- a crop grown by a neighbouring farmer shows promise of being superior in terms of yield, tolerance of locally common pests and diseases, taste, duration of storage etc.
- crops fail due to drought or pests
- seeds are destroyed in storage by weevils or other pests; seeds that were planted failed to establish
- the crop is difficult to store at home – e.g. legumes, vegetatively-propagated crops
- there is civil strife
- the farmer sold or consumed the entire harvest.

Possible sources of off-farm seeds include:

- seeds bought in local food markets, which are the single largest source for crops such as legumes. While the variety and source are not guaranteed, farmers often seek familiar varieties from reputed vendors who can specify the origins of the potential seed they are selling.
- social networks: relatives, friends and neighbours
- specialist 'seed farmers': knowledgeable local farmers who become well-known within the community as suppliers of good quality seed. As with social networks, these may supply seeds for cash, by exchange or as gifts
- 'seed fairs': local events at which farmers, government agencies, NGOs, researchers and commercial seed suppliers come together to make traditional and certified seeds and associated information available to farmers and to enable better linkages to be made between these various stakeholders
- development projects
- emergency aid, for example following a flood or civil disturbance
- retail outlets supplying certified seeds.

Farmer selection of seed for saving

Farmers may use different methods to select the seed they will save. These include:

- selecting in the field shortly before harvesting: this is a widely adopted method
- selecting in the field throughout the cropping season: similar to the above, but takes account of performance through the entire production cycle and will need some records to be kept and individual plants to be labelled

- selecting after harvesting based on characteristics of the seed only, such as colour and/or size: also a commonly used method
- random selection of seed from the bulk harvest: relies on 'natural selection' – the concept that plants that survive and produce seed will be the most fit (less fit plants won't have survived to produce seed) and this will be reflected in the next crop
- planting separate seed production plots; these are closely observed throughout the cropping season and 'rogued' to remove any plants that have unwanted characteristics (such as being late flowering, low yielding, susceptible to diseases or pests) and also any diseased plants and weeds to prevent undesirable cross-pollination and contamination of the seed.

In addition to selection based on the qualities of the crop and seed, some farmers will also base their selection on cultural values and beliefs that may or may not have a rational, scientific basis.

Seed storage

Effective methods of storing seeds are needed to prevent problems with pests and diseases and to avoid the seed deteriorating, which will affect germination rates.

Often seeds are stored just as they were harvested: un-threshed heads of sorghum and maize; unshelled pods of cowpeas, beans. But processing the seeds and then using various low-cost, simple but effective local storage methods can prevent problems arising during storage and improve the viability of stored seeds.

Prior to storage, seeds should be:
- thoroughly sun- or air-dried
- threshed or shelled
- winnowed
- graded: damaged and small seeds should be discarded – they can be fed to poultry
- cleaned: stones, weed seeds and other debris should be removed.

Simple ways of storing seeds include:
- storing high-up in the kitchen, where smoke from cooking stoves will provide some protection from weevils, moths and other pests
- use of local herbs, such as neem tree leaves to protect cowpeas against damage from bruchid beetles, or adding 4-6 teaspoons of chilli powder to every 1 kg of stored seed

- use of air-tight containers, such as calabashes, bottles with stoppers or tins with lids
- addition of ash to the seed
- use of special chemicals sold by agrochemical companies: but safety precautions must be observed to protect the farmer and prevent accidental consumption of treated seeds, which may be poisonous.

Exercise **Local seed multiplication and bulking**

Learning objective	Timing	Time
To enable farmers to acquire, learn and practice necessary knowledge and skills for on-farm seed production	Before planting season	2 hours

Steps

1 First the facilitator reminds group members of the difference between traditional and certified seeds.

2 Participants are asked to form groups of around six people. Ideally this should include one group consisting only of men and another consisting only of women.

3 The groups first list the traditional crops they grow. Choosing the crop grown by most group members, the group considers:
- Where do they currently obtain their seed: saved on-farm or obtained elsewhere?
- Why do they use this source?
- If they do or were to save their own seed, what qualities would they use to choose the seed they selected?
- How would they balance competing needs, such as production qualities, eating qualities (taste, cooking qualities etc) and market demand?
- How would they process the seed they chose to store?
- How and where would they store the seed?
- If they were unable to store their own seed, or their seed became damaged during storage, where would they turn to for seed?

The group records their answers using either drawing or words on flip-chart paper.

4 The groups then reconvene in plenary and each presents their findings. The facilitator then leads a discussion:
- Did the different groups use different criteria to choose the seed they decided to save? Were there differences between the criteria used by men and women?
- Did men and women value different characteristics in a crop? What impact might this have on household food security and incomes?
- How are seeds processed and stored? What impact might this have on the crop?
- How could the farmer group help farmers to improve the quality of seed they saved?

APPENDIX 1
Some examples of traditional crops

Amaranth, also called pigweed or African spinach *(Amaranthus spp.)*, is an annual plant that grows to about 60 cm tall. It is cultivated as a traditional leafy green vegetable but also grows as a weed in fields. It is tolerant of high temperatures, drought and low soil fertility. The leaves are nutrient-rich with high levels of protein, vitamins A and C, and calcium, potassium and iron, but also have high levels of oxalic acid: amaranth should be cooked by boiling in water which should be discarded as oxalic acid can interfere with calcium uptake. The very small seeds can either be sown in a nursery bed or directly in the plot at a depth of 4 mm. Seed germinates in 4-6 days. Amaranth can be intercropped with maize, beans or other crops. Because the seeds are small and the tiny young plants not very vigorous, planting in a nursery bed and transplanting when the seedlings are 5-10 cm tall, after about 2 weeks, helps the crop compete more effectively with weeds. Harvesting of stem tips and tender leaves can begin when the plants are 15 cm tall. Leaves can also be dried and stored for later use. Removal of flowers can extend the cropping period. Amaranth produces large quantities of seed.

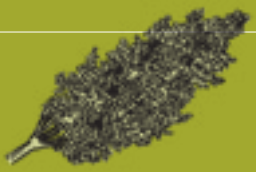
Black nightshade *(Solanum nigrum)* is grown as a leafy green vegetable but is also a common weed growing around fields. It is grown from seed as an annual crop, growing to around 60 cm tall. It does well in dry conditions and needs well-drained soils in full sun. The stem tips and tender leaves are picked and used as a green vegetable and are rich in iron, calcium and vitamins A and C.

Cowpea *(Vigna unguiculata)*, is a dual purpose crop: it can produce both edible greens and beans or it can be grown especially as a green vegetable. For a dual-purpose crop, seed is sown in rows 40 cm apart: leaves are harvested as needed until the plants touch and then every other row is harvested for greens, with the remaining rows left to produce cowpeas. Cowpeas are an excellent intercrop for maize; they help suppress weeds and, by fixing nitrogen, improve sol fertility. When grown just as a green vegetable, seed is sown twice as dense as for bean production. Cowpeas can be cut back to 20 cm tall, after which they will rapidly regrow, but if cut back to 5 cm regrowth will be much slower. Leaves can be cooked fresh or dried for later use.

Pumpkins *(Cucurbita maxima, Cucurbita pepo)* are large trailing plants, grown both for their large fruits and leaves. The large seeds are sown directly in the soil 2-5 cm deep, often on mounds. The leaves can be picked for several months. Leaves can be eaten fresh or dried and are good sources of protein, calcium, iron and vitamin C.

Finger millet *(Eleusine coracana)*, is grown for its small grain. It is an important food security crop: when intercropped with maize it can often produce a harvest in drier years when maize fails. The grains can be stored for long periods without experiencing damage from insects. It is tolerant of drought in the early stages and can grow in relatively dry areas, although it is not as drought-tolerant as sorghum. Finger millet is commonly cooked and eaten as porridge, made into bread or fermented into beer. The small grains make it laborious to harvest and difficult to mill. It is, however, highly nutritious, having a high level of the essential amino acid methionine (which is generally lacking in the diets of the resource-poor) and also has much higher levels of calcium, iron and phosphorus than maize. Its good nutritional qualities make it a good weaning food. It is usually grown by broadcasting onto fine seed beds. The main problem with growing finger millet is the difficulty of weeding: this is essential but some of the most common weeds are wild relatives of the crop and are very similar. It is also prone to attack by flocks of birds (quelea).

Sorghum *(Sorghum bicolor)* is a cereal that is well adapted to growing in drier areas with annual rainfall of between 500 and 700 mm per year: it can be successfully grown in areas which are too dry for maize. As well as being adapted to dry conditions it can also withstand periods of water-logging. Sorghum is milled and used in porridge, bread and fermented to make beer and is of similar nutritional value as maize.



Cassava *(Manihot esculenta)* is mainly grown for its tubers but the leaves can also be eaten as a green leafy vegetable. The leaves, however, must be cooked by boiling for at least 15 minutes to reduce a toxin, cyanide, to a safe level. The leaves are rich in protein and vitamin A. Leaves can be harvested from when the plants are established and harvesting can continue for several years.

APPENDIX 2
Advantages and disadvantages of intercropping

Advantages of intercropping:

- Some crops complement each other in various ways so that the combination of the intercrops is more efficient than either grown as a sole crop – the total yield will be higher:
  - Their periods of peak demands for light, water, nutrients and other resources may differ. For example, during the 2-3 months that yams take to sprout and establish, an intercrop of maize or melon would use these resources without adversely affecting the yams
  - Different crops may utilize different resources. For example, an intercrop of deep-rooted and shallow-rooted crops can exploit nutrients at different depths in the soil
  - An intercrop may be able to use a resource which the main crop can not. For example, the shade tolerant crop tania (cocoyam) growing under a canopy of oil palm can utilize the light passing through the canopy, which otherwise would have been wasted
  - Certain crops may exert beneficial effects on others. For example, plantains intercropped with young cocoa seedlings provide shade for the delicate seedlings.When legumes are intercropped with a cereal crop, the cereal benefits from the nitrogen fixed by the legume.
- Growing more than one crop at the same time reduces the risk of total crop failure; if one crop fails, the other might still produce a harvest
- Growing more than one crop means that demand for labour is better distributed throughout the year
- Spread of pests and diseases can be reduced: the intercrop acts as a physical barrier
- Intercrops can help ensure presence of beneficial micro-organisms in the soil
- Some intercrops, such as the dual-purpose crop lablab (Dolichos lablab), can break through a hardpan (a layer of hard subsoil or clay often caused by hoeing or ploughing at a constant depth), which otherwise would prevent downward movement of water into the soil and limit root growth
- Intercropping with cover crops prevents direct impact of rains on the soil, reducing soil capping/crusting which impede seed germination and increase runoff and erosion.

Disadvantages

- It is more difficult to tailor management practices to the different needs of more than one crop. For example, a pesticide which could usefully be applied to one crop to overcome a pest problem may damage the intercrop. Applying pesticide to both crops when just one requires it is wasteful. However, it must be stressed that inter-cropping itself has potential to reduce the need to employ pesticides, as described throughout the chapter. This is especially the case in systems purposefully designed to support ecological management of pests, such as push-pull inter-cropping systems. These are intercropping systems where "push" crops are planted alongside the main crop, to repel pests, and direct them towards "pull" crops, plants that are more attractive to them but also that do not allow them to thrive. **(See Module 8 "Agrobiodiversity, natural pest control and pollination services").**
- It is also more difficult to mechanize production and therefore requires a significant amount of manual labour. Often, however, small-scale farmers in Kenya cannot afford to mechanize their farm operations.

Season-long trial

Effects of intercropping cereal and grain legumes on household food security

Introduction

The planting of one single crop in a field is often promoted in various extension activities as a panacea to food security. However, in many situations intercropping could be more appropriate. This trial allows farmers to compare the two systems and come to their own conclusions

Objectives

To examine the benefits of intercropping vs. mono-cropping and explore various intercropping combinations

Materials required:

- Seeds for the selected crops
- Fertilizer or manure (depending on the group's decision)
- Farm implements
- Sisal twine
- Pesticides (depending on the group's decision)
- Note book and pens

Steps

1 The facilitator reminds participants what is meant by mono-cropping and intercropping and leads a discussion of experiences farmers have had with both systems.

2 The group selects a major cereal or other staple crop (1st crop) and two other crops such as legumes and/or leafy vegetables (2nd and 3rd crop) to be included in the trial.

3 The group next selects a field and prepares the land for planting as they normally would. The prepared land is then divided into four equal plots, each as similar as possible in terms of soil type, slope, shade from trees etc.

4 The plots are sown using the recommended spacing so that:
- plot 1 contains the staple crop grown as a mono-crop
- plot 2 contains the 2nd crop grown as a mono-crop
- plot 3 contains the staple and 2nd crop grown intercropped
- plot 4 contains the staple and 3rd crop grown intercropped.

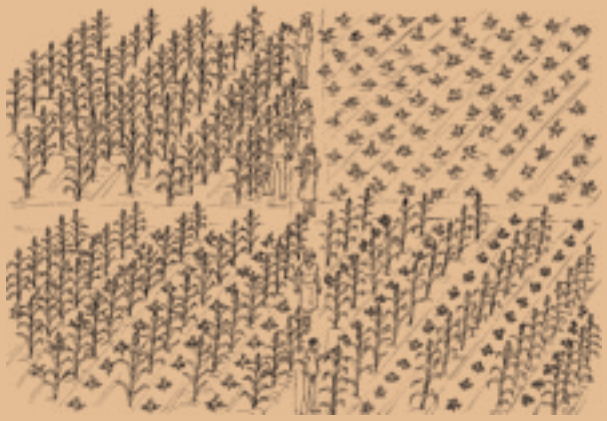
See diagram.

5 The facilitator leads a group discussion as to which parameters should be monitored and at what intervals. Some will likely be monitored regularly, i.e. Agro-Ecosystem Analysis (AESA), and others just at the end of the trial.

6 At regular intervals monitor and record the 'regular' parameters.

7 At end of the season evaluate the trials according to the defined 'end of trial' parameters.

Example of plot layout



Example of data collection parameters

Regular parameters	End of trial parameters
AESA	**Harvesting**
Planting date	Yield per unit area & Land Equivalent Ratio calculation (exclude guard rows)
Flowering date	
Maturity date	**Economic returns**
Emergence date/germination	Cost of labour, inputs, value of output per plot (both cereals & legumes)
Growth rates on weekly basis	
Plant height	**Nutritional value**
Pests /diseases (identify & count, population, etc.)	Nutrient content of the crop and variety of nutrients against recommended daily intake
Soil moisture	
Weed incidences	

How to compare yields using Land Equivalent Ratio (LER)

LER is the sum of the fractions of the yields of the intercrops relative to their sole crop yields under the same area.
For example, if:
Yield of sorghum as a mono-crop (plot 1) = 2 tonnes per hectare
Yield of cowpeas as a mono-crop (plot 2) = 0.5 tonnes per hectare
Yield of sorghum & cowpeas as intercrop (plot 3) = 1.5 tonnes sorghum + 0.25 tonnes cowpeas
Then, the LER is the sum of:
Sorghum yield as intercrop (1.5) + cowpea yield as intercrop (0.25) = 0.75 + 0.5 = 1.25
Sorghum yield as mono-crop (2.0) cowpea yield as mono-crop (0.5)
If LER is more than 1 (as in this example), then intercropping gives a better total yield than mono-cropping; if LER is less than 1, mono-cropping gives a better yield; and if LER is equal to 1, mono-cropping and intercropping give the same yield.

At the end of the trial the facilitator should lead a discussion

- What do the results and findings of the trials show?
- What are the benefits of mono-cropping vs. intercropping, considering aspects such as: food security, ease of cultivation, weeding etc., quantity of harvest, quality of harvest, access and duration of harvest
- How may intercropping vs. mono-cropping benefit various groups in the household differently, i.e. men, women, children? Are there benefits or drawbacks for sick people, people living with HIV and AIDS, or other vulnerable groups?
- Are there considerations related to the labour input in the various systems, i.e. considering who does various farming tasks and gender roles? Does this have implications for the potential adoption of the systems?
- What are the different options for utilizing and/or adding value to produce from the trial?

MODULE 3
utilization and nutritional value of traditional crops

This module builds on Module 2**, crop diversity and food security**, which deals with production of traditional food crops.

This module:

- **Emphasizes the importance of traditional crops**
- **Considers the impact of changing eating habits**
- **Describes the importance of balanced diets and reviews good food sources of the different nutrients the body requires**
- **Advises on the safe use of traditional foods**
- **Describes the role of home gardens in supporting food security and nutrition**
- **Explains the link between crop diversification and nutrition**
- **Provides some information on cooking traditional foods**

Introduction

Over the past decades, global trends such as globalization, economic development, population increase and urbanization have deeply changed patterns of food production and consumption – and, with these, people's diets. The increased availability and affordability of a wider range of foods has improved, overall, dietary diversity around the globe, and contributed in many cases to reducing the occurrence of chronic nutritional deficiencies. However, at the same time, foods that are highly processed, packaged, and rich in potentially unhealthy nutrients – saturated fats, sugar, salt – have also become widespread, and widely consumed. Their appeal comes from various factors: they often come ready to consume or are easier to prepare, and they are often relatively cheap to purchase.

Diets low in variety but high in energy, together with increasingly sedentary lifestyles, contribute to escalating problems of malnutrition – obesity, undernutrition and micronutrient deficiencies – and chronic diseases such as heart disease and diabetes.
Research has shown over the years that countries, communities or cultural groups that maintain their own traditional food systems and habits may be better able to conserve local food specialties, and the corresponding diversity of crops and animal breeds. In addition, they are also more likely to show a lower prevalence of diet-related diseases.

The importance of traditional crops

In recent decades, many Kenyans have stopped growing and eating traditional food crops in favour of those introduced from outside the region, such as maize. Although these introduced crops can perform well in high-potential areas, especially when improved and hybrid varieties are grown with the use of chemical fertilizers and pesticides, they are not well adapted to growing in large areas of Kenya's agricultural land, which can be categorized as arid and semi-arid lands or in low- and zero-input systems (that is when external inputs such as pesticides and chemical fertilizers are used sparsely, or are not used at all). This has resulted in a decline in agricultural production in these areas: crop failure in growing seasons with poor rainfall is

common and many farming households are now food insecure, often having to rely on distribution of relief food.

Traditional crops are a significant part of Kenya's agrobiodiversity. But what are traditional crops?

Traditional crops are crops that have been grown for a long time by local communities and that are well adapted to the local agro-climatic conditions. Many traditional crops are more 'drought tolerant' than modern crops and varieties.

Some examples of traditional food crops include: sorghum, millets, cassava, pigeon peas, cow peas, green grams, sweet potatoes, arrow root, green leafy vegetables (such as amaranth, pumpkin leaves, cowpea leaves), wild edible mushrooms and local fruits (guava, loquat and other wild fruits).

Traditional crops have several important advantages over modern crops.
They are:

- locally available
- in some cases, available even during 'lean' periods
- drought tolerant
- cheap and easy to grow
- highly nutritious
- disease and pest tolerant
- easier to source (higher accessibility of seeds)
- adapted to local conditions, and may thus reduce risks of crop failure.

When combined together properly, different traditional food crops can provide a balanced diet which contains enough energy and protein as well as essential vitamins and minerals, also called micronutrients, to sustain life and maintain good health.

Traditional crops also represent an important genetic resource that could be used by plant breeders to produce improved varieties of crops in the future, such as drought-tolerant varieties of sweet potatoes. The use of portfolios of traditional crop varieties is important to reduce risks of crop failure, in a context of unpredictable rainfall.

Changing eating habits

Many Kenyans have stopped growing and eating traditional crops in favour of maize because of:

- laborious processing methods associated with many traditional crops
- negative attitudes: traditional foods are commonly regarded as 'food for poor people' and regarded as 'backward'

- lack of convenience foods and snacks based on traditional foods, unlike for the introduced foods - such as roast maize
- loss of knowledge on methods for their preparation and attractive recipes using traditional foods.

Exercise **Changes in eating habits**

Learning objective	Timing	Preparations by group	Time	Materials
To illustrate changes in eating habits over time and their consequences	Any time	Volunteers to carry out interviews ahead of the next training session	2 hours for interviews 1 hour to prepare drawings. At next FFS meeting, 2 hours to present and discuss findings	Marker pens, flip-chart paper

Steps

1 Some of the group members are asked to volunteer and to form pairs. Each pair identifies an elderly person in their community.

2 The elderly person is visited and asked to describe the crops grown and foods eaten when they were young: what was the staple, what types and variety of fruit and vegetable were eaten, what wild foods were eaten, what livestock foods were eaten, how did the foods eaten vary throughout the year, when were the hunger seasons?

3 Can the elderly interviewees remember when new crops and foods were introduced to this area? What crops/foods were introduced and when (either as a date or in comparison to a key event)? Were they quickly adopted? Why did people adopt them?

4 Each pair produces a drawing of a typical, traditional main meal of the past, as described by the elderly person and for each food item a drawing showing where it came from, for example collected from the wild, grown on shamba, purchased etc. The drawing is labelled with the date it is depicting and the name of the interviewee.

5 At the next training session, the facilitator asks members to describe a typical main meal today: what different foods are combined to produce the meal? A volunteer draws the typical meal on a sheet of flip-chart paper.

6 Next, the pairs report back their findings from the interview they carried out with the elderly person. If possible, some of the elderly interviewees could be invited to attend the training session.

7 A facilitated group discussion follows:

- What differences are there in the foods eaten today and in the past?
- Why have these changes occurred?
- What effect have these differences had on food and nutritional security, farming practices, cooking methods, health, agrobiodiversity?
- Are there foods grown in the past that could be considered for reintroduction today? What constraints are there to re-introducing these foods? How can the FFS help overcome these?

Impact of declining use of traditional food

The declining use of traditional foods has led to a decline in agrobiodiversity through:

- disappearance of some well-adapted local varieties/cultivars of crop and breeds of livestock (See Module 4 "Livestock and agrobiodiversity")
- loss of some species of local wild animals and plants
- loss of knowledge and skills about traditional crops, wild plants and foods
- loss of culture in relation to preparation and utilization of these foods, for example their use in celebrations and festivities.

This decline in use of traditional foods has also contributed to:

- worsening food and nutritional security, especially in drought-prone areas
- increased vulnerability to malnutrition, including micronutrient deficiencies, resulting from changing food supply and poorer, less varied diets
- increased dependency on inputs, for example purchases of hybrid maize seeds, pesticides and fertilizers.

Wider use of traditional foods can be promoted by:

- increasing awareness of their benefits through information and communication within rural communities
- ensuring better access to quality seeds of traditional crops
- developing and promoting convenience foods made from traditional crops foods through supermarkets, roadside restaurants, hawkers and kiosks
- developing and promoting snack foods based on them, such as biscuits and cakes
- including traditional foods regularly in restaurant menus, school, worksite, hospital and other institutional catering programmes
- developing adequate methods to reduce laborious processing work associated with many traditional crops.

This will help to improve demand, encourage more wide-scale production and processing and reverse the negative image of traditional foods. This in turn will improve food security, increase farmers' incomes, enable sustainable conservation of these potentially valuable genetic resources and enhance agrobiodiversity.

The importance of nutrition

Nutrition is both a science and a field of practical action. It refers to the different types of food, the nutrients they contain and the roles they play in child growth, maintenance of health and normal bodily functions. In this broader context, nutrition is concerned with how food is produced, processed, distributed, prepared and consumed; and also how it is digested, absorbed and used by the body after being consumed.

Nutrients are the components obtained from food that are used to meet the body's needs. If people do not receive all the energy and nutrients they need, they will become malnourished, their immune systems will become weak and they can fall sick and die. Small children are especially vulnerable to malnutrition and infectious diseases as their nutritional needs for growth and proper mental development are very high relative to their size and body weight.

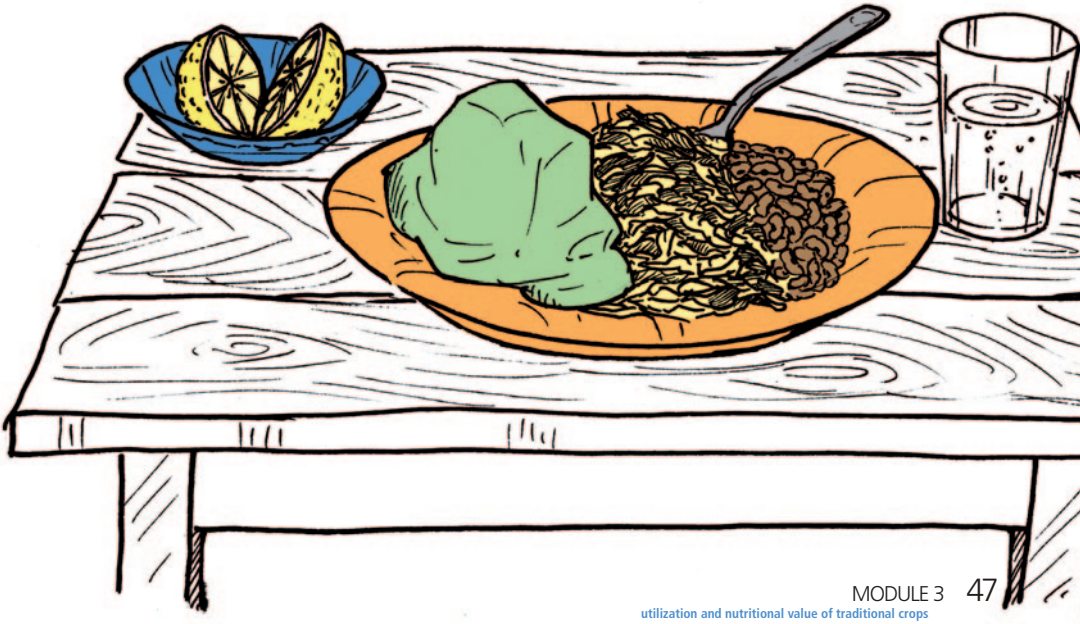
Foods can be simply classified according to the main type of nutrients they contain. These include:

- carbohydrates, fats and oils: *'energy giving foods'*
- proteins: *'body building foods'*
- vitamins and minerals: *'protective foods'*.

Balanced diets are those made up of a variety of foods that together provide sufficient quantity and quality of energy, building and protective nutrients to maintain good health. Biodiversity in agricultural systems (agro-biodiversity) is essential to sustain diverse, healthy diets.

Biodiversity and nutrition

Biodiversity is key to ensure dietary diversity, which in turn is a cornerstone of good nutrition and health. Nutrient composition between foods, but also among varieties/cultivars/breeds of the same food can differ dramatically. For example, sweet potatoes cultivars can differ by a factor of 200 or more in their content of carotenoid – a group of micronutrient that has in some cases been associated with beneficial health effects, and that is responsible for the yellow/orange color in some fruits and vegetables such as apricots and carrots; protein content of rice can range from 5 to 14 percent of the weight depending on the variety; carotenoid content of bananas can be less than 1 µg/100 g for some cultivars to as high as 8,500 µg /100 g for other cultivars. Intake of one variety rather than another can make the difference between micronutrient deficiency and micronutrient adequacy.



Link between crop diversification and nutrition

For people living in rural areas, the major source of family food is often their farms. If a variety of crops, including traditional crops, are grown this will help to achieve food and nutritional security: that is sufficient quantity and quality of food available year-round to provide the energy and essential nutrients needed for child growth and development and to sustain life and maintain good health.

Importance of crop diversification

Producing and eating a variety of foodstuffs, including traditional foods:

- provides a wider variety of the required nutrients for family members
- improves household food security
- improves cropping systems: for example, growing traditional crops as mixed/intercrops (see Module 2 "Crop diversity and food security")
- reduces risk of crop failure by growing more drought-tolerant crops
- enhances sustainability and conserves local agrobiodiversity.

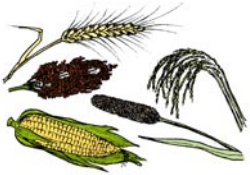
Every meal should contain a variety of different foods.

Food categories

For normal functioning of the body, it is necessary to eat a wide range of foods, to ensure a healthy, balanced diet containing all the essential nutrients.

Staple foods, such as cassava, sorghum, sweet potatoes, pulses, banana, millet and arrow root, provide energy and some protein requirements but are often deficient in micronutrients, such as vitamins and minerals. These other nutrients can be provided by other traditional foods, such as legumes, some meat/fish, poultry and dairy products, if affordable, as well as green leafy vegetables, which should be eaten alongside the staple foods (see table below and Appendix 1). A piece of fruit – particularly citrus fruits, rich in Vitamin C, and Vitamin A-rich, orange-coloured ones, such as apricots and peaches – should be eaten after each meal to enhance the absorption of iron from different foods. Tea or coffee should be avoided immediately after a meal as it reduces iron absorption from foods.

Major food categories

Type of food and main nutrients	Examples of foods	
Cereals for energy, protein and some vitamins	maize, sorghum, millet, wheat, rice	
Starchy roots/tubers for energy	sweet potatoes, cassava, arrow root, yam, Irish potatoes	
Legumes for protein, some fat, vitamins and minerals	beans, peas, pigeon peas, cow peas, green grams, amaranth seed flour, groundnuts	
Vegetables for vitamins and minerals	cassava leaves, sweet potato leaves, black night shade, kale, cabbage, spinach, cow pea leaves, amaranth	
Animal products for protein, vitamins and minerals	Milk and milk products, eggs, fish, meat, insects	
Oils and fats for energy. Some oils are also essential for maintenance of good health	Cooking oil, shortening, butter, ghee, avocadoes, fatty meat, yoghurts, cheese	
Sugars for energy and to add flavour to food, but not essential in the diet – and too much can be harmful	Sugar, cakes, sweets, biscuits	

Exercise **Nutrients, their functions and sources**

Learning objective	Timing	Materials
By the end of the session, participants will be able to: 1 Explain what is meant by nutrition, nutrients and balanced diets 2 Describe different nutrients in foods, their source and functions	1 hour	Flip chart paper, marker pens, local materials representing various forms of foods for role play

Steps

1 Four volunteers are each allocated a role to act out: each is given the symptoms of a different nutritional deficiency disease:
- Actor 1 is scratching all over his/her body
- Actor 2 passes by with a protruding stomach and red/brown hair
- Actor 2 meets Actor 3 (Vitamin A deficiency) who is looking for a lost marble but has difficulties seeing in the dusk. Actor 2 locates the marble without difficulty. Actor 3 thanks Actor 2 and tells him/her about his difficulties in seeing at night.
- Actor 4 arrives and is offered an orange by Actor 2 but complains about sores in the mouth.

2 In plenary, participants brainstorm on;
- what have they seen?
- what were the different actors suffering from? How might their conditions be related to their diets? [it is not necessary to define the exact deficiency condition, but rather to recognize that conditions like these can be caused by poor diets that lack essential nutrients].
- why it is important to eat different types of food as part of a balanced diet?
- how can typical local meals be improved so they provide a more balanced diet, including essential vitamins and minerals? What implications does this have for the types and variety of crops grown?

3 The facilitator leads a discussion on various types of food nutrients, their sources and how to produce balanced meals - without spending large amounts of money.

Cooking and preserving foods

When planning and preparing meals, it is important to ensure that they meet individual's nutritional needs. Special consideration should be given in meal planning to small children and pregnant and lactating mothers, as well as sick people.

To avoid food poisoning, foods should be prepared and served under very hygienic conditions. Remember to:

- keep yourself clean (wash your hands with soap and water before food preparation)
- keep the food clean
- keep equipment and dishes clean
- keep the cooking and eating area clean
- store foods safely
- reheat left over food to boiling point before eating.

Cooking makes food safer to eat by using heat to destroy germs and parasites. Some foods, such as some vegetables and fruits, are best eaten raw or lightly cooked as this maintains the maximum nutritive value. But other foods, such as cassava tuber and some beans, must always be cooked as they are poisonous when raw.

Some foodstuffs can be preserved when there is surplus for use during lean times. Methods to preserve foods include:

- Traditional methods, for example drying, smoking and preserving in sugar, vegetable oils or vinegar (e.g. to make into jams and chutneys)
- Modern methods, such as pasteurisation, vacuum packing and addition of artificial food additives.

Be careful: some traditional leafy vegetables can be poisonous!

One of the reasons that traditional leafy vegetables have become less popular, especially amongst younger people, is that some can taste rather bitter and they may also be tough and stringy. In addition, some contain naturally occurring substances that can be poisonous and so care needs to be taken, especially when experimenting with vegetables that have not been grown in the area before or which have been neglected for a long time.

Farmers and those responsible for cooking the family meal are likely to already be aware that some foods can be dangerous unless prepared and cooked properly. Many types of bean, for example, need to be soaked, have the water drained off and replaced and to be boiled for at least 10 minutes to make them safe to eat.

One simple precaution is not to eat too much of any one foodstuff: in any case, a variety of different foods is more advisable than eating a lot of just a few foodstuffs.

For many of the large number of traditional leafy vegetables that are eaten in various parts of Kenya, formal scientific studies to determine their safety have not been undertaken. However, a very useful way of finding out which foods can be poisonous and how to deal with this is to ask elderly people, especially elderly women, who are members of the local community.
For many traditional leafy vegetables, there are long-established traditional ways of treating and cooking them to reduce bitterness, make them more tender and to deal safely with any potentially poisonous substances: for example, some are soaked in several changes of water; others are boiled and the water discarded; for others special substances are added to the cooking water. So, before trying unfamiliar traditional vegetables, seek local advice. This illustrates how important it is to keep alive indigenous knowledge about traditional vegetables in addition to conserving the vegetables themselves: without knowledge of how to grow, harvest, store, process and cook them, the vegetables are of little use!

Exercise **Preparing traditional foods**

Learning objective	Timing	Materials
By the end of the session, participants will be able to: 1 Explain the various methods of preparing and utilizing traditional foods 2 Prepare and present traditional dishes	4 hours (2 sessions)	Flip chart paper, marker pens, ingredients for the various food items, required utensils

Steps

1 The facilitator introduces the session and learning objectives.

2 In small groups, participants discuss different methods of food preparation using locally available traditional foods. The findings are written or drawn on flip-chart paper.

3 Each group presents the various preparation methods in plenary and the facilitator leads a discussion on various ways of utilizing traditional foods.

4 In their small groups, participants decide on one recipe based on traditional foods which they will jointly prepare and bring the dish to the next session. [If they do not know what dish to cook they could ask elderly women from their community for suggestions: what traditional dishes did the elderly person used to cook when they were younger; what were the ingredients and how did they prepare and cook them?]

5 In plenary, participants agree on a set of criteria on which to judge the various dishes: this might include taste, ease of preparation and cooking time, nutritional value, appearance, availability of ingredients, cost, amongst others.

6 At the start of the next session, each group describes and presents their dishes and explains what they contain and how they were prepared: how did this compare to the food they usually cook?

7 All participants taste each dish and vote on the winner, based on the previously agreed criteria.

8 The facilitator leads a discussion:

- Which dishes were most popular and which ones least popular? Why was this?
- Will participants now cook any of these dishes at home?
- If so, which ones and why? If not, why not?

Role of home gardens

Kitchen or home gardens are small, intensively-managed plots, usually located near to the homestead, on which a wide variety of vegetables, including traditional and modern vegetables, fruits, medicinal plants, edible herbs and spices, some staple foods and perhaps also some shade and ornamental plants are grown. Home gardens can therefore increase the diversity of crops grown, make an important contribution towards household food and nutritional security, provide a more pleasant environment in which to live and enhance agrobiodiversity.

Home gardens are often tended primarily by women: often most of the production is used for household consumption, thereby directly benefiting the family. Because kitchen gardens are situated close to the home, they tend to be looked after with more care than fields further away: they are more likely to be fertilized with manure from livestock, which are usually kept near the home, or with home-made compost, and may even be watered, thereby further boosting year-round production and yields.

Traditional crops grown might include: *Amaranthus*, *Solanum indicum ssp*, *Solanum nigrum* (black nightshade), cowpeas, pumpkins and cassava, amongst many others **(see Appendix 1)**.

Where urban markets are accessible, introduced crops such as cabbages, tomatoes and carrots are also often grown for sale. Since women often manage home gardens and control the income generated, this can make a significant contribution to household economies, providing an important source of cash for household essentials.

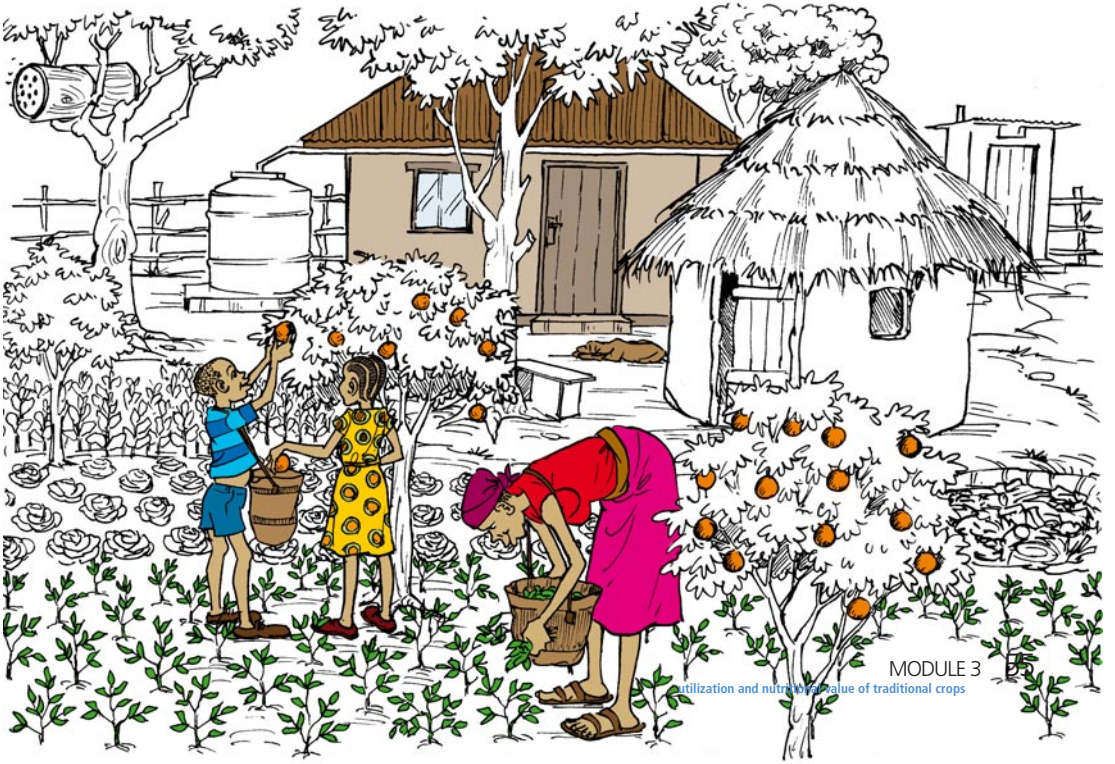
Kitchen gardeners often practice intercropping and, especially during the rainy season, 'volunteer' crops can appear – that is useful plants, such as leafy green vegetables, that self-seed. Some home gardens may be intended to supplement the household's income, and as such they may be more commercially-oriented, producing crops for local markets and sourcing seeds and other inputs from commercial sources. However, most home gardens are usually designed and managed to supplement the household's food supply, and increase access to fresh produce year-round. In this latter case, production is usually organic and environmentally friendly, with little or no use of pesticides or chemical fertilizers, using locally available seeds and home-made compost.

The value of kitchen gardens, especially ones that include traditional vegetables, has often been overlooked by extension workers in favor of a recent focus on exotic vegetables grown for domestic and export markets, such as French beans. Kitchen gardens, however, can make an important contribution to the food and nutritional security of resource-poor families, without the need for bought-in inputs, such as certified seeds and pesticides. Currently most Kenyans, and especially the poor, do not eat enough vegetables and fruit and so their diets are lacking in essential vitamins, minerals and protein. Kitchen gardens provide an especially useful source of nutrient-rich foods

for weaning-age children, pregnant and nursing mothers, the sick (including people living with HIV and AIDS) and the elderly. For example, traditional green leafy vegetables are rich in nutrients and are well adapted to local conditions. They are often 'short season' and can be productive during the dry season, helping to provide food even during the 'hungry season'.

Much of the information and knowledge regarding production and utilization of traditional vegetables is at risk. As traditional vegetables are phased out in favor of exotic ones, and with loss of knowledge transfer between generations due for example to migration, or the death of parents from HIV and AIDS or malaria, there is a danger that this knowledge will also be lost. With the loss of indigenous knowledge on traditional crops, there is also the risk that useful local varieties are permanently lost, and with them that potentially valuable plant genetic resources will also disappear – genetic resources that could have been extremely useful to plant breeders in the future.

In recognition of this, numerous efforts have been made over the years by international and national organizations, in Kenya as elsewhere, to study, document, and appreciate the value of traditional varieties for food security and nutrition, and to protect them and the associated knowledge from extinction. Kitchen gardens in which a variety of traditional vegetables are grown are an example of a production system that can make important and valuable contributions at the household, national and global levels, improving food security and contributing to on farm conservation of agrobiodiversity (that is conservation in the original site where the crops are found).



Exercise **Mapping a home garden and improving its design to support nutrition**

Learning objective	Timing	Materials
By the end of the session, participants will be able to: 1 Appreciate the role of home gardens in supporting nutrition and food security 2 Design a home garden to maximize its benefits to the households' nutrition	1hr 30 minutes	Flip chart paper, marker pens, masking tape, cards

Steps

1 Introduce the session and learning objectives.

2 In plenary, participants brainstorm on the types of foods found in their home gardens (if they have any), and identify the ones they consider to be 'traditional foods'. The foods are drawn/written on the cards.

3 In small groups, participants assess the benefits of maintaining home gardens and utilizing traditional foods in relation to food security and nutrition.

4 In their small groups, participants discuss how the design of their home gardens can be maximized to ensure optimal benefits for food security and nutrition:

- Which crops do they consider essential to supplement the household's food supply? Do they vary by season?
- How many crops, and different varieties, will they be able to plant, considering the average size of home gardens in the area?
- What is the best combination of crops to achieve maximum benefits to the household in terms of nutrition and food security, within such space?

Their answers are written on a flip chart paper sheet. On a second paper sheet, participants make a drawing of the ideal home gardens, and identify the different crops that are grown there using cards.

5 The groups make presentations in plenary and the facilitator leads a discussion on the value of home gardens to maintain and promote the use of traditional foods; and the importance of this for their households' food security and nutrition.

Glossary

Blood clotting

Blood clotting, or coagulation, is the process through which the body forms a clot over an injury occurring in a blood vessel, to naturally prevent excessive blood loss. After the injury is repaired, the clot is normally dissolved. However, there are some instances in which this does not occur, or in which a clot forms without any injury occurring in blood vessels – this is a dangerous situation as it can disrupt blood circulation within the body's veins and arteries, and lead to conditions that are potentially fatal – such as deep vein thrombosis and pulmonary embolism. Several health conditions that are closely related to one's diet – including obesity, diabetes, high cholesterol and blood pressure levels, are considered major risk factors for the development of these problems.

Carbohydrates

Carbohydrates are one of the three key macronutrients essential for the correct functioning and survival of living organisms. Their primary function is to supply energy to the body, including to the brain and nervous system. Carbohydrates can be categorized as simple and complex. Simple carbohydrates are small molecules that are broken down easily and quickly by the body, releasing energy rapidly, and increasing the level of sugar present in the blood. Examples include table sugar, honey and fruits. Complex carbohydrates are absorbed more slowly by the body, and as a result they release energy more steadily and over longer periods of time. Because of this, they increase blood sugar less, and are less likely to be stored in the body as fat reserves. Examples of foods containing complex carbohydrates include grains, beans, and root vegetables.

Carotenoids

Carotenoids are chemical compounds created by plants that act as pigments, and are responsible for the bright orange, red and yellow colors present in several fruits and vegetables, such as apricots, carrots, papayas and lemons. Besides the benefit to plant health, some carotenoids (such as beta-carotene) absorbed through diet have been in some instances linked by research to health benefits, such as decreased risk for certain disease types, and protective effects on eye and skin health.

Chronic disease

Several conditions are referred to as chronic, or non-communicable diseases, depending on the definition used. Generally speaking, chronic diseases are long-standing illnesses that cannot be prevented or cured with medication. Several risk factors that increase the likelihood of occurrence of some chronic diseases – such as cardiovascular disease and certain types of cancer – are linked with diet. These include for example overweight and obesity, high blood pressure and low fruit and vegetable intake.

Fats

Fats are one of the three key macronutrients essential for the correct functioning and survival of living organisms. Their main function is to supply energy to the body. Fats are the slowest form of energy – slower than both simple and complex carbohydrates – and also the most efficient energy source, due to the higher density of energy they contain per gram. Because of its efficiency as an energy source, the body stores any excess energy in the form of fat. There are three types of fats. Mono and polyunsaturated fats, which mostly derive from plant sources; and saturated fats, which mainly derive from animal foods and pose greater health risks to humans, as they increase cholesterol levels and the risk of atherosclerosis – the

accumulation of fats within the inner walls of the arteries – a condition conducive for example to stroke and coronary heart disease.

Immune system

The immune system includes organs (such as bone marrow and lymph nodes) and processes of the body that protect the body by ensuring resistance to toxins and infections.

Infectious disease

Infectious, or communicable diseases are those that are caused by pathogens such as bacteria, viruses, fungi and parasites, and that can spread from one person to another. Examples include tuberculosis, malaria and measles. The emergence of some infectious diseases can be prevented through vaccination, and treated with specific medications.

Metabolic rate

The rate at which metabolism – the sum of chemical processes that take place within organisms, and that are essential to their functioning and survival – occurs. Metabolism includes for example the processes through which the body synthesizes proteins, to use them to build and repair tissues; and those through which it breakdowns substances to use them as energy.

Minerals

Minerals are nutrients that are essential to, but that cannot be synthesized by, living organisms. Humans absorb most of the minerals essential for their health through diet, from plant sources and by drinking water. Examples of minerals essential to our body include calcium and iron. Calcium, among other functions, helps maintaining healthy bones and teeth, and can be found in foods such as dairy products and some green leafy vegetables. Iron is essential to the circulation of oxygen around the body, and is found in both animal and plant food sources, such as liver, read meat, eggs, pulses and nuts. The form of iron found in animal sources (haem iron) is the one that is most easily and readily absorbed by our organism. Absorption of iron from plant food sources (non-haem iron) is instead affected by various other compounds found in such foods, which can reduce absorption. The consumption of Vitamin C-rich foods (for example citrus fruits) or meat together with such plant food sources facilitates the absorption of non-haem iron.

Nutrient

Nutrients are substances that are essential to organisms to carry out basic life functions – such as surviving, growing and reproducing. Among so-called macronutrients, which supply energy to the organism, three groups are key – carbohydrates, fats and proteins (see separate definitions in the glossary). In addition to macronutrients, micronutrients – including dietary minerals such as iron and salts, and vitamins – are also essential for correct functioning, growth and development of organisms.

Protein

Proteins are one of the three key macronutrients essential for the correct functioning and survival of living organisms. Their main function is to build and repair body tissues and structures.

Vitamins

Vitamins are nutrients that are essential to the organism, in limited quantities, but that the organism itself cannot produce in sufficient amounts and must thus acquire from dietary sources. At present, 13 vitamins are recognized, each providing a range of beneficial effects to the human body. For example, Vitamin C, which is found in foods such as citrus fruits, tomatoes and papaya, supports the health of the immune system, and facilitates the absorption of iron.

APPENDIX 1
Nutrients, sources, their functions and deficiency disorders

Nutrients	Sources	Function in body	Effect of deficiency
Carbohydrates	Cereals: maize, SORGHUM*, MILLET, rice, wheat Tubers: CASSAVA, SWEET POTATO, Irish potato, YAMS, ARROW ROOTS	Provide energy and heat for bodily functions and growth Add bulk to the diet	**General emaciation and wasting**
Fats and oils	Animal origin: milk and milk products, fatty meat Plant origin: vegetable oils (e.g. coconut oil, sunflower oil), margarine, shortening	Provide energy and heat Some oils are essential for maintenance of good health and absorption of some vitamins	**Skin and cognitive problems, vision issues**
Proteins	Animal origin: Meat, fish, eggs, milk and milk products Plant origin: pulses, nuts e.g. GREEN GRAMS, SIM SIM, COWPEAS, soya beans, ground nuts and cashew nuts; SORGHUM, MILLET, rice, wheat	Essential for growth, structure and functions of all cells in the body	**Kwashiorkor: stunted under-weight children**
Vitamins			
Vitamin A	Animal origin: liver, meat, fish Plant origin; PAWPAW, carrots, mangoes; AMARANTH; BEAN LEAVES; PUMPKIN LEAVES (in general: red- and orange coloured fruits; green leafy vegetables)	Strengthens the immune system; normal eye functioning and vision in dim light; healthy skin;	**Susceptibility to infectious diseases** **Night blindness and permanent blindness** **Skin roughening**
Thiamine (B1)	Whole grain, nuts, SORGHUM, MILLET, legumes, milk, poultry, fish	Assists in utilization of carbohydrates and release of energy	**Beriberi: pain, paralysis and swelling of legs and arms**
Riboflavin (B2)	Green leafy vegetables, meat, eggs, milk	Assists in utilization of carbohydrates and release of energy	**Sores at corner of mouth**
Niacin	Meat and meat products, fish, eggs, fresh peas		**Pellagra: itching and scaly skin; diarrhoea and dementia**
Vitamin B6	Yeast, liver, pulses, cereals	Essential for growth of all young animals	**Nervousness, irritability, insomnia, muscle weakness, and difficulty in walking**

Vitamins

Vitamin B12	Liver, meat, fish, milk, eggs	Functioning of cells	**Pernicious anaemia**
Vitamin C	Citrus fruits (e.g. oranges, lemons), tomatoes, green leafy vegetables, potatoes	Formation and maintenance of healthy of skin and bones	**Scurvy: swollen, bleeding and ulcerated gums, loose teeth, weak bones and teeth (in infants), bleeding beneath skin**
Vitamin D	Eggs and milk Sunlight	Absorption of calcium from food Formation of bones	**Rickets**
Vitamin K	Green vegetables and cereals	Normal clotting of blood	**Slow blood clotting in infants**

Minerals

Iron	Animal origin: meat, blood, fish Plant origin: cereals, starchy roots, green/yellow vegetables, COWPEAS, pulses	Component of haemoglobin: transportation of oxygen around body; supports brain development and functioning	**Anaemia resulting in poor child development and learning; decreased physical activity and productivity in adults**
Calcium	Animal origin: milk, eggs, fish Plant origin: MILLET, tubers, pulses and vegetables	Formation of bones and teeth	**Weal bones** **Rickets**
Iodine	Animal origin: sea foods Plant origin: cereals, legumes Iodized table salt	Helps controls body's metabolic rate	**Goitre** (swelling of the thyroid gland in the neck) **In children: poor child development; cretinism**
Fluorine	Sea foods, tea and water	Prevents dental decay	**Discolouration of teeth due to excess intake, primarily due to high levels in water**

***Foodstuffs shown in CAPITALS are traditional foods**

NB: As you can see from this table, most foods contain mixtures of nutrients. For example, while cereals are a very good source of energy, they are also an important source of protein and B vitamins. Milk and meat contain a lot of protein, but they are also a source of fat, while most nuts and oilseeds are rich in both energy and fat. In order to stay healthy or recover quickly from illnesses, people need to eat a balanced diet every day, containing a variety of foods, including: cereals, roots and tubers; pulses/oilseeds and meat/poultry/fish/milk; vegetables and fruits.

APPENDIX 2
Recipes based on traditional food crops

Sorghum and Millet recipes

Whole sorghum irio/githeri

Ingredients	
De-hulled sorghum	1 cup
Small onion	1
Small green pepper	1
Grated carrots	2 cups
Shortening	1 tablespoon
Cooked dry beans	1cup
Salt to taste	

Method
- Prepare sorghum as for boiled sorghum
- Fry chopped onion in melted shortening for 2-3 minutes
- Add grated carrots, lower the heat and fry till done
- Add chopped green pepper, sorghum and beans
- Stir and cook for 4 minutes
- Serve hot.

Whole sorghum with cowpeas

Ingredients	
Whole polished sorghum	1 cup
Cowpeas	¾ cup
Margarine	1 tablespoon
Coconut	½
Onion	1
Salt	1 teaspoon
Water	3 cups

Method
- Wash sorghum thoroughly and drain
- Wash and cook cow peas until tender. Drain
- Grate coconut, add 2 cups warm water and squeeze the liquid out through the sieve
- Melt margarine in a pan, add chopped onion and sauté for a few minutes(3-5)
- Add cowpeas sorghum, coconut milk and salt, heat to boiling
- Lower heat and simmer for 40 minutes or until the sorghum grains are soft. If water dries up before grains are cooked, add the third cup of water and allow the water to be absorbed before removing from heat.

Sorghum/millet mandazi

Ingredients	
Sorghum or millet flour	1 cup
Wheat flour	2 cups
Margarine	2 tablespoons
Eggs	2
Sugar	3 tablespoons
Baking powder	3 teaspoons
Water/milk	1 ½ cups
Cinnamon	½ teaspoon (optional)
A pinch of salt	
Cooking oil	

Method
- Sieve all the dry ingredients into a mixing bowl
- Rub in margarine to bread crumb consistency. Add in slightly beaten eggs
- Slowly add water or milk mixing thoroughly to a dough which is not too soft or too hard
- Heat enough cooking oil to provide 1 inch depth in a pan
- Roll to ¼ inch thickness and cut into desired shapes
- Turn the mandazi to cook on both sides until brown.

Sorghum/ Millet Chapati

Ingredients	
Wheat flour	1 cup
Sorghum/ Millet flour	1 cup
Oil	
Salt to taste	

Method

- Sieve all dry ingredients together
- Add water to the flour to form firm dough
- Knead thoroughly incorporating 2 tablespoons of oil and allow it to stand for a few minutes
- Cut dough into small balls
- Roll each ball on a flour dusted surface to a thin flat circular form and apply little oil on the upper side
- Fold and leave to stand for 5-10 minutes covered with a damp cloth. Roll out and fry both sides on a hot pan with a little oil until brown.

Sorghum/Millet Bread

Ingredients	
Sorghum/ Millet flour	2 cups
Wheat flour	2 cups
Sugar	1 tablespoon
Oil	2 tablespoons
Salt	1 teaspoon
Warm water	1 cup
Yeast	1 teaspoon
Lukewarm water	¼ cup

Method

- Dissolve yeast in lukewarm water with a pinch of sugar, keep aside for 20 minutes
- Mix together oil, sugar, salt and warm water
- Sieve wheat flour and sorghum flour, mix well and make a dough with the mixture 2.The dough should not be too hard or too soft
- Cover the dough with a wet cloth for 30 minutes.
- Knead it again
- Grease the mould. Roll out the dough and put in the mould. Allow it to rise to double size
- Bake for 40 minutes
- Brush the top with oil after baking.

Sorghum/Millet Biscuits

Ingredients	
Sorghum/Millet flour	3 cups
Margarine	½ cup
Fine sugar	2 cups
Eggs	2
Lemon or orange juice	3 tablespoons
Baking soda	0.5
Baking powder	2 teaspoons

Method

- Sieve flour, baking powder and baking soda together
- Cream margarine and sugar till fluffy, add eggs, lemon juice and mix thoroughly with flour into dough, which is not too soft or too hard
- Cut the dough into small pieces and shape them to balls
- Arrange the balls on a flat baking tin leaving enough space in between for expansion
- Press the balls with a fork to flatten
- Bake for 30 minutes.

Sorghum/Millet Cake

Ingredients	
Sorghum/Millet flour	3 cups
Wheat flour	3 cups
Sugar	2 cups
Margarine	1 cup
Eggs	4
Baking soda	1 teaspoon
Baking powder	3 teaspoons
Milk	1 ½ cups
Vanilla	1 teaspoon (optional)

Method

- Cream fat and sugar together until white, fluffy and looks like whipped cream
- Add lightly beaten egg; beat the mixture until it is smooth and stiff
- Sift sorghum, wheat flour, baking soda and baking powder together
- Sift half the flour mixture once more this time directly into the creamed mixture. Fold in lightly
- Add the milk, sift and fold in the other half flour mixture
- Spread the mixture evenly into a cooking sufuria greased with margarine and bake for 40 minutes.

Ugali (Stiff Porridge)

Ingredients	
Sorghum or millet	1 cup
Water	4-5 cups
Sugar to taste	

Method
- Boil the water
- Add flour while stirring to avoid lumps and continue cooking until stiff for 10-15 minutes depending on the quantity
- Reduce heat and cover for 2 minutes to cook then stir again. Remove and place on a flat plate. Serve with stew, fried dish or sour milk.

Uji (Thin Porridge)

Ingredients	
Sorghum or millet flour	1 cup
Water	4-5 cups
Sugar to taste	

Method
- Mix flour with ½ cup water and place in a covered container and allow to stand for 24-48 hours in a warm place. (Omit this step if unfermented porridge is preferred)
- Bring remaining water to boil and add the paste while stirring. Cook for 10 to 15 minutes until smooth and thick
- If sour milk is used add at this stage and cook for another 1 to 2 minutes
- Sprinkle with sugar to taste and serve hot.

Sorghum Banana Pan Cake

Ingredients
Sorghum flour
2 ripe bananas
1 teaspoon baking powder
Cooking oil

Method
- Remove skin from bananas and mash to a pulp
- Add baking powder and enough sorghum flour to make a thick soft dough
- Roll out on to a floured surface and cut with an inverted glass or cup into round pieces
- Deep-fry these in hot oil, until golden brown.

Cassava recipes

How to prepare cassava flour

- Peel and wash fresh, cassava roots
- Cut into thin chips (about 5mm thick) for fast drying
- Dry on clean trays on a raised platform (to prevent contamination by dust, and foreign matters
- When dried, mill finely and sift if necessary
- Pack in polythene bags or any other airtight containers

Note: It is important for the chips to dry in one day so that the flour will be of good quality for baking.

Cassava Mandazi

Ingredients	
Wheat flour	1 cup
Cassava flour	1 cup
Baking powder	2 teaspoons
Fat	1 tablespoon
Salt	A pinch
Sugar	2 tablespoons
Deep frying fat	½ litre
Warm water	1/2 cup

Method
- Weigh all the ingredients
- Mix all dry ingredients
- Add the fat and rub in
- Add warm water and knead to make a firm dough
- Roll the dough on a board to a thickness of 4mm
- Cut into rectangular shapes and fry in hot oil until brown.

Cassava Chapati

Ingredients	
Wheat flour	1 cup
Cassava flour	1 cup
Fat	2 tablespoons
Salt	A pinch
Deep frying fat	½ litre
Warm water	1/2 cup

Method

- Weigh all the ingredients
- Mix all dry ingredients and roll in the fat
- Add warm water and knead to make dough
- Make balls and roll on a board to make a circular shape, 2mm thick
- Apply oil on the surface and fold
- Roll it again and cook on a frying pan.

Cassava Doughnut

Ingredients	
Cassava flour	2 cups
Sugar	¼ cup
Margarine	1 tablespoon
Egg	1
Baking powder	2 level teaspoons
Grated nutmeg	½ teaspoon

Method

- Cook ½ cup cassava flour in ½ cup boiling water for 1 minute
- Mix together the remaining flour with sugar, margarine, baking powder and nutmeg
- Add the cooked cassava flour and mix together until mixture resembles breadcrumbs
- Whisk eggs until light, and add to the mixture. Mix into a stiff dough, which leaves the sides of the bowl clean
- Mould into doughnut shapes and fry until golden
- Drain and serve warm.

Cassava Strips

Ingredients	
Cassava flour	1 cup
Cow pea paste	1 cup
Onion	1 large
Salt	½ teaspoon
Vegetable oil	3 ¼ cups

Method

- Soak cowpeas, de-hull, and grind into a smooth paste
- Beat cowpea paste with wooden spoon to incorporate air
- Add ground onion, salt and flour, mix well. Allow to stand for 10 minutes
- Heat the oil. Extrude the mixture through a cake decorator into the hot oil
- Fry until golden and crisp
- Serve for cocktails and snacks.

Cassava Cocktail Titbits

Ingredients	
Cassava flour	1 cup
Cowpea flour	1 cup
Egg whites	2
Baking powder	1 teaspoon
Salt	½ teaspoon
Onion (ground)	1 small
Vegetable oil	3 cups

Method

- Wash cowpea seeds, remove husks
- Dry and mill finely
- Add onion and salt to bean flour
- Beat egg whites until fluffy and add to the mixture
- Mix well with other ingredients
- Add enough water to make a stiff dough
- Roll out thinly and cut into shapes
- Deep fry and serve with drinks.

Note: 2 cups cowpea paste may be used in place of cowpea flour

Cassava Cookies

Ingredients	
Cassava flour	2 cups
Margarine	½ cup
Sugar	½ cup
Baking powder	2 teaspoons
Pinch of salt	
Grated nutmeg	
Water	

Method

- Sift flour and baking powder into a dry bowl. Add sugar
- Rub the margarine into the flour
- Add enough water to make a stiff dough (should not stick to the sides of the bowl)
- Roll out on a board covered with flour and cut into shapes with biscuit cutters
- Bake in a hot oven until lightly browned all over (takes about 15 to 20 minutes).

Recipes for pigeon pea

Pigeon pea dhal

Dhal is a cooked and fried thick soup-type preparation eaten with chapatti or boiled rice. Basically dhal is prepared from de-hulled pigeon peas.

Ingredients	
Wheat flour	1 cup
Dhal	1 cup
Water	2 cups
Chilli powder	½ teaspoon
Salt	1 teaspoon
Tumeric	½ teaspoon
Ghee oil	1 tablespoon
Onion	1 medium
Tomatoes	2

Method

- Soak the dhal in water for 1 hour, drain out excess water, and clean the dhal well
- Boil the water and put the dhal in it while boiling
- Add salt, turmeric, chilli powder, and allow in a vessel for 35 min by covering with a lid
- Now heat the oil and add onion and the cumin seeds until the onion and cumin seeds turn brown. Then mix this with the cooked dhal, or fry fine pieces of onion and tomato in ghee add to the cooked dhal
- Serve dhal hot or cold with rice, chapati or bread.

Pigeon pea githeri

This is a product of pigeon pea dhal, and whole maize grain and is generally consumed in Kenya.

Ingredients	
Pigeon pea dhal	1 cup
Maize (whole grain) or de-hulled sorghum	¾ cup
Tomatoes	2
Green chillies	1 small
Edible oil for frying	1 tablespoon
Salt to taste	

Method

- Cook pigeon pea dhal and maize grains to a desirable softness
- Fry the oil and add the green chillies and tomatoes
- Add the cooked pigeon pea dhal and maize grains
- The content is mixed thoroughly and salt added according to the taste.

Muthokoi

This is prepared by using whole seed or dhal of pigeon pea in combination with de-hulled maize (can be substituted with sorghum).

Ingredients

Whole seed/dhal	
Pigeon pea seed	1 cup
Maize de-hulled	¾ cup
Carrot	1medium
Cabbage	25 g
Garlic	1 piece
Onion	1
Edible oil for frying	2 tablespoons
Salt to taste	

Method

- Cook the pigeon pea and maize
- Fry the spices and onion in edible oil and add carrot and cabbage
- Add the cooked pigeon pea and maize grains.

Pigeon Pea Logs

Ingredients

Dehulled pigeon pea	1 cup
Salt	¾ teaspoon
Fat	30 grams
Lime juice	1 Teaspoon
Egg	1/3 cup
Onion minced	1
Bread crumbs	½ cup
Minced celery pepper	1 tsp

If desired use extra bread crumbs and oil for frying

Method

- Boil pigeon pea in 2 cups of water till all water evaporates. Grind pigeon pea with rolling pin or pass through a mincer
- Saute minced seasoning in the fat, add to pigeon pea with unbeaten egg, salt and lime juice, also add ½ cup of crumbs. Mix wee and divide into six portions and shape into logs about 4 inches long
- Dip logs one by one into flour paste then roll in bread crumbs, patting them on firmly. Complete other logs with paste and breadcrumbs
- Heat oil in a frying pan. Fry in heavily smoking fat,1 or 2 at a time. Keep rolling continuously to keep the shape
- Drain on absorbent paper, arrange on dish, and garnish with celery sparsely. For a main dish, serve with cheese or other sauce.

Pigeon Pea Egg Shells

Ingredients

Pigeon pea	1 ¾
Eggs	3
Pepper	
Chopped celery	1 tablespoon
Fat	30 g
Bread crumbs	¾ cup
Onion	1 medium
Liquid or beaten egg white	1
Lemon juice	1 teaspoon
Flour paste	
or beaten egg white	1/3 cup
Extra bread crumbs	¾ cup

Method

- Hard boil 3 eggs and cool
- Mash or crush pigeon peas with pork or rolling pin
- Sauté the minced seasoning, crumbs, salt, citric acid and liquid (which may be beaten egg yolk and pigeon pea liquid)
- Check the taste and divide into 3 equal portions
- Remove shells from the eggs and wipe dry. Cover each egg with 1 portion of this mixture, shape to look like large eggs
- Dip in flour paste, roll in crumbs
- Roll in crumbs again and smoothly
- Heat the oil in a frying pan and fry one egg at a time in smoking oil until brown, keep rolling constantly to get the oval shape
- Drain on absorbent paper and allow to cool
- Cut across the center, either lengthwise or across, to show the cut egg surrounded by the pigeon pea mixture
- Arrange on dish, garnish with tomato.

Sweet potato recipes

Boiled sweet potatoes

- Boil the sweet potatoes in water with the skins on, peel and cut into slices before serving
- Alternatively, half boil the sweet potatoes, remove the skin, roast on fire until brown. Cut in slices and serve hot.

Fried sweet potatoes

- Cut cold boiled sweet potatoes until free from lump. Season with salt, put in a frying basket and cook for 5 minutes.

Sweet potato mashed with pigeon peas/cowpeas

Ingredients		Method
Sweet potato	1 medium to large	• Cook peas till cooked
Peas	1 cup level	• Place fresh sweet potatoes in the lower part, add peas, cook till soft
		• Mash serve with stew (vegetable/meat) or milk.

Sweet potatoes and groundnuts

Ingredients		Method
Sweet potatoes	1 kg	• Boil potatoes in salted water
Roasted ground nuts (pounded)	2 cups	• Before they are tender, add pounded groundnuts, carrots and peas
Cow peas or Pigeon peas	1 cup	• Cook a bit longer and then simmer
Carrot	¼ kg	• Serve when cooked.
Salt to taste		
		Note: Can be ideal for packed lunch for children

Sweet Potato Soup

Ingredients	Method
Sweet potatoes	Peel sweet potatoes
Water	Cut them in pieces and cook in a little water until soft
Salt	Mash them and add more water to make soup
Yoghurt	Add salt and yoghurt and bring soup to boil, stirring often
	Serve.

Sweet Potato Pancakes

Ingredients		Method
Sweet potatoes	1 kg	• Peel potatoes and drop them into cold water to prevent discoloration
Eggs	3	• In a large bowl, beat the eggs and add chopped onions
Onion	1	• Gradually beat in the oatmeal or wheat flour and add salt
Oatmeal or wheat flour	1cup	• Dry potatoes and grate coarsely through a sieve and press out as much liquid as possible
Salt	½	• Add into the mixture and stir thoroughly
		• In a heavy frying pan, heat 8 tablespoons of oil over high heat
		• Pour in half cup mixture and flatten to 10 cm diameter
		• Fry over moderate heat for two minutes on each side until golden and crisp on edges
		• Repeat until the mixture is all used up
		• Pancakes may be transferred to the oven to keep hot.

Pumpkin recipes

Pumpkin Soup
- Chop the pumpkin, onion and garlic
- Fry the onion, garlic and cinnamon in a little oil
- Add the chopped pumpkin
- Add water and bring to boil
- Simmer until the pumpkin is very soft
- Before serving, sprinkle coconut on top.

Pumpkin Cowpea/Pigeon Pea Stew
- Boil cowpea /pigeon pea until cooked
- Boil chopped pumpkin until very soft and mash
- Add to the cooked pigeon pea /cow pea.

(You can also boil cassava, millet or sorghum with the stew to add carbohydrates for more energy)

Cow pea /Pigeon pea Paste

Ingredients		**Method**
Boiled cow peas/ pigeon peas	1.5 cups	Boil the peas in water with a little salt until very soft Mash to make a smooth paste
Water		Add onion, margarine and lemon juice and mix.
Salt		
Grated Onion	1 tablespoon	
Margarine	1 Teaspoon	
Lemon Juice	1 tablespoon	

Processing of vegetables

Reasons for processing vegetables
- Reduce bulk and perish ability leading to ease in transportation and marketing
- Add value to the fruits and vegetables thus improve family income
- Reduce post-harvest losses and ensure the supply of vegetables throughout the year.

Method
- Pick tender healthy leaves for drying
- Dried kales/cowpea leaves/cabbages/amaranth, etc.
- Select and wash the vegetables
- Chop finely
- Meanwhile prepare blanching solution (50g salt for 5 litres water)
- Put this solution on fire to boiling point
- Put the chopped vegetables in the boiling solution for 2-3 minutes (i.e. blanching)
- Remove and drain off the water
- Put on trays to dry. When dry, remove and pack on moisture proof containers; store in a cool, dry, dark store.

Wild spinach (amaranth) soup

Ingredients	
Wild spinach leaves	5 bunches
Onion	1
Ground spices	1 tablespoon
Carrots	4
Water	3 cups

Method

- Wash the amaranth
- Prepare and wash the onions
- Wash the carrot
- Chop the carrots and onion into cubes
- Fry the onions until brown and add the chopped carrots
- Chop the amaranth and add into boiling ingredients
- Cook for 5 minutes and season with spices to desired taste.

Season-long trial

Adaptability of traditional leafy vegetables

Introduction

Although traditional leafy vegetables used to be a common part of meals in most communities in Kenya, recently they have become less popular as introduced vegetables, such as cabbage and kale, have become more widely eaten.

Objectives

To determine the local adaptability and suitability of traditional leafy green vegetables

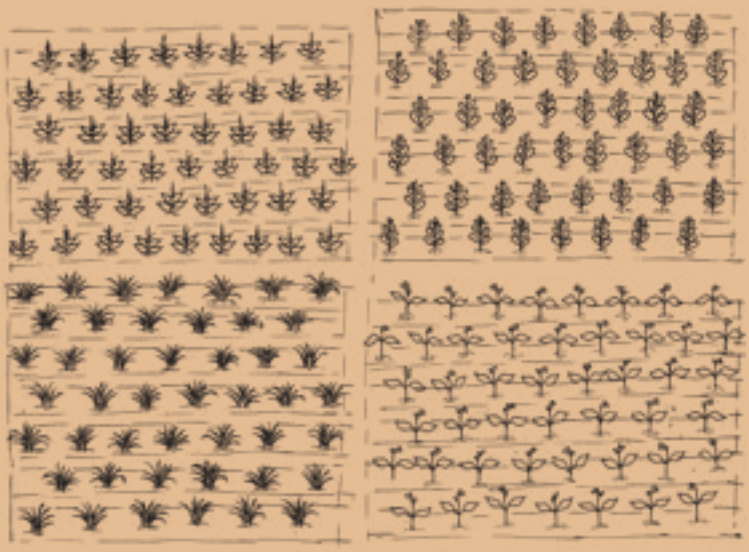
Materials

- seeds for the selected crops
- tools
- sisal twine
- manure
- organic pesticides (if normally used)
- notebook and pens

Steps

1. Discuss experiences among farmers of the traditional leafy vegetables (see also Module 2: Crop diversity and food security) which are currently grown or were previously grown in their locality.
2. Select four traditional vegetables that the group is interested in growing.
3. Choose a field and prepare the land for planting as usual. Mark out four equal sized plots, with each plot being as similar as possible in terms of soil type, slope, shade, etc.
4. Plant each plot with one of the four crops.
5. Discuss and agree in the group as to which parameters will be monitored, either regularly i.e. AESA, or just at the end of the trial.
6. At regular intervals monitor the AESA parameters.
7. At end of the season evaluate the trials according to the defined 'end of trial' parameters.

Example of plot layout



Example of data collection parameters

Regular parameters

AESA
Date of planting & emerging
Germination % & date
Pests / diseases
Weed incidences
Soil moisture
Drought tolerance
(optional in high potential areas)

End of trial parameters

Time of onset of harvesting
Harvest interval
Duration of harvest
Amount of harvest (yield per unit area)
Palatability

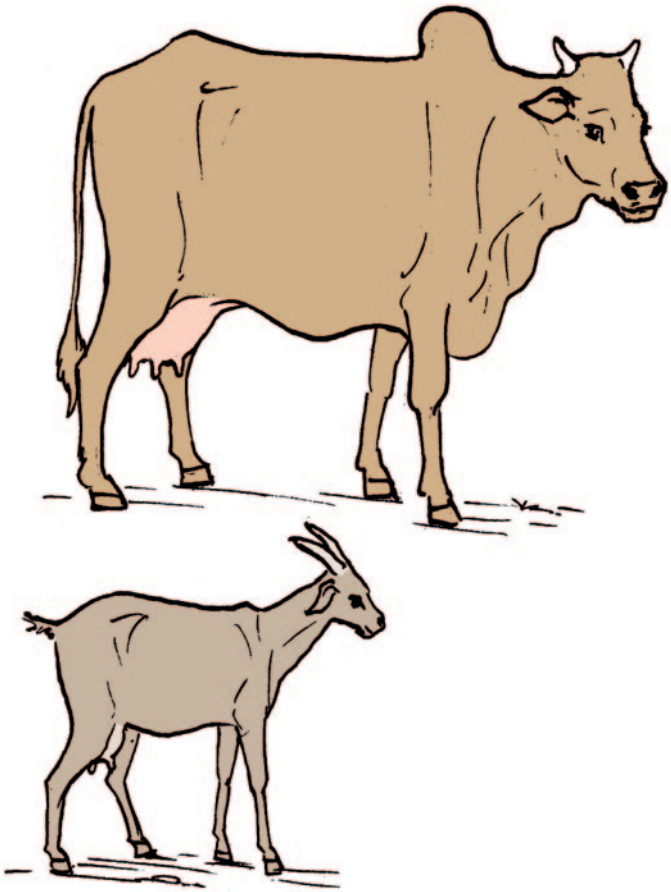
At the end of the trial the facilitator should lead a discussion

- Based on above parameters, discuss the results/findings and come up with possible recommendations: which vegetables would group members consider adopting and why?
- What is the importance of the nutritional value /content of the various vegetables?
- What are the economic returns of growing the various crops (labour and inputs cost compared to market value) and who benefits if crop is sold or grown for household consumption?
- What are the gender roles and considerations with regards to production, preparation, utilization and marketing?
- Are the seeds for these vegetables accessible, and what would be the difference relative to modern/commercial vegetable seeds?
- What are the different ways that these vegetables can be utilized and cooked? Are there ways to add value or increase shelf-life of the product?

MODULE 4
livestock and agrobiodiversity

This module:

- **Considers how indigenous breeds differ from modern ones**
- **Reviews threats to and value of indigenous breeds**
- **Provides some guidelines for breeding indigenous breeds**
- **Focuses on benefits from local poultry and the risk of bird flu**
- **Considers the role of livestock in various farming systems and their implications for agrobiodiversity**

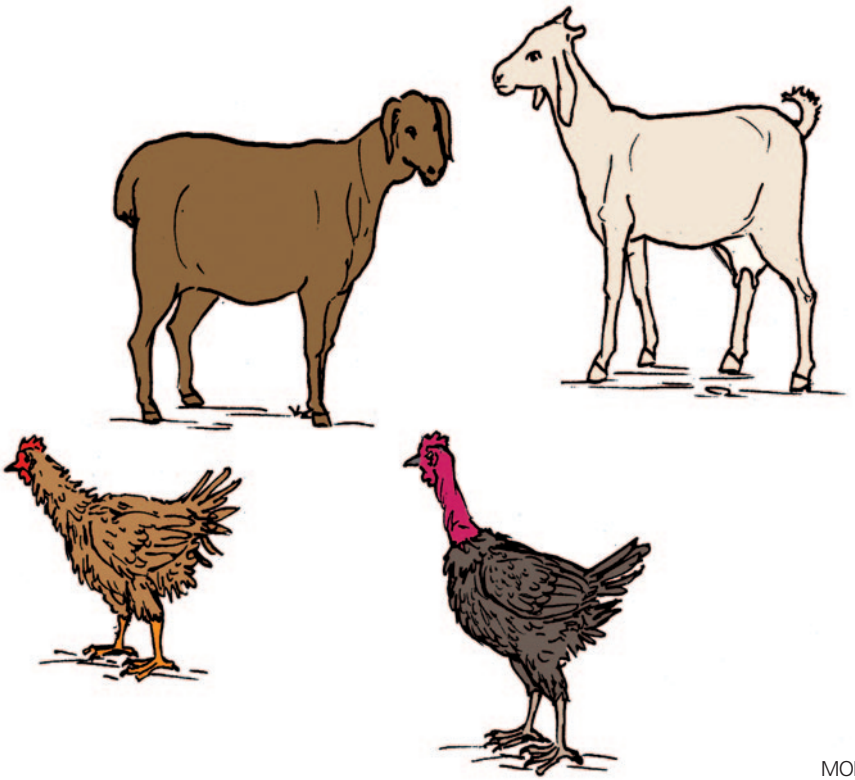


What are indigenous breeds of livestock?

Indigenous (or traditional, local) breeds of livestock are the thousands of locally distinct types of domestic animals – including cattle, camels, sheep, goats, pigs and poultry – that have for hundreds of years been developed and kept by livestock keepers throughout the world.

Many indigenous breeds are found throughout the world. Examples of indigenous breeds kept in Kenya include: Orma Boran cattle, Red Masai sheep, Galla and Small East Africa goat, and the naked necked and frizzled feathered chicken.

Indigenous breeds are usually found in a limited geographical area and have been developed by a combination of natural selection (the survival of the fittest) and deliberate selection by people (choosing to breed from animals that show desired characteristics). As a result, over large numbers of generations, they have become well adapted to local conditions and to meeting the needs of local livestock keepers.



Indigenous breeds tend to be well adapted to harsh conditions and are more tolerant than modern breeds to locally common parasites and infectious diseases, drought, heat stress and water shortage and are able to utilize poor quality feeds and trek for long distances. Indigenous breeds are therefore well suited to marginal areas where many resource-poor livestock keepers live.

Indigenous breeds often provide a wide range of products and services beyond meat, milk or eggs – such as fibre and wool, dung, hides and skins, transport and draught power – and often play important cultural and social roles, such as for dowry, traditional fines, and as the focus of celebrations and festivities. Being usually very well adapted to the local environmental conditions, indigenous breeds may be more resilient to climatic threats such as drought, and thus represent a source of insurance in times of hardship. Traits such as ease of calving and good mothering ability, docility and ease of handling are important and valued characteristics.

Indigenous breeds have a wide range of genetic diversity within a breed – that is, although similar, not all individuals are identical.

Definitions

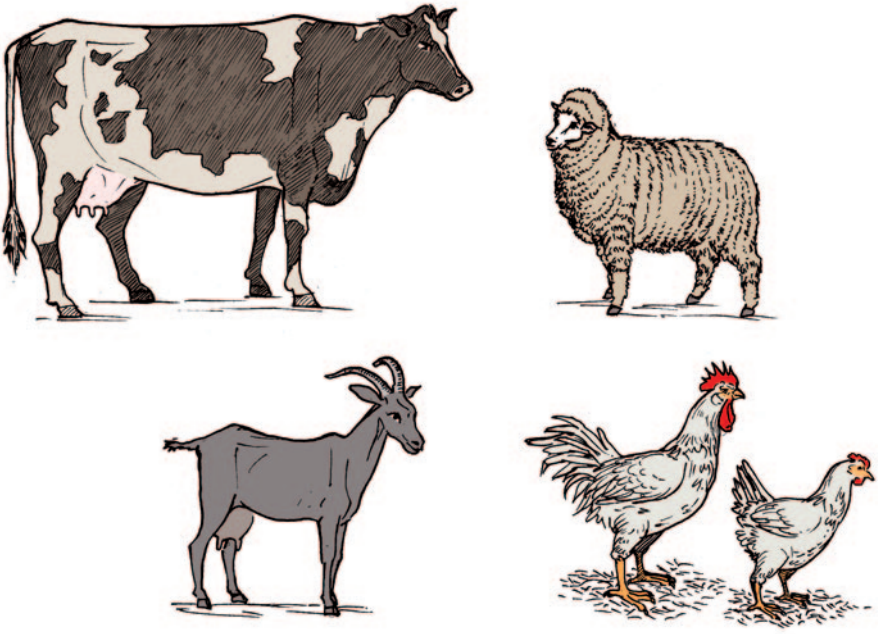
The term **indigenous breed** is used in this chapter to indicate those breeds that are originating from, adapted to and utilized in a particular geographical region. They form part of the Locally Adapted Breeds category, which comprises those breeds which have been in the country for a sufficient time to be genetically adapted to one or more of its traditional production systems or environments.

The term **modern breed** is used in this chapter to indicate those breeds used in intensive production systems or marketed by international breeding companies. These are part of the Continually Imported Breeds category, which indicates breeds whose local gene pool is regularly replenished from one or more sources outside the country.

How do indigenous breeds differ from modern breeds?

Modern (commercial, improved) breeds of livestock have been bred to be highly productive under favourable conditions. Most modern breeds were developed in the North – for example in Europe or North America – and have been developed to meet the needs of livestock keepers in these areas, who often use intensive, high-input, industrial farming systems.

Examples of modern breeds include: Friesian cattle, Merino sheep, Toggenburg goats and hybrid layer and broiler chickens.



To thrive and be productive, modern breeds require a high level of inputs, such as large amounts of good quality feeds and veterinary care, skilled management, and an environment that is not too stressful – generally they are best suited to a temperate climate which is neither too hot nor too cold and are often housed.

Modern breeds have been bred for a narrow, specific production purpose which meets the demands of consumers: to give large yields of low-fat milk, to grow rapidly and produce lean meat, or to lay many eggs in intensive, industrial farming systems. They are unsuited to provide other products or services, such as draught power, or to thrive in alternative (low-input) farming systems. They may also be prone to reproductive problems – such as troublesome calving or inability to breed naturally (as occurs in some modern turkey breeds) – and may have poor mothering instincts. But these problems tend not to matter in the industrial systems for which they were developed and where artificial insemination is common, veterinary assistance readily available and young animals are often not reared by their mothers.

Modern breeds have limited genetic diversity within a breed – all the individual animals are very similar and tend to share a few common ancestors. Modern breeding methods, such as the use of progeny-tested bulls and artificial insemination, mean that only a few of the best performing males are used in breeding programmes.

Threats to indigenous breeds

In recent years, extension advice, livestock development projects and restocking schemes have all tended to promote the use of modern breeds. At the same time, some farmers now regard indigenous breeds as being 'backward'. As a result, many indigenous breeds have either been replaced completely or have been cross-bred with modern breeds. Over time this has resulted in many indigenous breeds becoming rare or even disappearing completely. As of 2014, it is estimated that 17 percent of breeds are at risk of extinction, and 58 percent are of unknown risk status as no data from the previous ten years was reported to FAO[1].

Value of indigenous breeds

Indigenous breeds are important both for individual farmers and at the national and international level.

Livestock keepers, especially the resource-poor who live in harsh, marginal areas and who lack ready access to inputs such as breeding services, high-quality feeds, veterinary advice and service, often rely on indigenous breeds.

Indigenous breeds are hardier than modern breeds. Keeping indigenous breeds is much less risky, can enhance food security, improve and expand livelihoods due to the wide range of products and services they provide and increase social capital. Some consumers may prefer livestock products derived from indigenous breeds, which in turn may fetch higher prices on the market. For example, indigenous breeds of chickens are sometimes preferred over intensively-reared hybrid ones, which have a much softer meat.

[1] Source: FAO. 2015. *The Second Report on the State of the World's Animal Genetic Resources for Food and Agriculture*, edited by B.D. Scherf & D. Pilling. FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome (available at http://www.fao.org/3/a-i4787e/index.html).

Indigenous breeds also represent a valuable resource for national, regional and international breeding programmes. The genetic make-up of modern breeds is narrow. As market conditions change – such as consumers wanting low-cholesterol meat or products derived from livestock reared in more natural 'free-range' systems – different types of modern breeds are required. The genetic variation and diversity found in indigenous breeds represents a rich source of useful traits that can be used in cross-breeding programmes to produce modern breeds that meet changing demands.

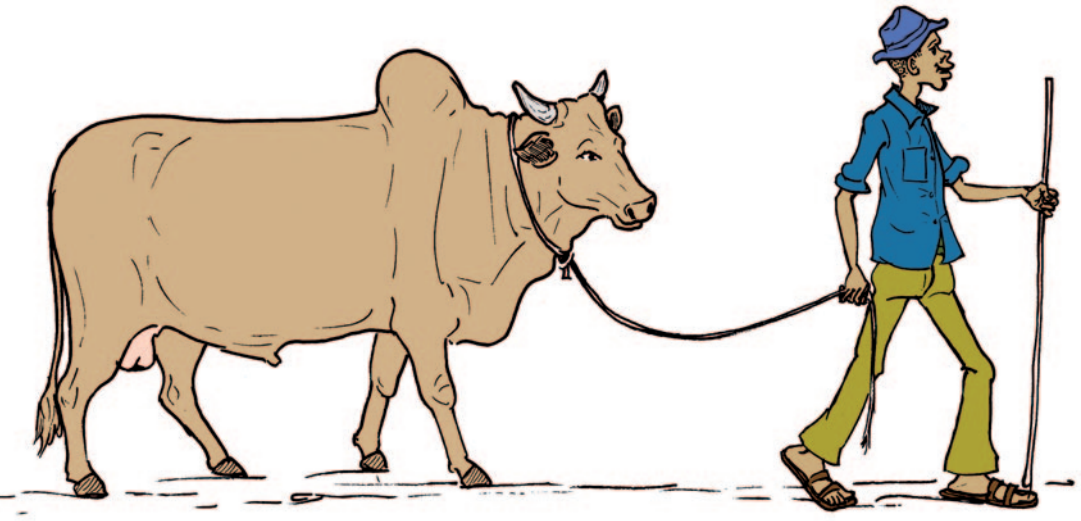
To some extent, conservation of the Kenya's indigenous genetic resources is being carried out in the sheep and goat stations and livestock improvement farms run by the Department of Livestock Production. But farmers also have a part to play. The most effective way of conserving indigenous breeds is for livestock keepers to continue rearing them in the areas where they were developed and where their characteristics are still valued. By continuing to keep indigenous breeds, and by keeping alive the indigenous knowledge and cultural traditions associated with them, small-scale farmers are providing a valuable service, not only to themselves and their communities but also to the wider global community.

Breeding indigenous livestock

When breeding indigenous breeds of livestock some basic rules should be followed:

- Use only healthy males that are good examples of their breed: if in doubt seek veterinary advice
- Keep records on animals' parentage as well as their production, reproduction and health
- Keep as reproducers heifers from cows considered as the best ones for farmers own goals. Replace in priority unproductive, diseased cows or with low fertility
- Do not allow fathers to mate with their daughters or mothers, or sons with their mother or sisters: to avoid this, bulls should be replaced when their daughters are ready for mating
- Castrate or dispose of males that are not needed for breeding
- Do not allow heifers to breed when they are too young or too small: this will usually not be before they are 18 months old
- Avoid mating small cows with bulls that are too large or using semen from large breeds: this will produce large calves and cause problems with calving
- If using artificial insemination, take care in choosing the breed used: smaller dairy breeds such as the Jersey or Guernsey may be more suitable for small-scale farmers upgrading their local zebus than larger breeds such as Friesians

- To avoid loss of indigenous breeds, farmers should avoid cross-breeding unless they are deliberately upgrading their stock. Expert advice should be sought in selection of breeds for cross-breeding and management of the cross-breeding system
- The choice of a breed type should be made in relation to your own goals and needs (milk yield, butterfat yield, hardiness, traction). A breed should be changed only if its use is expected to increase productivity by at least 30%
- When changing the breed, ensure to have long term supply of genetic material (new reproducers or semen). When applying rotational crossing, the breed of semen or bulls used should be changed every generation, balancing a productive breed with a hardier one.



Exercise **Comparison of indigenous and modern livestock breeds**

Learning objective	Timing	Preparations by group	Time	Materials
To consider the relative advantages and disadvantages associated with indigenous and modern breeds of livestock and to identify constraints to adoption of modern breeds	Any time	To provide two cows, goats, chickens, etc, one a modern breed and the other an indigenous one	2 hours	2 cows, goats or poultry, flip-chat, marker pens

Steps

1 The facilitator asks the group to carefully look at the two animals, one from a indigenous breed, the other from a modern breed.

2 The facilitator then leads a discussion. Based on what they can see, their own experience and what they have learned from others:

- What are the advantages and disadvantages of the indigenous breeds compared to the modern one? Consider cost, feed requirements, tolerance of harsh conditions, susceptibility to disease, housing needs, productivity, range and quality of products, etc.
- What do markets and consumers want? Can this best be met from indigenous or modern breeds?
- Have participants had either very good or very bad experiences with keeping modern breeds? Participants are encouraged to share their individual experiences.
- What are the lessons to be learned from the participants' experiences?
- Is it riskier to keep modern breeds? Can the risks be minimized?
- Is it more profitable to keep modern breeds?
- What about the poorer members of the community, such as women-headed households, orphans, the sick and elderly: are they able to keep the modern breeds?
- Are there situations when it might be better to keep indigenous breeds rather than modern ones? If so, what are these? Might cross-breeds be useful in some situations?
- What changes have there been in the breeds kept locally over the past 25 years? Why have these changes occurred? What have been the consequences?
- Has this discussion made participants re-evaluate which breeds they will keep in the future?
- What help do group members need in making the most appropriate choice of breeds and managing challenges such as cross-breeding?

Indigenous poultry breeds

Indigenous breeds of poultry are the most commonly kept type of livestock. They are present wherever there are human settlements and nearly all rural households keep at least a few.

Comparison of indigenous free-ranging poultry with housed modern breeds

indigenous breeds free-ranging	parameter	modern hybrid layers & broilers housed
usually small (1-20 birds)	size of flock	large flocks
low (scavenging for feed)	inputs, e.g. feed	high (commercial feeds)
low (40-60 eggs per bird per year)	egg yield	high (250-300 eggs per bird per year)
Low – although may fetch a premium price; home consumption and small cash income	income	high; market-oriented
high cultural/social value (gifts, religious festivals, etc.)	cultural/social value	little cultural/social value
can survive in harsh environments with minimal inputs	hardiness	low require housing and feeding
free-ranging and exposed to other domestic and wild birds therefore susceptible to infectious diseases. Some breeds may, however, be more resistant to certain disease types.	disease control	housed therefore not exposed to other birds disease control through vaccination is routinely practiced
higher risk from predators (e.g. mongooses, hawks and rats etc.). However, also higher capacity to evade predators, due to the birds' stronger physical abilities	predation	housed therefore protected from predators
none or very simple housing	housing	houses or cages of various types, such as deep litter, slatted floor
long broody periods routinely kept with cockerels and replacement chicks hatched and reared	broodiness/breeding	no broodiness not kept with cockerels replacement chicks purchased from commercial hatchery
slow	growth rate	high

As well as providing high quality protein and essential micro-nutrients – which are especially important in the diets of children, pregnant and nursing women, the elderly and the sick – poultry and eggs are readily sold whenever small amounts of cash are needed.

Indigenous breeds, especially when free ranging, are vulnerable to diseases including Newcastle disease – a common and highly infectious disease which can kill all the birds in a village. Vaccines exist which are very effective in preventing Newcastle disease but these may not be accessible in remote areas. Also, the packs of vaccines tend to be for large numbers of birds – and once prepared for use need to be used within a few hours. For this reason, it is more effective if groups of farmers cooperate and jointly vaccinate their birds. Some vaccines are now produced which do not need to be kept in refrigerators, which is a great advantage in remote areas.

The risk of bird flu

Bird flu – known to scientists and vets as highly pathogenic avian influenza – is a serious disease which people can catch from poultry. Most people who become infected with bird flu die, although fortunately this is a very rare event: so far the disease has not occurred in Kenya, although it has occurred in other parts of Africa, including, in early 2017, neighbouring Uganda.

It is important, however, that everyone is aware of the risk that bird flu poses, recognizes the signs of the disease, knows how to act when they see these signs and also knows how to reduce

the risk of the disease occurring. The Government of Kenya has set up a Task Force on Avian Flu which has provided the following information:

What are the symptoms of bird flu in chickens?

- Sudden death
- Lack of energy or appetite
- Swelling of head, eyelids, comb or legs
- Purple discoloration of the wattles and combs
- Discharge from the nose

If you notice any of the above symptoms, immediately contact the Veterinary Department.

How can you protect yourself and family from bird flu?

The following are simple precautions you can take to protect yourself and family against bird flu:

- Avoid touching, eating, selling or transporting sick or dead chickens, other poultry or wild birds
- Report such cases to the nearest veterinary or public health office, chief or other relevant local authorities
- Do not sleep in the same house with chickens. Sleeping in the same house with chickens increases the possibility of contracting bird flu
- Keep chickens in a separate structure away from residential houses.

Is it safe to eat chicken?

- Yes. The Government of Kenya has taken necessary measures by banning the importation of poultry and poultry products from regions that have reported bird flu to avoid introducing the disease. However, you are advised not to eat uncooked or undercooked bird products. Always cook poultry until there are no pink or red parts in the meat
- Always wash eggs before cooking. Cook eggs until the yolk is hard
- Separate raw and cooked meat and do not place cooked meat on the same plate where raw meat was
- Exercise hygiene while preparing foods.

How do I protect my chickens from contracting bird flu?

- Always be on the look-out for any symptoms of avian flu in your poultry
- Avoid your poultry being in contact with wild birds by housing them in a covered shelter.

What action do I take regarding dead or sick chicken and birds?

- Report all cases of sick or dead chicken/birds to the nearest veterinary or public health office.

Exercise **Role play**
responding to a suspected bird flu outbreak

Learning objective	Timing	Preparations by group	Time
To introduce group members to the danger of bird flu so they can recognize the symptoms, know what to do if they suspect a case and learn how to reduce the risk of the disease occurring	Any time	3 volunteers learn their roles	10 minutes for the role play and 1 hour for discussion and question and answer session with divisional veterinary officer

1 The facilitator asks for three volunteers and explains the storyline. Once the actors have learned their parts, they act out the role play to the whole group:

Actor 1: Feeding her chickens is watched by her neighbour, Actor 2, when she notices that the chickens are not looking and behaving normally. She describes the symptoms to her neighbour: "Look, my birds are not hungry and look different. That one has a discharge from the nose. They must be sick."

Actor 2: "I remember hearing a radio programme about a disease in chickens called bird flu. Your birds seem to have some of the symptoms the veterinary doctor on the radio talked about."

Actor 1: "If it's only flu, that's not serious – I had flu last year and I was just sick for a few days with a fever. I didn't even go to the clinic."

Actor 2: "No, bird flu is very serious. It can even kill people!"

Actor 1: "Are you sure? So what should I do – what did your radio doctor say?"

Actor 2: "As far as I remember he said you must not touch the sick or dead birds and you must report the case to the nearest vet or public health office. Here, you can borrow my mobile phone I have some credit."

Actor 3: The Divisional Veterinary Officer, later that day: "You did the right thing calling us right away. It might not be bird flu but we need to make sure as bird flu is a very serious, deadly disease. We will do some tests but meanwhile I will show you how to protect yourself from the risk of bird flu. Keep your birds away from your house and never sleep in the same house as your birds. Avoid touching, moving or selling sick or dead birds – whether domestic poultry or wild birds. Make sure you cook poultry meat and eggs thoroughly – no soft yolks or pink meat. And always wash your hand after handling poultry."

Actor 3: A few days later. "I'm pleased to tell you that it wasn't bird flu, it's fowl pox – you are in no danger and your birds should recover. But you did the right thing: if it had been bird flu your prompt action would have helped prevent the disease affecting people – you would have saved lives! Fortunately so far we have had no cases of bird flu in Kenya but many other countries have not been so lucky, so we need to keep alert. If you suspect a case of bird flu, call us right away."

2 The facilitator leads a discussion about bird flu, how to reduce the risk and what to do if bird flu is suspected. Inviting the Divisional Veterinary Officer to attend the session will allow trainees to ask questions about bird flu as well as other poultry issues. This is a good opportunity to explore better ways of keeping poultry and ways of dealing with problems, such as Newcastle disease vaccination.

Note: This approach could be adapted to deal with any other zoonotic diseases (that is diseases than can be spread from animals to people), such as rabies.

- Do not touch sick or dead chickens or wild birds
- Sick or dead poultry and birds should not be eaten or given to other animals including dogs, cats and any other animal.

Livestock in different production systems

Livestock play important roles in a wide range of production systems in Kenya.

In pastoral systems, which occur in arid and semi-arid areas, mobile or semi-mobile pastoralists depend largely or wholly on indigenous breeds of cattle, camels, sheep and goats for their livelihoods.

In agro-pastoralist systems, which also occur in arid and semi-arid areas, livelihoods depend on both livestock and on drought-tolerant crops. Indigenous breeds of livestock are grazed both off-farm and on the farmers' fields to take advantage of crop residues after harvest.

In mixed crop-livestock systems, which occur in areas of higher rainfall, settled farmers combine crop production with livestock rearing. Livestock, which may be modern breeds, cross-breeds or indigenous breeds, may be confined to stalls (zero-grazing system), tethered or grazed in paddocks, and fed on crop residues, specially grown fodder crops (such as Napier grass) and bought-in feed.

In intensive commercial systems, modern breeds of livestock tend to be fed on bought-in feed and are often housed.

Whilst pastoral, agro-pastoral and mixed crop-livestock systems can support considerable agrobiodiversity, more intensive systems – in common with intensive arable systems – tend to support little agrobiodiversity. In intensive systems, there tends to be little or no link between crop and livestock production, which has implications for the environment: manure, which is a valuable product in mixed-crop livestock systems, can become a problem in intensive systems, accumulating in large heaps which attract flies and other vermin, with the run-off polluting local water sources.

Livestock and rangeland

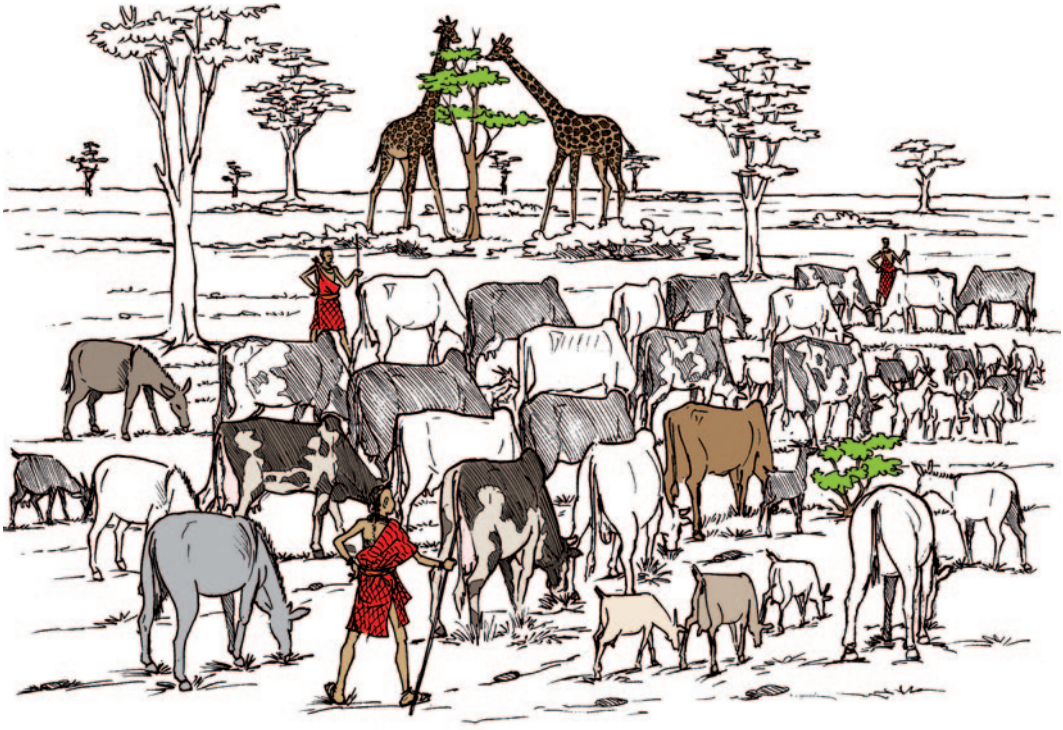
Rangelands in eastern Africa are landscapes in arid and semi-arid areas where the predominant vegetation is grass but where there are also areas of woodland and shrub land as well as scattered trees.

Traditionally, rangelands have been utilized by pastoralist people to graze and browse their herds and flocks of livestock. They also often support large numbers of wild animals, especially grazers

and browsers, such as antelopes, zebras, giraffes and elephants, and predators, such as lions and hyenas, as well as countless smaller species.

Natural vegetation, including trees and shrubs, plays an important role in stabilizing and protecting fragile rangeland soils and also provide other useful products and services: fuelwood, poles for building, thorny branches for livestock bomas, herbal medicines, gum arabic, forage and seed pods for livestock and fodder for bees, and shade for people and livestock, amongst others.

In the past, traditional knowledge and practices ensured that rangeland natural resources were not overexploited: for example, in pastoralist areas tracts of grassland were reserved for use only during droughts and access and use was negotiated with neighbouring clans. The tendency was to conserve biodiversity, recognizing the value of the different species of wild animals and plants to support livelihoods, or at least being prepared to tolerate and co-exist with them. These



traditional systems depended on low population densities and access to large areas of rangeland which enabled pastoralists and agro-pastoralists (and wildlife) to trek to take advantage of localized rainfall and subsequent growth of grass and browse within the larger, dryland landscape.

In recent decades, rapid population growth and restrictions on use of and access to many traditional extensive rangelands – due, for example, to creation of national parks and reserves and large, privately owned ranches – has placed enormous pressure on both the traditional systems and rangelands. In some areas rangeland has been ploughed-up in an attempt to introduce crop production, although this is a risky strategy in such marginal areas: crop failure is common, especially when drought-sensitive crops such as maize are planted. A trend towards more frequent and more severe drought (associated with global warming) has made the situation worse. The result has been degradation of rangeland: clearing of vegetation, erosion of soil and creation of gullies. In many cases this has been exacerbated by conflict between neighbouring pastoralist tribes and between pastoralists and cultivators.

Efforts to rehabilitate degraded rangelands need to address land tenure and user rights and combine traditional knowledge and practices with appropriate scientifically-based technologies and approaches. Meanwhile, efforts to diversify pastoralist livelihoods need to be approached in a way that ensures sustainable natural resource management.

Livestock in mixed farming systems

Livestock play a number of important and useful roles in mixed farming systems that enhance sustainability, increase productivity, diversify the products and services produced and help maintain agrobiodiversity.

Livestock can convert low-value waste materials, such as crop residues, and natural resources collected from or available on public land, such as grass and other wild plants, and turn them into high-value products.

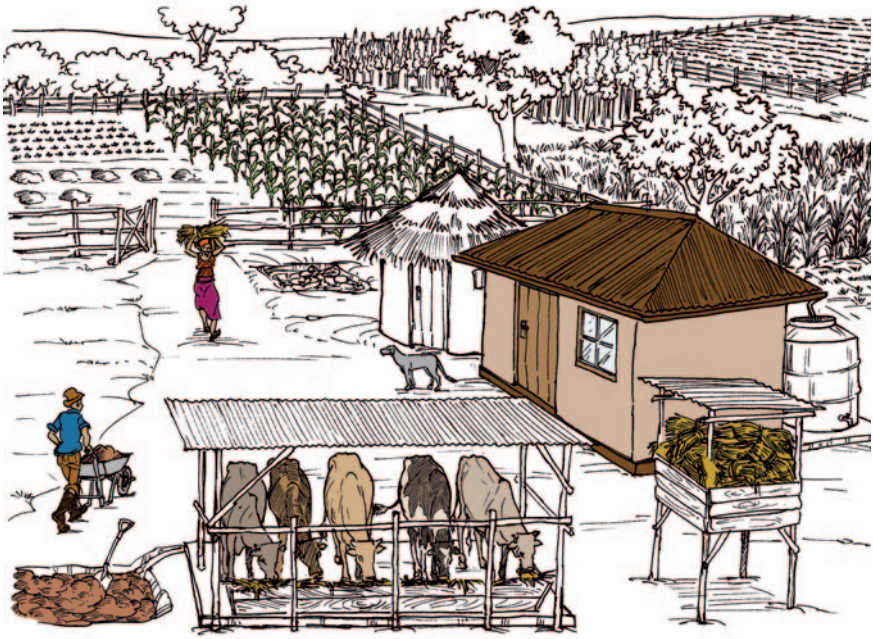
Keeping dairy cattle encourages farmers to plant perennial fodder crops, such as Napier grass and forage legume trees and shrubs. If these are planted along contours on sloping land they can help prevent soil erosion. Legume trees and shrubs, which can fix nitrogen, can be used in alley cropping systems to improve soil fertility and boost yields of nearby crops, such as maize. If cattle are stall-fed or tethered it is easy to collect their manure and apply this to the land as a fertilizer to boost crop production. In zero-grazing systems even the cows' urine can be collected and used as a valuable fertilizer.

Cattle and donkeys can be used for draught power, such as ploughing and weeding fields and transporting water and other goods. This spares people, especially women and children, from the

drudgery of doing this work by hand. It also allows households to cultivate larger areas more effectively and efficiently, for example by achieving better weed control which can boost yields.

Maggots (which are the larvae of certain types of flies) and termites can be produced or collected from the wild and used as high-protein feeds for local poultry. Manure from cattle, offal and blood slaughter houses form a good medium for growing maggots.

Having livestock on a farm diversifies the products and services produced, reduces risk and enhances food and nutritional security. For example, if crops fail during drought periods they can be fed to cattle, sheep or goats. In times of insecurity or natural disaster, livestock can be moved to safe areas – unlike crops which have to be abandoned in the field. Also, livestock and livestock products can often be readily sold to meet urgent needs for cash, such as for medical emergencies, to pay school fees or for the purchase of seeds and other essential farm inputs.



Exercise **How do livestock fit into local farming systems?**

Learning objective	Timing	Time	Materials
To introduce group members to the multiple benefits of integrating crops and livestock in mixed farming systems	At beginning of the training cycle	2 hours for farm surveys and an additional 2 hours for groups to present their findings and for a facilitated discussion	Flip chart, marker pen

Steps

1 Participants form small groups and visit either a member's farm that has both livestock and crops or a member's farm that has no livestock (or just poultry).

2 The group looks around the farm identifying:
- examples where livestock are or could be beneficial to crop farming
- examples where crops support or could support livestock rearing without diverting food from people
- examples where keeping livestock has or could have environmental benefits
- examples where keeping livestock is or could be a threat to crop farming or the wellbeing of the farming household and wider community
- The group records its findings on a farm map or drawing.

3 Groups share their findings in plenary.

4 The facilitator leads a discussion:
- what are the advantages of mixed crop-livestock farming?
- what types and breeds of livestock would be most appropriate in the local environment?
- what impact does combining crops and livestock have for food security, nutritional security, incomes, sustainability, ability to cope with stress such as drought, floods or civil disturbances?
- will group members now consider adopting a more integrated crop-livestock production system? What challenges might they face in doing so? What help could the group provide in order for them to overcome these challenges?

Intensification pressure and threats to agrobiodiversity

As populations increase, farm size tends to decrease with each generation and access to common resources, such as rangeland, is also reduced. This means that farming households need to make better use of smaller parcels of land – that is they need to intensify their production to ensure their families are well fed and they have surplus production for sale.

One way of achieving this is to introduce livestock into the farming system, as discussed above.

The need for intensification can, however, encourage farmers to stop keeping indigenous breeds of livestock in favour of the more productive, modern breeds: for example replacing several zebus with one or two Friesians. This can be effective in high-potential areas where farmers have good access to inputs and services – such as high-quality feeds, artificial insemination and veterinary care – and ready access to markets for sale of surpluses, such as milk. But in marginal areas, where most resource-poor small-scale farmers live, keeping modern breeds may be a risky option: for example, there is unlikely to be adequate feed available, local bulls may be too small to serve modern dairy cows, artificial insemination services may be lacking, and veterinary services may not be readily available.

Even in high-potential areas, most farmers do not achieve the full potential from their modern breeds – mainly due to them having insufficient forage available on-farm and lack of money to buy-in additional forage or compound feeds.

In some circumstances – especially in marginal areas – adoption of modern breeds can lead to reduced food security, and increased risk of losing animals due to disease or drought. It can also lead to indigenous breeds becoming less common, or even dying out altogether, and the associated loss of indigenous knowledge and culture – which reduces the options available to local farmers in the future and could lead to the loss of valuable traits for future cross-breeding programmes. However, introduction of imported breeds can also increase agrobiodiversity and provide new opportunities, provided it complements local breeds and is introduced in a well-planned manner.

Exercise **Role play – be cautious when replacing indigenous with modern breeds**

Learning objective	Timing	Preparations by group	Time
To introduce group members to the danger of intensification pressure and threats to agrobiodiversity	Any time	2 volunteers learn their roles	15 minutes for the role play and 2 hour for discussion

Steps

1 The facilitator asks for two volunteers and explains the storyline. Once the actors have learned their parts, they act out the role play to the whole group.

Actor 1: grazing his/her zebu cow along the roadside when his neighbour (Actor 2) appears. After greeting him/her, Actor 1 asks his neighbour: "Has the Friesian cow you purchased last month arrived yet?"

Actor 2: "Yes, I brought it home a fortnight ago after selling three of my zebus. In fact it has only two days until it will calve down and then I will be swimming in milk and cash!"

Actor 1: "Don't be so sure, I really doubt that that cow will adapt well here with this hot weather and scarce feeds... by the way what are planning to do about the tick menace..."

Actor 2: "You remind me of how Mr. Wang'ombe lost all his grade cows he had purchased from the same place, but that was just bad luck – mine will survive."

Actor 1: "Are you sure? And where are you going to be grazing? Did you consult the Livestock Officer to guide you on the most appropriate breed for this place?

Actor 2: "All that mattered to me is to get a cow that can give me a lot of milk, as for feeds and those bloody ticks...I'll tackle them later. There is a lot of grass along this road…"

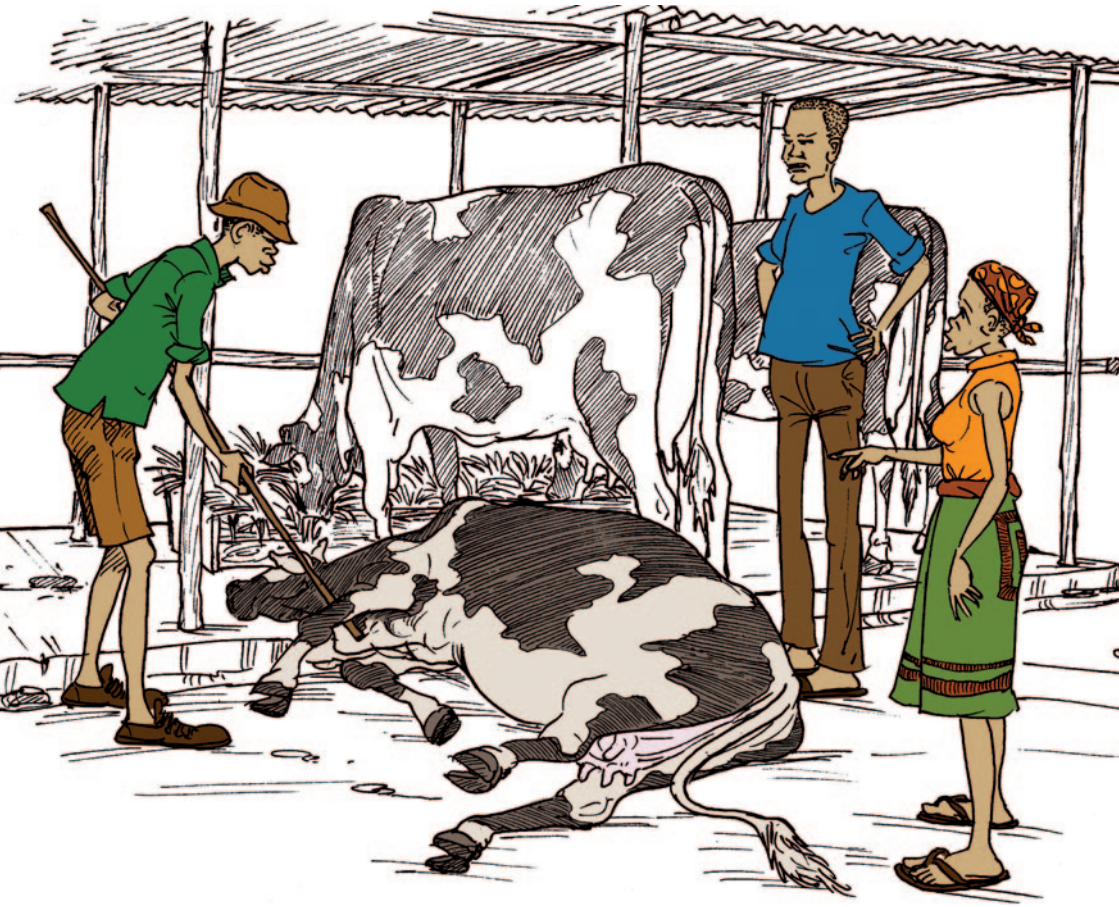
A week later:

Actor 1 on his way to the duka passes through Actor 2's home only to find his neighbour digging a hole: to his surprise it's a hole to bury the dairy cow. "I am terribly sorry... so sorry..."

Actor 2, "The pain of losing this cow is unbearable, remember I sold my three zebu cows...I wish I consulted the Livestock Officer, or just kept my indigenous cows with their low milk yields...see the huge loss I have taken..."

2 The facilitator leads a discussion.

- Which breeds of livestock survive best in the local conditions?
- What precautions/steps should farmers consider before replacing their indigenous breeds with modern breeds?
- Do they have the required management skills and experience?
- Do they have access to the necessary inputs and services?
- Do they have year-round access to profitable markets for surpluses, especially perishable products such as milk? Are local roads passable in the rainy season?
- Which breeds are best suited to the local conditions?



Season-long trial

Reducing chick mortality

Introduction

The productivity of local, free-ranging poultry is severely hampered by high chick mortality rates. Typically, out of every 10 chicks hatched, only 3 or 4 survive. This results in fewer chickens available to produce eggs and meat for household consumption or sale

Objectives

To increase local poultry chick survival rate

Materials

- 2 broody hens
- 24 fertile eggs
- supplementary feed
- Newcastle disease vaccine (optional)

Procedure

1. Two broody hens are selected and each sat on 12 fertile eggs.
2. After 21 days, when the eggs hatch, one hen and her chicks is left to free-range while the other hen and chicks are provided with some protection against predatory animals, birds and snakes. The exact design and construction of the protection will depend on what materials are locally available and can vary from a simple traditional basket to more elaborate wire pens.
3. Newcastle disease vaccination is done after 3-4 weeks in both cases.
4. Both hens and chicks are given the same supplementary feed (such as sorghum grain, kitchen waste, peelings from bananas/potatoes, lake shrimp, omena dust, etc – based on what is locally available).
5. The hens and chicks are observed throughout the trial and any differences noted, such as cases of sickness and deaths.
6. When the chicks are 8–weeks-old the trial ends.

Parameters to be monitored

- number of chicks surviving
- number of chicks that are diseased/sick
- weight or size of surviving chicks at 8 weeks.

	Free ranging		Protected	
Week	Number chicks	Observations	Number chicks	Observations
1				
2				
…				
8				

At the end of the trial the facilitator leads a discussion

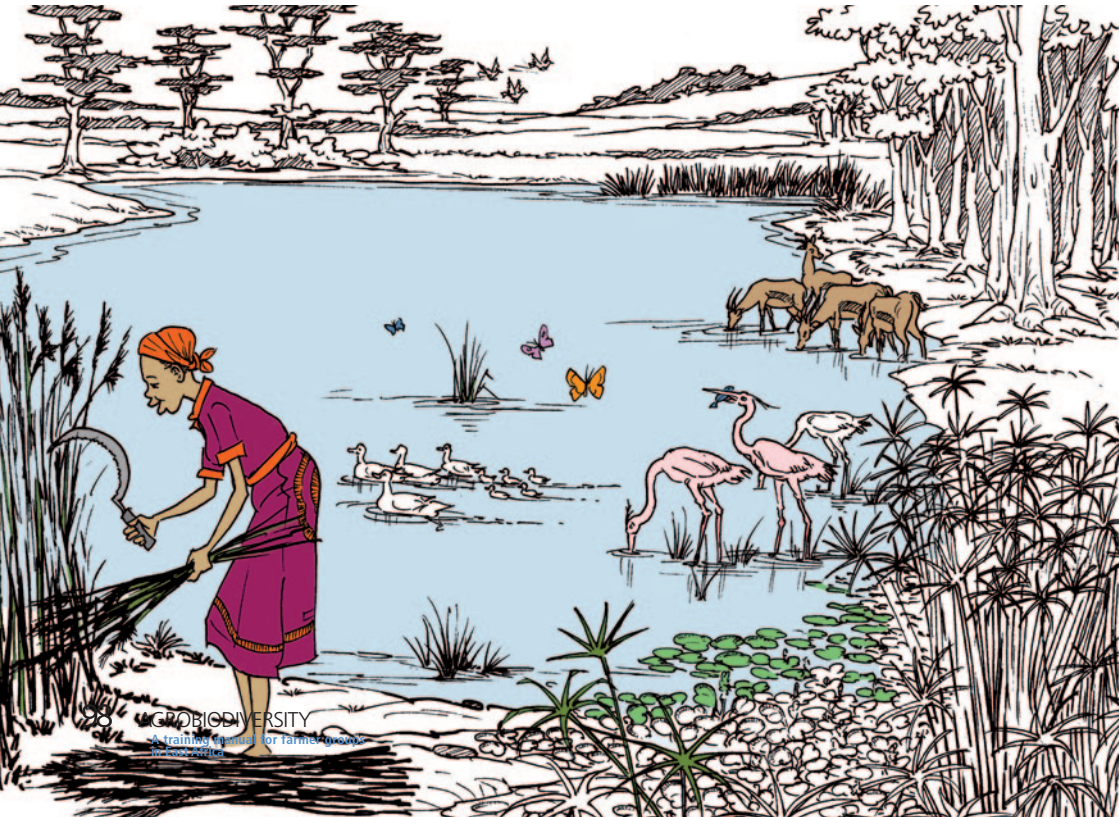
- Did protecting the chicks help to reduce chick mortality?
- Did the method used to confine the chicks have any disadvantages?
- Are there other ways that farmers could use to reduce chick mortality?
- What are the gender roles associated with local chicken management: feeding, watering, deciding when and how to sell, who makes decision on how the money will used, slaughtering etc?
- What does a cost/ benefit analysis tell us about the approaches used in the trial, especially in relation to use of supplementary feeding? Is it cost-effective to confine chicks and feed them versus letting them free-range?
- What role do local poultry play in household food security and incomes?
- Do poultry contribute to other aspects of farming? Is their manure useful; do they help control pests; do they attract pests; do they damage crops; are they a potential source of disease for people?
- What should farmers do if they suspect their poultry or wild birds have bird flu?
- Are there other ways of incubating eggs besides use of broody hens? Do ducks make good substitutes for hens? Are basket incubators useful?
- What disease control measures do farmers currently practice – and what disease problems do they experience?

What options are there for utilizing eggs and live birds? What is the relative importance of home consumption, sales and socio-cultural uses?

MODULE 5
inland aquatic biodiversity

This module:

- **Discusses utilization and changes in aquatic biodiversity**
- **Explores sustainable utilization of aquatic species**
- **Considers prevention of pollution in aquatic ecosystems**
- **Discusses diversification of livelihoods based on aquatic agrobiodiversity**
- **Considers the impact of alien invasive species**
- **Mainstreams HIV/AIDS and gender in fish marketing**



Inland water bodies and livelihoods

Inland waters include natural water bodies, such as swamps, rivers, flood plains, lakes and ponds, and modified, human-made habitats, such as rice fields, reservoirs and aquaculture ponds.

All water bodies, natural and modified, support ecosystems made up of micro-organisms, plants and animals which interact with each other through complex food chains: for example, microscopic algae (tiny water plants) capture energy from sunlight and are grazed by tiny crustaceans, which are fed on by small fish, which are preyed on by larger fish – which in turn support fish eagles, otters and people.

Inland waters provide a wide range of foodstuffs and other products that are useful to people: plants such as reeds for thatching and basket making, and a wide range of edible animals such as molluscs, crustaceans, fish, amphibians, reptiles and birds.

Some communities are specialized fisher folk whilst others integrate farming or other activities with fishing and exploitation of other aquatic resources: the latter may rely more on inland waters as an important safety-net when their terrestrial farming activities fail. And inland waters are also used for a number of other activities, such as providing water supplies for people, as sources of water for irrigation and power generation, for water-borne transport, tourism and leisure, and waste disposal. Not all these uses are compatible and some are harmful both to other uses and to the aquatic ecosystem as a whole. If properly managed, however, inland waters can support sustainable livelihoods and the conservation of aquatic biodiversity. Equally critical is how the entire watershed – which is the area that covers the source of the water, the mouth and the entire course of the river – is managed: inland waters are all too often the sink into which chemicals, agricultural runoff, sediments and other forms of pollution accumulates, all of which can have highly detrimental effects on aquatic ecosystems.

Exercise **Introduction to aquatic biodiversity**

Learning objective	Timing	Time	Materials
To introduce the importance of aquatic biodiversity and appreciate the broad range of species in aquatic ecosystems that are relevant to livelihoods and food security	Any time	2 hours	flipchart paper and marker pens

Steps

1 The facilitator first introduces the concept of aquatic diversity; that is the range of different types of species that coexist in aquatic ecosystems – including fish but also plants, reptiles, birds and invertebrates.

2 Participants are then asked to form groups of around six people and each group visits one of their members' farms, if this includes an aquatic body that is relevant to the farming system; or a local water/fishing site that is relevant to the community. The purpose of the visit is to carry out a rapid survey of:
- What species are observables – fish, plants, birds, amphibians, invertebrates, others?
- What direct benefits (produce) does each species provide (including less obvious and secondary ones)?
- What indirect benefits (services) might the species also provide, including in relation to traditional (cultural) practices?

3 The crops and other useful plants and trees found on the site should be recorded as a sketch map on a sheet of flip-chart paper. For each species, the direct and indirect benefits they provide are also recorded, either as drawings or as lists.

4 The group members then reassemble for plenary discussion. The facilitator leads the discussion to share results from the groups. It may be helpful to prepare summary tables of findings, as shown below.

Species diversity
- List the species (see below) with local names (and scientific names if known) and their uses
- For each species, indicate properties (specific advantages/disadvantages), such as ease of catch, storage, taste and use characteristics, and marketability; also, note down relevance of the species for cultural practices (traditional meals, religious or festive occasions), if any.
- What aquatic species used to be found in the system, but are no longer found; what others were more recently introduced?
- What plants and tree species were found and used in the aquatic system in the past, but are no longer found, and what were they

Species	Uses (properties)	Species no longer found	Uses (properties)	Species recently introduced	Uses (properties)

Exercise **Trends in fish catches**

Learning objective	Timing	Time	Materials
To determine what changes have occurred in local inland water bodies over the past few decades, what impact this has had, and to consider what actions could be taken by individuals and communities to improve sustainability of catches	Any time	2 hours	flipchart paper and marker pens

Steps

1 Pairs of volunteers are recruited who know an elderly relative or neighbour who is knowledgeable about fishing in the area. They undertake to interview the elderly person before the next training session.

2 The pair visit the elderly person and interview them about their memories of fishing when they were young:
- When are they talking about – how long ago: either linked to a date or a significant event?
- What types and numbers of fish were caught then?
- Who caught them using what equipment?
- What were the fish used for: home consumption as fresh fish; for sale; preserved in some way?
- Was fishing relied on entirely or was it combined with other livelihood activities: if so, what?
- What problems did the fisher folk encounter in those days?
- What major changes have occurred in the fishery: what caused them and what impact did they have?
- How has the water body changed: depth, size, water quality, vegetation, wildlife present, extraction of water and other competing uses etc?

3 The pairs should capture the information on a sheet of flip-chart paper using a combination of drawings and words and figures.

4 At the next training session, each pair present their findings and the facilitator leads the group in a discussion:
- What are the main changes between then and now?
- Are the changes beneficial or detrimental?
- What change has there been in the types of fish caught: species, size, numbers?
- How has the water body changed over time: what might have caused these changes?
- What actions could individuals take to improve the fishery or counter any undesirable changes?
- What actions could the community take?
- What help do individuals or the community need and what role could the farmer group play?

Sustainable utilization of aquatic species

Inland waters, whether lakes, ponds or rivers, are vulnerable to overexploitation, pollution and other threats to the sustainable utilization of the natural resources they support.

Strategies to ensure conservation of aquatic biodiversity and support sustainable livelihoods based on aquatic resources include:

- protection of fish breeding grounds
- respect of the size (age) of the fish, i.e. do not fish juveniles
- use of appropriate fishing equipment
- prevention of pollution
- diversification of livelihoods for fisher folk
- care with commercialization of fisheries
- fish farming
- care with introduction of alien species.

Protection of breeding grounds

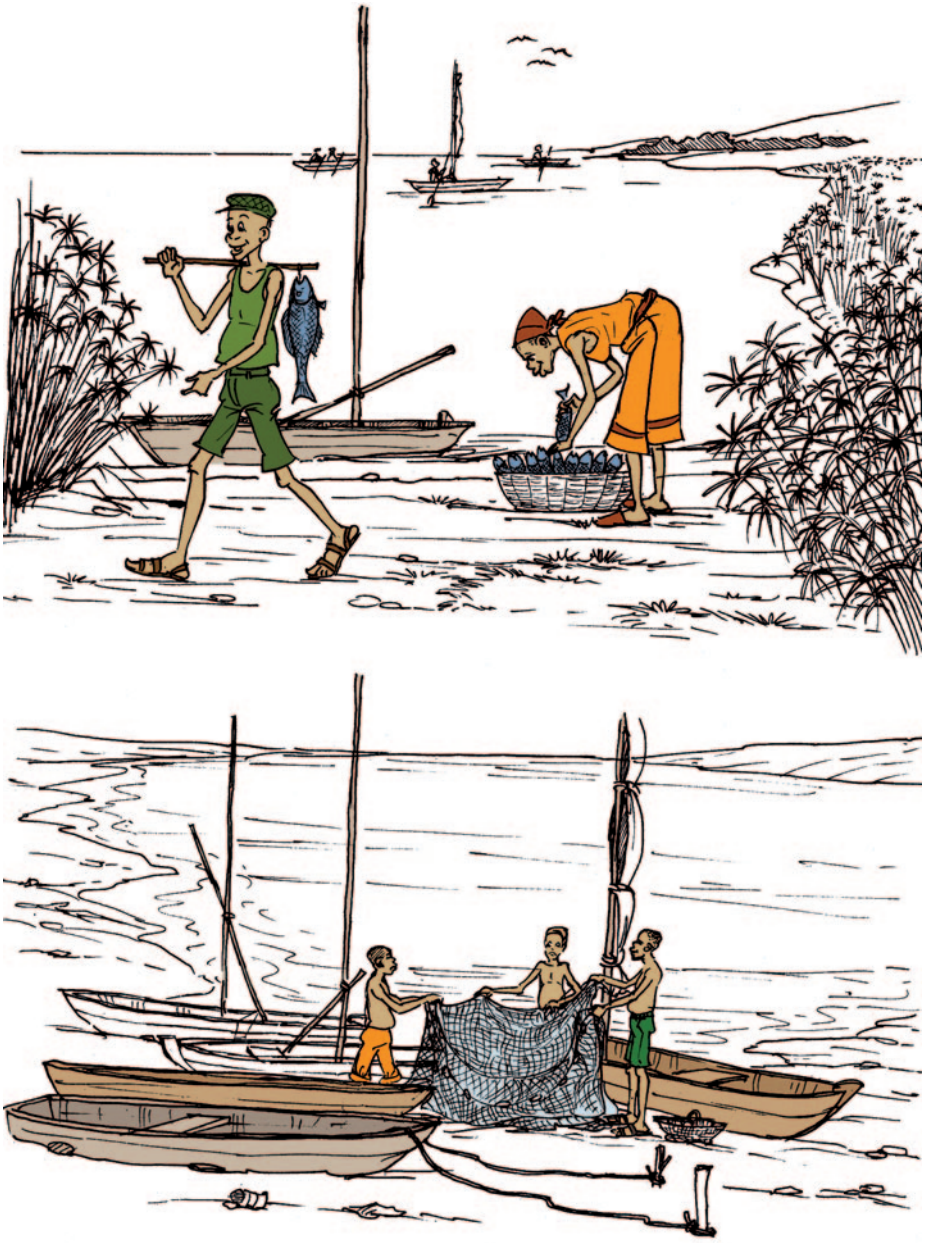
Different types of fish depend on different habitats to breed and for shelter for their fry. Some important fish breeding habitats include:

- flood plains at the peak of the rainy season: for example, for catfish and lungfish
- swampy lake shores
- water hyacinth mats, papyrus beds and other areas of dense vegetation
- flooded forests.

These habitats need to be recognized, respected and protected to ensure that fish and other aquatic species can breed successfully.

Use of appropriate fishing equipment

Traditional methods of fishing, such as the use of simple fish traps and home-made nets, have largely been replaced in many inland fisheries with modern methods which use synthetic nets and hook and line. These modern methods can be very efficient – too efficient in fact: long lengths of strong nets made of small mesh can capture nearly all the fish in an area, leaving too few to breed and sustain the population. To prevent this happening, various laws and local regulations have been introduced, which aim at conserving the fishery resource and its diversity and sustaining livelihoods: certain fishing gear and methods are totally outlawed, such as use of chemicals, poison, explosives and undersize nets. Another important thing to consider is where to use certain fishing gear. In some areas, long nets and hook lines cannot be placed across rivers or creeks, or at the entrance of lakes, because they will act as barriers and will not let fish migrate up and down a river.



Protected fish breeding grounds, above – and unprotected, below

Exercise **Based on case studies**

Case study 1

In the early 1960s through to the 1970s, Lake Naivasha had a thriving fishing industry. But the number of fishermen increased and they started using increasingly effective fishing gear. In the 1980s the catch started dropping and by early 1990s catches were so low that even the fishermen complained. Through a consultative forum of all stakeholders, it was agreed to close the lake to fishing, and reduce the number of licensed fishermen when the closed period expired. The immediate effects of these measures were loss of entire livelihoods for some and reduction of income for those who were supplementing farming with fishing.

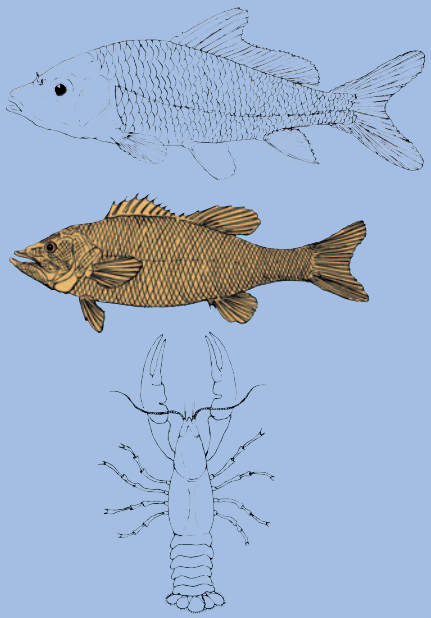
Currently the lake has somewhat recovered, but the species composition has changed. The previously dominant indigenous fish species, a type of tilapia (*Tilapia zilli*), has been replaced by common carp (*Cyprinus carpio* – top drawing), black bass (middle drawing) and crayfish (bottom drawing), none of which are indigenous to Kenya.

The facilitator generates discussion on issues to learn through questions like:

- how did the closure of the lake affect the fishermen?
- what could they have done to reduce the effects?
- how can we avoid a similar situation in the future?
- what lessons can be learned?
- in this case, are the introduced aquatic species beneficial or harmful?
- do you know of other cases where alien species have been introduced (in aquatic ecosystems or elsewhere)? If so, what impacts did this have?

The study provides some important lessons:

- Narrowly focused livelihoods are fragile and can be risky: when the Naivasha fishery closed, those who relied solely on fishing lost their livelihoods. Livelihoods that rely on a broader combination of activities, such as fishing and farming, are more resilient.
- Alien invasive species, such as carp, black bass and crayfish, can have both positive and negative impacts on food production in aquatic systems and are likely to also have other impacts on biodiversity and ecosystems: great care is needed before any deliberate introductions are made and to prevent unintended escapes, for example from fish farms.



Case Study 2

There is a beach on Lake Victoria from where good catches of tilapia and Nile perch used to be landed. However, the fishermen started to use mosquito nets as fishing nets. These small-meshed nets, which were illegal, caught large numbers of all types and sizes of fish. Despite the illegality of the nets being used, the community supported and protected those using them. Within a short period, however, fish stock declined and the fishermen started migrating to more distant waters, around a nearby island. But the local island fishermen were aware of what had happened at the beach, and violently repulsed the intruders. Although this conflict could be portrayed as a clan war, in fact the real cause was the threat to livelihoods and conservation of agrobiodiversity.

The facilitator should ask questions such as:

- what caused the conflict?
- who do you see as the person wronged?
- how would you solve/avoid this situation?

A lesson to be learnt is that misuse of natural resources can lead to conflict when competing users scramble for the limited resource available. Resolving such cases is difficult if the guilty party does not recognize their role in causing the problem or is unwilling to change their behaviour.

Case Study 3

Kogonga Farmer Field School was established to address the problem of declining catches which followed the introduction of inappropriate fishing gear and destruction of fish breeding grounds. Drawing on the provisions of the Kenya Fisheries Act (CAP 378), the school demarcated the boundary of the breeding area, prohibited fishing there and backed this up by deploying a community patrol team. The school also increased productivity in the lake by adding cow manure within the breeding zone to encourage algal growth (Note: In some situations, this action could be a source of pollution in terms of excessive nutrient loading which will reduce the oxygen-carrying capacity of the water and kill fish and other aquatic life). To supplement their income, the school embarked on alternative income-generating activities by growing tomatoes and onions for sale.

The result of this multi-pronged approach was that, after just four months, the size of Nile tilapia (*Oreochromis niloticus*; 'nyamami') caught increased to 500 grams and incomes were increased from the sale of vegetables. More recently larger fish, up to 3 kg in weight, have been caught and the food security and incomes of the whole community have improved.

Questions to ask include:

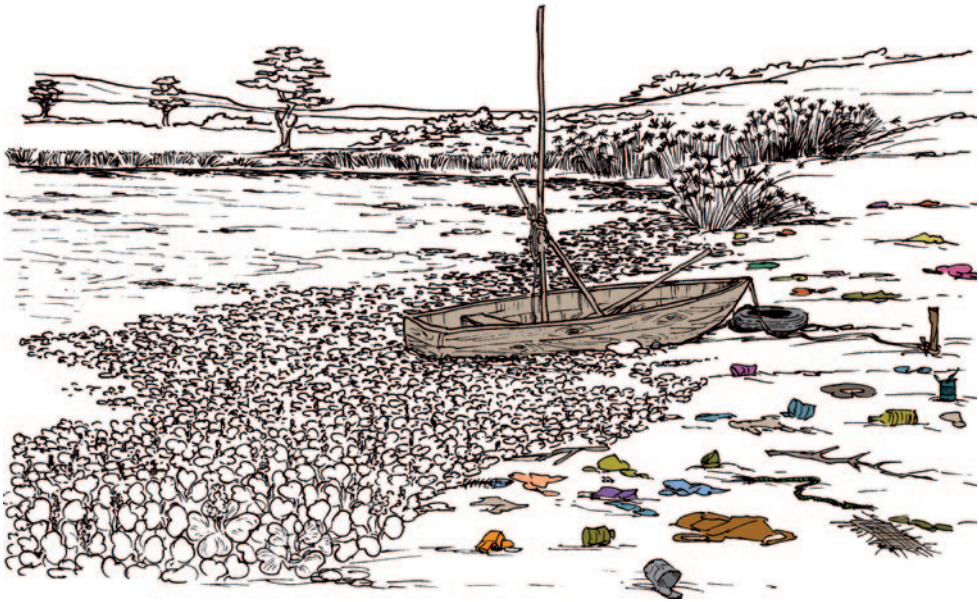
- what was the problem illustrated in the story?
- how was the problem tackled?
- how did the group members supplement their income?
- what is the situation now?
- what can we learn from this and apply in our situation?

The lessons to learn are that sound environmental management improved overall yields and that it is possible to integrate fishing with other agricultural activities.

Prevention of pollution

Pollutants can contaminate fish and other foods obtained from inland waters, which can be a direct threat to the health of people consuming those foods. Pollutants can also alter the environment leading to changes in species composition as some aquatic biodiversity will be advantaged while others will be disadvantaged.

Pollution can come from the land, water or air. Examples of pollutants include fish wastes (scales, intestines etc), oil and fuel from boat's engines, fertilizer, silt, human/animal wastes and industrial and agricultural chemicals. The use of pesticides in agriculture poses a serious threat to biodiversity – including aquatic species – for example, because of spray drift, for insecticides, and run off for pesticides. In Kenya, traces of the broad-spectrum pesticide carbofuran were found to persist, after application, in numerous environments, such as water bodies, soils and maize plants. This poses a high threat in terms of water contamination, thus to fish and amphibian populations, as well as to birds and small mammals. Studies have found that, when chemicals are used on agricultural fields near bodies of water, at concentrations sufficient to impact insect and plant populations, the richness in amphibian species in the surroundings will be lower. In addition, traces of chemicals with potential harmful effects to human health were also found in fish sold and consumed in urban markets across different counties. All this suggests that non-chemical alternatives, where possible, are preferable to the use of chemical products; and that, when the use of chemicals is necessary, products that are more selective, that is, that target a restricted group of target pests, must be preferred. **(See Module 8 "Agrobiodiversity, natural pest control and pollination services").**



Exercise **Prevention of pollution**

Learning objective	Timing	Time	Materials
To create awareness of pollution and consider what actions to be taken to mitigate and prevent further pollution	Any time	1.5 hours	Large basin, plastic bottle, sand, leaves and various types of pollution collected from the local water body, clean water, rags, paper, flip-chart paper and marker pens

Steps

1 The facilitator fills the large basin with clean water then adds into the water the assorted items that were collected. He/she then proceeds to ask participants whether they would drink the water.

2 Using the answer given, the facilitator then introduces the aspect of pollution by asking participants to list or draw pollutants that they have observed within their environment.

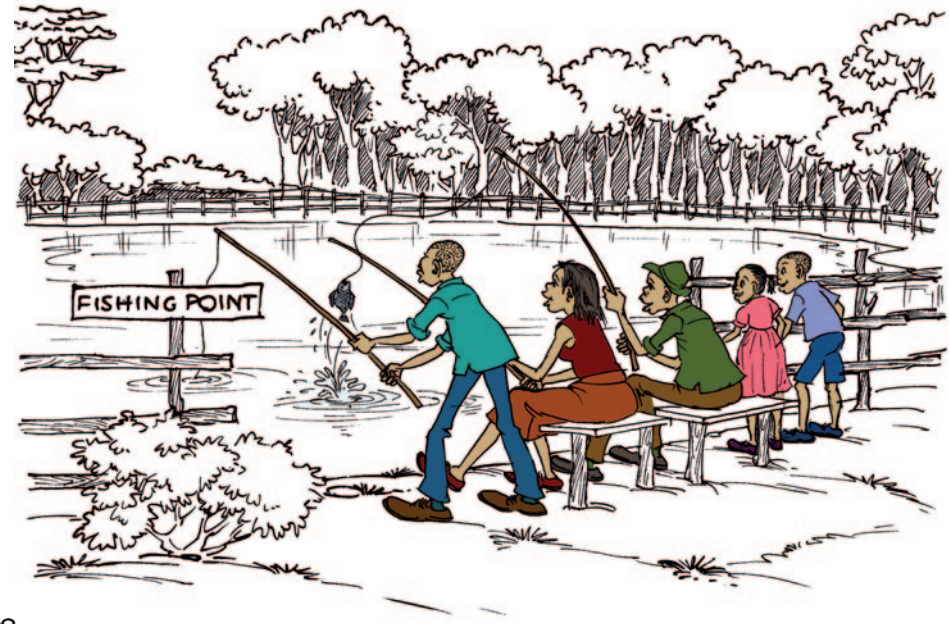
3 The facilitator then leads the group in a discussion:
- what effect does each pollutant have on the environment?
- where does the pollutant originate from?
- how does it affect their lives/livelihood?
- how can it be prevented from occurring in the environment?
- what action can individuals and the community take?
- how can they collaborate with neighbouring communities to take joint action?

Diversification of livelihoods

Livelihoods based on a single resource are vulnerable and risky. As the case study from Naivasha demonstrates, depending solely on fishing in an inland water is risky: when the fishery was closed to conserve the fish stocks, specialist fisher folk lost their entire livelihoods. Also, if people depend on fishing, as populations grow and more and more people take up fishing, inevitably the fish stock will reduce and may eventually collapse all together.

Diversifying livelihoods means combining fishing with other food producing and/or income generating activities. These might include crop or livestock-based farming, small-scale business or waged employment, amongst other options. Some combinations of activities are especially beneficial as they recycle nutrients between different production components or result in additional food production with little or no additional effort or investment. Fish farming and agriculture can be complementary activities: fish ponds provide water for irrigation or conversely water stored for irrigation can support fish; and nutrients produced on the farm, including crop wastes and animal manures, can be utilized as fish food. When fish ponds are emptied for cleaning, the silt can be a rich source of nutrients that can be used to increase soil fertility.

Integration of fishing and aquaculture into rice paddies is another opportunity: paddies can naturally contain large number of potentially useful species, including fish, shellfish and amphibians, and they can also be deliberately stocked with fish, such as carp. Inclusion of aquatic animals in rice paddies



provides motivation to reduce pesticide and herbicide use as many of the aquatic animals serve as natural predators and grazers. Integration of aquaculture and rice farming can therefore increase agrobiodiversity at the same time as increasing food production, decreasing costs for pesticide and herbicide usage, and increasing income-generating potential from the paddy.

Sport fishing in private dams is yet another opportunity that can be explored as an income generating activity. Large dams or reservoirs of water can be stocked with fish and interested parties can come and fish using line and hooks at a nominal fee. Apart from supplying food, the activity will also serve as recreation for those who want to relax and will help to promote local tourism. This activity has the advantage of not conflicting with any government policy and can also be operated at a group level. When the fish stock gets depleted, it can easily be restocked with fish from the wild or farms, thereby conserving the species while reducing pressure on other natural ecosystems.

Commercialization of fisheries

Commercialization of inland fisheries can present both opportunities and threats. If properly managed and regulated, commercialization can provide opportunities to increase cash income and generate jobs and business opportunities and, at the national level, generate foreign exchange. But there is also a risk that as the fishery is commercialized, inappropriate fishing methods, more powerful boats and modern fishing gear will be used, which can rapidly deplete fish stocks. Also, as fish are diverted to distant markets that pay a premium, local households, which have traditionally depended on fish for a large part of their diets, can experience deteriorating food and nutritional security. In some cases, just the small fish are left for the local community: where regulations prohibit the landing of such undersized fish, conflicts can arise with fisheries protection officers.

When fisheries are commercialized, often most of the benefits are captured by traders, processors and exporters rather than local, small-scale fisher folk. In some cases, fisher folk become tied to just one buyer who acquires the rights to their entire catch in exchange for loans and other inducements. In the long term, such arrangements can be disadvantageous to the fishermen, limiting their options and resulting in households being deprived of fish.

Fish farming and aquaculture

Aquaculture can take a variety of forms: inland water bodies, such as lakes, can be stocked with fast-growing species for which there is a ready market; rice paddies can be stocked with fish; and some species can be farmed in either purpose-built ponds or in existing water storage structures, such as irrigation reservoirs.

Not all species of fish can be farmed but some, including various types of tilapia and catfish have adapted well to this system.

Alien species

Alien species are plants and animals that, though not naturally found in an area, have been introduced either deliberately or accidentally. In some cases, alien species can generate beneficial economic opportunities. But inland water ecosystems are complex: it is extremely difficult to predict what impact a new species might have, and once that species is established it is often very difficult, even impossible, to remove it. Alien invasive species are non-native introduced species that spread rapidly, often displacing indigenous species and causing ecological problems.

Water hyacinth is a purple-flowered floating plant native to South America. Introduced into Africa as an ornamental plant, it has rapidly spread in freshwater bodies and is now found in Lake Victoria, Lake Naivasha and elsewhere. Water hyacinth forms dense floating mat with long roots which dangle in the water which can form excellent cover for fish eggs and fry (young fish). But they can also grow to such an extent that they prevent oxygen from entering the water, which can kill fish and other aquatic species, and prevent access to large areas by boats. Vast amounts of money have been spent trying to control water hyacinth on Lake Victoria: various methods have been tried but the most successful seems to have been the careful introduction of another alien species, a weevil (tiny beetle) from South America that feeds only on this plant.

The major component of the catch from Lake Naivasha is now made up of alien species: crayfish, black bass and carp are all introduced species. Nile perch, now an important component of the Lake Victoria fishery, is also an introduced species: this voracious predator has decimated the rich diversity of smaller indigenous fish species that used to be common in the lake.

In general, extreme care should be exercised in the deliberate introduction of alien species, and in preventing their accidental release. Laws have now been introduced which in many cases make such actions illegal.

Exercise **Alien species**

Learning objective	Timing	Time	Materials
To understand what alien and alien invasive species are, to identify alien and alien invasive species in the local area, to consider what impact they are having and what could be done to control and/or exploit them	Any time	2 hours	none

Steps

1 The facilitator starts by asking participants what they understand by the terms 'alien species' and 'alien invasive species': the objective is for all members to share a common understanding of the terms.

2 The facilitator then asks if anyone can give an example of alien species/alien invasive species anywhere in the world and what impact they had: if no examples are forthcoming the facilitator could provide an example from a different agro-ecological zone:
- What was the species?
- How did it become introduced?
- What impact did this have?
- What efforts have been made to control and/or exploit the species?

3 The group is then asked to suggest alien/alien invasive species in the local area: members are encouraged to consider plants and animals of all sizes including those that live on land and in and near water.

4 For each species suggested, members are asked to confirm whether it is an alien/alien invasive species. If it is:
- How did it become introduced, when and by who – was it an intentional introduction or an escape?
- What impact has the introduction of this species had on farming, livelihoods, the wider environment, agrobiodiversity?
- Was its introduction a good or bad thing – or are there both pros and cons which impact on different stakeholders in different ways?
- Do members consider that the introduced species needs to be controlled in some way? If so, why and what methods could be used – can these be applied at an individual level or is community or a higher level of organization needed?
- What difficulties are likely to be encountered in controlling or exploiting the introduced species? How can these difficulties be overcome? What external assistance is needed and where could this be obtained?
- What role could the farmer group play?

Integrating hiv/aids and gender issues in fish marketing

Most fish traders are women. A major challenge is how to empower women fish traders to enable them to avoid exploitation and abuse. There are instances where women have been reportedly subjected to sexual exploitation in exchange for fish. Most of these women report that they feel helpless or have no other options but to give in to the demands of the male fishermen in order to get fish to sell. This system of 'sex for fish' has been termed 'jaboya' referring to the man who would always give a particular woman priority, or even give his fish to her in exchange for sexual favours.

The issue has contributed to increase in incidences of HIV and AIDS, yet has not been adequately tackled due to its highly sensitive nature. Using a role play, the group training can facilitate discussion on this issue and highlight other options such as seeking credit, to discourage such risky behaviour.

Exercise **Role play – empowering women against 'jaboya'**

Learning objective	Timing	Preparations by group	Time
to discourage the practice of sex-for-fish and show women other ways of gaining control of the fish marketing system	any time	5 volunteers learn their roles. Invitation of local village bank official and/or fisheries officer to attend training session	20 minutes for the role play and 1.5 hours for discussion and question and answer session with village bank official/fisheries officer

Steps

1 The facilitator asks for five volunteers and explains the storyline. The actors then act before the whole group after learning their parts.

Actor 1: A woman arriving at the beach looking for fish to purchase approaches **Actor 2**, a fisherman, who admires her and openly seduces her. She refuses and so the fisherman suddenly hikes the price of his fish. She protests over the price hike and the man threatens to move on with his fish. The woman laments over the responsibilities she has to fulfil to her family and how fish trade is the only way she can cope. The man states that she has two options pay up or 'pay in kind'.

Actor 3: A second woman trader passes by and finds Actor 1 in a dilemma over which option to take. She questions her friend over what brought her to the beach and why she was talking to a man of such bad repute in the village. After a struggle, Actor 1 explains her dilemma.

Actor 3 offers to help by taking her friend to introduce her to her village bank official (**Actor 4**). The village bank official then explains the easy terms by which seed money can be obtained and offers to take her to the beach *banda* (the shed where fish is weighed and sold).

The women go to the beach *banda* where she purchases her fish without any conditions attached. She expresses her surprise and the man (**Actor 5**) at the *banda* explains that fish prices at the *banda* are regulated and the Beach Management Unit and Fisheries Officials ensure fairness in the trade. She turns towards Actor 2, who is embarrassed and disappears from the vicinity as the woman expresses gratitude for being delivered from his grip.

2 The facilitator then leads a discussion about fish marketing, then invites the village bank official and/or fisheries officer who have been invited to attend the session to answer questions asked by participants.

Season-long trial

Increasing and diversifying fish pond yields

Introduction

The tilapia is a popular choice for rearing by fish farmers. However, tilapia tend to breed rapidly, resulting in lots of small fish but few larger fish that are marketable

Objectives

To evaluate tilapia growth rates in polyculture (that is tilapia reared together with a species of catfish) compared to monoculture (just tilapia) ponds

Materials

- labour to construct two ponds
- two 2.5 inch PVC pipes for inlets and outlets
- 50 kg agri-lime for the two ponds (optional)
- 360 kg of manure
- 400 tilapia fingerlings
- 20 catfish fingerlings
- 400kg of supplementary feeds (home formulation* is cheaper but commercial dairy meal is convenient)
- ruler and weighing scale

*** Home-made feed should consist of 60% milled cereal grain (maize, wheat, rice or their by-products) and 40% protein (milled lake shrimp, omena dust, omena, blood or soya bean meal). The feed should be well mixed and fed dry, in powder form.**

Steps

1. Two similar fish ponds, each at least 10 m long by 10 m wide with a depth of 1 m, are constructed close to each other and fertilized in the normal way in preparation for stocking with tilapia.
2. Each pond is stocked at the same time with 200 fingerlings of tilapia (both sexes).

3. After one month, pond 2 is also stocked with 20 catfish (*Clarias gariepinus*) fingerlings. No catfish are added to pond 1.

4. Both ponds are treated the same, with similar amounts of food provided to each for a period of 8 months from the time of initial stocking with tilapia.
5. Equal amounts of manure are applied to both ponds for the whole period.
6. Monthly sampling of fish is conducted to determine how the tilapia are growing in terms of length and weight (20 tilapia are caught each month for monitoring and then released back into the ponds. The average weight or length of the tilapia is calculated: add together the weight or length of each of the 20 tilapia and divide this total by 20 to give the average weight/length).

Parameters to be measured

Average total length of tilapia (from tip of mouth to end of the tail) and/or average total weight of tilapia

	Pond 1		Pond 2	
month	Average length (cm)	Average weight (g)	Average length (cm)	Average weight (g)
1				
2				
3				
4				
…				
8				

At the end of the trial the facilitator leads a discussion

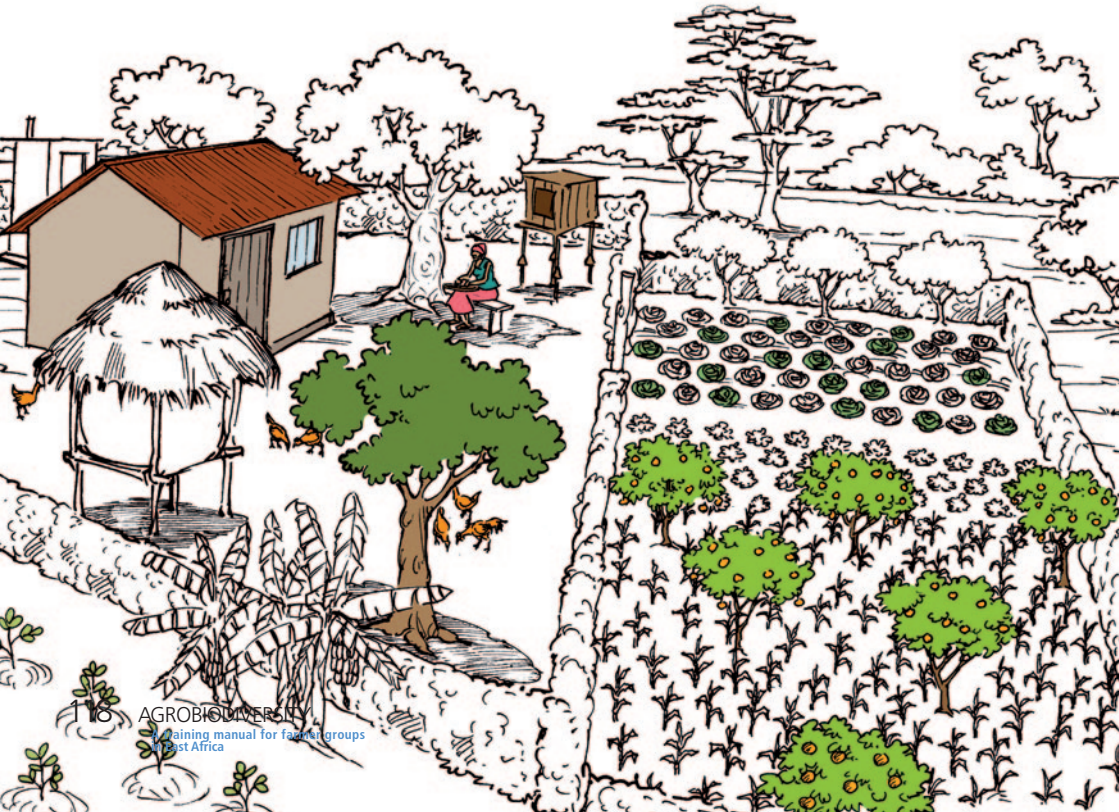
- What effect did the catfish have on the growth of tilapia?
- What effect did the catfish have on the number of tilapia (adults and fingerlings) in the pond at the end of the trial?
- Were the catfish tasty and was there a market for any surpluses?
- What advantages or disadvantages did each set-up have in terms of production?
- How are responsibilities distributed between men, women and youths in fish farming, for example pond construction, feeding, pond maintenance, harvesting and marketing?
- Which system best promotes food security: monoculture or polyculture? Is diversification of types of fish reared good for food security?
- What options are there for utilization of the fish produced, such as home consumption, sales, value addition?

MODULE 6

agroforestry, communal forestry resources and related services

This module:

- **Defines agroforestry in the context of ecosystems**
- **Reviews the importance of trees in a range of situations**
- **Considers the benefits of agroforestry**
- **Describes the links between forestry resources, poverty alleviation and food security**
- **Explores the relationship between forests and water**
- **Describes how tree nurseries can be established and managed**
- **Reviews alternatives to – and ways of reducing the need for – fuel wood**
- **Discusses issues with invasive species, using the case of *Prosopis***



What is agroforestry?

Agroforestry is defined here to mean the integration of trees with crops and livestock, with the objective of diversifying and sustaining agricultural production and sustainably managing agro-ecosystems, to enjoy multiple social, economic and environmental benefits, both direct and indirect, from the trees in the system.

Forestry management and ecosystems

Ecosystems are natural systems made up of plants, animals and micro-organisms linked to the physical features of the landscape, all of which interact. Ecosystems include natural systems such as grasslands and forests.

Agro-ecosystems are specific types of ecosystem which depend on human activity and from which people derive food and other useful products and services.

Any activities that attempt to manage ecosystems need to take into consideration the many goods and services that the ecosystem provides at different levels, including individual species and interactions between different species and the environment. Especially for agro-ecosystems, the role of the interaction of people with these different levels of biodiversity also needs to be considered. Any change at one of the different levels – from an individual species, communities of species, up to the entire landscape – may impact on essential services, such as nutrient recycling, pollination, predator-pest relationships or the regulation of the water cycle.

Agroforestry management therefore needs to be considered in the context of broader agro-ecosystems and agrobiodiversity.

Trees

Trees are an important natural resource and include:

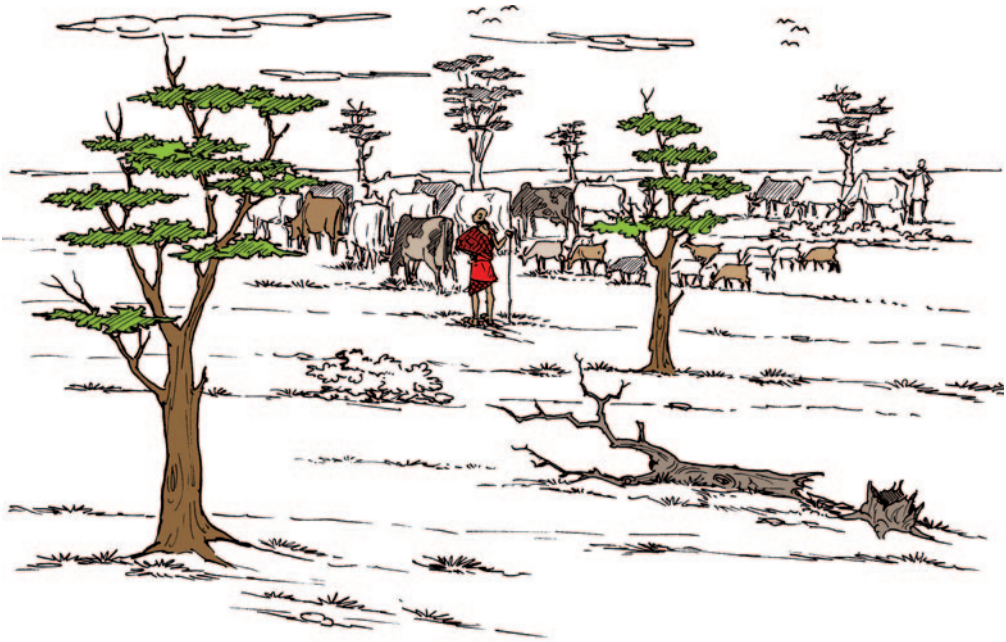
- trees within natural forests
- trees within planted forests
- trees on rangeland
- trees on farms.

Trees on rangeland

Rangelands in eastern Africa are landscapes in arid and semi-arid areas where the predominant vegetation is grass but where there are also areas of woodland and shrub land as well as scattered trees.

Traditionally, rangelands have been utilized by pastoralist people to graze and browse their herds and flocks of livestock. They also often support large numbers of wild animals, especially grazers

and browsers, such as antelopes, zebras, giraffes and elephants, and predators, such as lions and hyenas, as well as countless smaller species.



Natural vegetation, including trees and shrubs, plays an important role in stabilizing and protecting fragile rangeland soils, and also fuelwood, poles for building, thorny branches for livestock *bomas*, herbal medicines, gum arabic, forage for livestock and fodder for bees, and shade for people and livestock, among others **(see also Module 4 "Livestock and agrobiodiversity").**

Trees on farms: agroforestry

Trees and shrubs play an important role in nearly all land-based ecosystems. But when land is developed for agriculture, trees and shrubs that were naturally growing on the site are usually cleared. The benefits that trees and shrubs provide, however, can be restored by planting selected trees and shrubs into agricultural landscapes – a practice known as agroforestry.

Trees and shrubs can be used in many different situations on a farm. The choice for individual farmers will depend on their objectives and local circumstances. Some ways that trees and shrubs

can be incorporated into farms include:

- dispersed in crop land: scattered trees grown in the field providing shelter and enhancing soil fertility
- along boundaries and as living fences and hedges
- on soil conservation structures, such as to stabilize terraces
- alley cropping: selected trees and shrubs (often leguminous species) planted between rows of crops
- as windbreaks
- as shelter and shade around homesteads and for livestock
- as woodlots
- as fodder-lots for livestock
- as sources of tree-based medicinal products.

Fodder legume trees:
leucaena (top)
and calliandra (bottom)

Exercise **Trees on farms**

Learning objective	Timing	Preparations by group	Time	Materials
To appreciate the multiple benefits of growing trees on farms, to identify opportunities for planting additional trees and to consider what trees could be planted where	Any time	None	2 hours for tree surveys and an additional 2 hours for groups to present their findings and for a facilitated discussion	Tree identification book (such as *Trees of Kenya* by Tim Noad and Ann Birnie), flip-chart paper and marker pens

Steps

1 Participants form groups of about six people. Each group chooses one of their members' farms to visit: this could either be a farm they know has many trees on it or one that has few trees.

2 The groups visit their selected farms and observe the trees growing there:
- What types of trees are growing (if the species cannot be identified, samples of the leaves, flowers, fruit and/or bark should be collected and a sketch of the tree made showing size, shape and location should be made for later identification either by other group members or using a tree book)?
- Where are the trees growing within the farm and what function are they serving?
- What products and services are the trees providing?
- Are there any disadvantages associated with any of the trees: such as shading crops, competing for nutrients and water?
- Are there opportunities to plant additional trees that will complement or be compatible with other crops and farm enterprises? Which types of tree could be planted? Which opportunities should be prioritized and why?

3 The groups record the information about trees on the farm in the form of a map which shows what type of trees are being grown where and where additional trees could usefully grow. For each type of tree the direct and indirect benefits provided are indicated, both at household and community level.

4 The groups present their findings back in plenary and the facilitator guides a discussion about the findings:
- Were the farmers taking maximum advantage of the opportunities their farms presented for planting trees?
- What constraints are there to planting additional trees?
- How could the farmer group help overcome these constraints?
- Which tree species used to be found within the locality but cannot be found now?

Benefits from agroforestry

Agroforestry focuses on species of trees and shrubs which are particularly useful for the products and services they provide.

Some examples of useful products and services include: legume trees and shrubs which fix nitrogen and improve soil fertility; fruit and nut trees; fodder trees, especially legumes that provide protein-rich fodder for livestock even during dry periods; forage for bees; and timber, poles and fuelwood.

Many trees are multipurpose, providing a range of benefits at the same time. For example, a legume tree may provide shelter, timber, act as a living hedge, prevent soil erosion, fix nitrogen, feed bees and other pollinating species with nectar from its flowers, provide protein-rich fodder for livestock from its leaves and pods and nitrogen-rich mulch from its leaves.

Trees on farms diversify production and contribute to sustainable livelihoods. By providing foodstuffs and other useful products which can be sold in times of need, they enhance food and nutritional security and increase incomes. Agroforestry systems are found particularly beneficial for women, who are often the ones burdened with the task of collecting fruits, forage and fuelwood from trees. Increased access to such products on farm can have multiple benefits, as it frees up time that can be dedicated to other activities, including potentially income-generating ones. In addition, increased access to tree products can have a beneficial impact on individual and household nutritional status – directly, through increased diversity of foods available on farm, and indirectly, as having access to more fuelwood can facilitate the preparation of foods that are more nutritious, but require more energy for cooking.

Diverse benefits from trees

Agroforestry and agrobiodiversity

Agroforestry contributes to agrobiodiversity in several ways. At the local level these include: directly increasing the diversity of plants on the farm; reducing the pressure on natural/communal woodland and bush land by producing fuelwood, timber, fodder and medicinal products on-farm; enhancing sustainable agriculture through prevention of soil erosion and improvement of soil fertility; and providing habitats for a wide range of animals, plants and micro-organisms, including beneficial insects and birds which pollinate crops and control crop pests.

On a larger scale, growing trees can act as carbon sinks, removing carbon dioxide from the air, and thereby making a contribution to the control of global warming. Trees also help stabilize watersheds (by allowing water to infiltrate slowly and therefore enabling a continuous flow of water in streams and other water bodies) and can increase local rainfall by creating micro-climates (changes to the climate of that particular area which can impact on the water cycle). In recognition of the important services that trees provide, Payment for Ecosystem Services schemes are in place throughout the world, to reward farmers for the environmental services their trees provide, especially in relation to carbon sequestration and conservation of wildlife.

Forestry resources, poverty alleviation and food security

Resource-poor people living in rural areas depend largely on natural resources for their livelihoods. Individual land holdings tend to be small and are becoming smaller due to population growth and sub-division, increasing the pressure to diversify, intensify and secure some needs from off-farm activities. Some of the poorest people own no land at all.

Sustainably managed common forestry resources can enhance people's livelihoods and wellbeing through both direct and indirect benefits, thereby reducing poverty.

Forest resources, as well as trees on farms, offer the benefit of not having a fixed harvesting time. Resources such as trees can be harvested in times of need; in this respect they can operate as a savings mechanism, in a similar way to livestock.

Direct benefits include physical products that can be collected in forests or made from forest resources, such as:

- fuelwood, charcoal
- timber, poles
- thatching materials and fibres
- wild fruits, nuts, mushrooms
- medicinal plants
- resins and gums
- honey
- wild animals and birds.

Indirect benefits include the wide range of environmental services that forests provide:

- protection of watersheds and catchments
- formation of soils
- nutrient recycling and access to nutrients in deep soils
- creation of micro-climates
- conservation of biodiversity
- carbon sequestration
- cultural, spiritual and leisure amenities.

Sustainable management of common forest resources will enhance food security and provide opportunities for income generating activities, including non-traditional activities such as ecotourism and butterfly farming. Identifying opportunities to add value to raw materials, to produce goods and services that meet real demands and to access viable markets will further enhance the poverty alleviating potential of forestry resources. In all cases, however, care must be taken to avoid overexploitation of forestry resources and minimize risks taken by poor people.

To be successful, such poverty-reduction initiatives need to be built on a strong foundation. Before starting any community-based forestry initiative, it is important to assess whether:

- communities have clear tenure and access rights (do they enjoy rights that last for longer than it takes a tree to grow to maturity?)
- good governance prevails in the community
- community members understand the link between sustainable forestry and poverty alleviation and have the capacity to manage the resources accordingly.

Exercise **Direct and indirect benefits from trees**

Learning objective	Timing	Time	Materials
To learn about the benefits from trees and agroforestry systems	Any time	2 hours	Tree identification guidebook, flip-chart paper and pens

Steps

1 Participants form small groups of about six people each and first consider the physical products (direct benefits) they can obtain from different types of trees that grow in the local area, either planted on farms or naturally growing. They should be encouraged to think of foods and other natural products that are derived from trees or places where trees grow, and products that can be made from trees and forestry products. The group should be asked to capture the products in the form of drawings, one per tree species. Drawings should show the tree, which should be identified either by name or by showing its main features for later identification, where it grows, and the direct benefits it provides.

2 Next, participants should consider indirect benefits they gain from trees, that is, benefits other than physical products. They should be encouraged to think of benefits that are very local as well as those that are enjoyed further afield. To get the process going, ask for suggestions to be sure that everyone understands what is required; offer a suggestion such as 'shade' in case suggestions are not forthcoming. The group should be asked to capture the indirect benefits by adding these to the drawings.

3 The groups share their findings in plenary and the facilitator leads a group discussion:

- What constraints are there to obtaining products from trees on communal land and government-owned forests?
- Will they plant more trees on their farms? If so, which trees will they plant and why?
- Where will the seedlings come from and how and where will they plant them?
- Has this session changed members' attitudes to trees?
- What help can the farmer group provide so members can derive more benefits from trees in the future?

Relationship between forests and water

Water scarcity is a major threat to achieving food security and reducing poverty. The impacts of climate change and population growth are likely to make water even scarcer in coming decades.

Well-managed forests, natural and planted, as well as trees on farms, can have a beneficial impact on water supplies by:

- improving the quality of water, such as by reducing soil erosion
- regulating the seasonal flow, by acting as a sponge
- reducing the rate of runoff – preventing landslides and floods
- creating micro-climates.

This means a more dependable supply of water to meet people's basic requirements and for agriculture, and a reduction in water-related shocks, thereby improving wellbeing and food security.

Tree nursery establishment and management

Farmers and communities need ready access to affordable and healthy tree and shrub seedlings, of species that are suited to the local conditions, to enable them to practice agroforestry or to plant or replant forests.

Establishment of small-scale tree nurseries, either by individuals or groups, such as women's or youth groups, is a simple and practical way of ensuring suitable tree seedlings are available in the local area. Tree nurseries can also be an income generating opportunity.

In a tree nursery, trees and shrubs are grown either from seeds or cuttings, depending on the species. Seeds and cuttings can either be sown or planted in containers or in nursery beds. In dry areas, growing tree seedlings in containers can be beneficial as they experience less shock when transplanted to their final planting positions.

Seed identification and sourcing

It is important that the types of seeds or propagation materials suitable for the locality are identified and the sources from which they can be found identified. For example, can seeds or wildings be collected from nearby forests or from around mature trees, or from organizations dealing with trees, such as the forestry department or an NGO? Collecting and selling tree seeds to tree nurseries or other institutions may also be an income-generating activity.

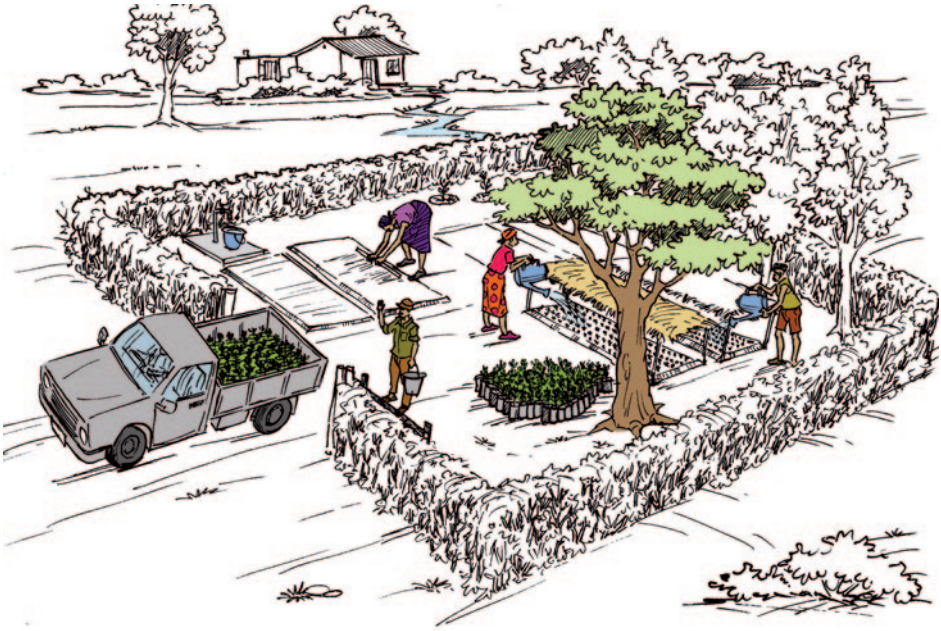
Sites for tree nurseries

To raise 10,000 seedlings a year requires an area of at least 10 metres x 10 metres. Nursery beds should be around 1 metre wide with 1 metre between beds to allow easy access. The site should be:

- level or terraced
- accessible to vehicles
- sheltered by a windbreak
- well–drained
- lightly shaded by trees
- protected from livestock by a thorny living fence
- near a water source: 10,000 seedlings need 300 litres of water a day.

In dry areas, sunken beds can be useful to conserve water and prevent seedlings from drying out too quickly. Dense shading is needed for freshly transplanted seedlings: this can be provided by woven mats of grass or other locally available materials, suspended above the beds using small poles as support.

Up to 50 000 seedlings can be watered by hand using a watering can; for larger nurseries piped water is recommended.



Container raised seedlings

Seedlings can be grown in either specially made 20 cm wide polythene tubing, which is cut into lengths of 10 cm, tied to make bags and holes made in the base to allow good drainage. Alternatively, re-used containers can be used such as milk packets, plastic cooking fat containers or tins.

Containers should be filled with a well-drained potting soil, such as soil (forest soil is ideal) mixed with sand, watered well to allow the soil to settle, and then several seeds sown per container. The soil is covered with cut grass to reduce evaporation of water and placed under shade. Alternatively, seeds can be sown in boxes or nursery beds and later transplanted into containers when their first true leaves appear.

Tree seedlings need the following attention:

- nursery beds and containers need to be kept free from weeds and protected from pests
- watering should be done regularly
- roots that grow out of the container need to be pruned, about every two weeks
- hardening off: reduce watering 2 to 4 weeks prior to planting and gradually remove shade
- planning and record keeping: it is useful to keep records of trees sown and costs incurred.

Alternatives to fuelwood

Most of the world's poorest people rely on fuelwood or charcoal for their energy needs, especially cooking.

The need to collect fuelwood is a burden, especially for women and children who are often principally responsible for this activity. Most fuelwood is collected from scattered trees, fallow or uncultivated land and forests; unrestricted and unregulated open access can lead to depletion of resources, degradation and eventually desertification.

In many areas, harvesting wood and making charcoal is illegal – and yet, resource-poor people have few alternative means of satisfying their energy needs. Collection and sale of fuelwood or

making of charcoal is an income-generating activity that requires little or no capital, and so is accessible to the poor and even the landless.

Reducing need for fuelwood

There are several approaches to reducing the need to collect fuelwood that can relieve pressure on overexploited natural resources and reduce the burden on women and children.

These include:

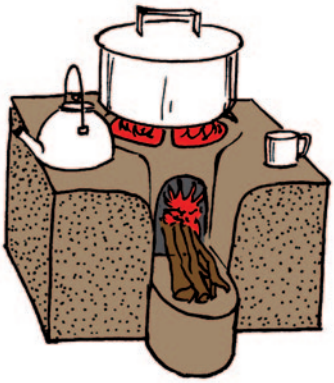
- planting fast-growing trees (such as clones of eucalyptus that are resistant to pests and diseases) for fuelwood harvesting on farms or in communally-managed woodlots, such as at schools
- burning alternative fuels (see below)
- using energy-efficient stoves (*jikos*) rather than open fires
- using 'fireless' cookers
- diversification of income generating activities away from reliance on selling fuelwood and charcoal.

Alternative fuels include:

- dry maize stalks
- dry leaves
- sawdust
- cow dung
- dry maize cobs
- coffee husks
- sugar cane waste
- biogas
- solar (solar boxes).

Energy-efficient stoves

Cooking on traditional three-stone fires is inefficient: most of the heat produced is lost to the environment. Cooking is usually done indoors and these fires produce a lot of smoke, which is known to be harmful to health.



Simple energy-efficient stoves, such as the *Upesi* stove, are designed to be more efficient: heat produced from burning wood or other fuel is retained, less heat escapes into the atmosphere and the amount of fuel used can be reduced by half. An additional benefit is that less smoke is produced, which means less respiratory diseases especially for women and children: household smoke is a major killer of children under five.

Upesi stoves are made from clay, which is fired in a kiln. The clay acts as an insulator, retaining the heat from the burning fuel and directing it to the cooking pot. In western Kenya, successful projects have been established in which women have been trained to make *Upesi* stoves, providing them with an income as well as making the stoves available locally.

Another approach to introducing energy-efficient stoves in Kenya has focused on schools. One project supplies large, energy-efficient stoves to boarding schools by providing a revolving loan: the school pays back the loan from savings on woodfuel expenditure and the loan is then advanced to more schools.

'Fireless' cookers

Fireless cookers are simple insulated containers. Foodstuffs are first cooked for a short time on a conventional cooking fire or stove before being transferred to the fireless cooker, where they continue to cook slowly for up to 6 hours with no further use of fuel, saving up to 70% of the fuel that would otherwise be required.

The insulated container can be a simple basket, box or sack – anything which is large enough to take the cooking pot and at least 100 mm of insulating material to pack round it. The insulating material can be hay, straw or any other available material that provides good insulation.

With beans, which can be harmful if not adequately cooked, it is important that they are boiled for at least 15 minutes before being transferred to the fire-less cooker for 1.5 to 2 hours to finish cooking and become soft.

Exercise **Comparison of fuel needs for conventional versus fireless cooking**

Learning objective	Timing	Preparations by group	Time	Materials
To introduce the fireless cooker and to investigate its potential for saving fuelwood	Any time	To collect enough fuelwood to cook two pots of beans on two conventional three-stone fires	1 hour for introduction and making of fireless cookers. 2.5 hours to cook the beans. 1 hour to sample beans and discuss potential benefits and applicability of the technology	Two cooking pots, stones for two three-stone fire and beans for cooking, and a sack or basket and dried grass or other insulating material to make the fireless cooker

Steps

1 The concept of fireless cookers is introduced, ideally by showing an example of a fire-less cooker or some printed materials from a project which promotes this technology.

2 Some volunteers make a fireless cooker as a demonstration for the farmer group. All members are encouraged to make suggestions for improvements.

3 Two piles of fuelwood are prepared, each contain a similar quantity of wood that is considered to be more than enough to cook a pot of beans on a conventional cooking fire.

4 Participants then divide into two groups: one group cooks beans conventionally using a three-stone fire, the other starts the beans on an energy-efficient stove for 15 minutes before transferring the cooking pot to the fireless stove (the two main groups could be subdivided into sub-groups so more people are directly involved).

5 Each group completes the cooking of the beans. During the 2 hours that the beans are left in the fireless cooker additional activities can be undertaken.

6 After two hours the beans are removed from the fireless cooker and compared to those cooked over the conventional fire. Participants taste each pot of beans and the facilitator leads a discussion:

- Are there any differences in the taste or appearance of the beans?
- How much fuelwood is left in each pile? Did the beans cooked using the fireless cooker use less fuel? If so, is this saving worth the effort of making the cooker?
- What impact could this saving have on the household and community?
- Are there any benefits other than fuel wood saving?
- What improvements to the design or alternative choices of material might make a better fireless cooker?
- Would participants consider adopting the fireless cooker? If so, what would they make it from and what would they use it for?
- In what situations would the fireless cooker be used and for what would it not be suitable?
- What other fuel-saving initiatives could be adopted to provide further fuel savings?

Exercise **Reducing requirement for fuelwood**

Learning objective	Timing	Preparations by group	Time	Materials
To get participants thinking about their current fuelwood requirements, how and at what cost these are met and possible ways of improving the supply or reducing the amount required which will bring benefits at household and community level	Any time	None	2 hours	none

Steps

1 First, the facilitator guides a discussion on fuels used for cooking: what fuels are used, where do they come from, how long or much money does this cost a household each day.

2 Have participants ever considered how they could save time and/or money by reducing their fuel requirements – without stopping cooking? Participants brainstorm on possible ways of reducing amount of fuel needed.

3 If ideas do not arise from brainstorming, facilitator asks participants to consider different approaches: increasing amount of fuel wood available, using alternative fuels, using energy-savings approaches…

4 Are there any additional benefits or constraints at the household level associated with these options? How can the farmer group help overcome constraints? Are there projects and organizations that can help? Can a plan of action be drawn up to reduce fuelwood requirements for group members and the wider community?

5 What benefits may arise at community, national or regional levels if fuelwood requirements could be reduced?

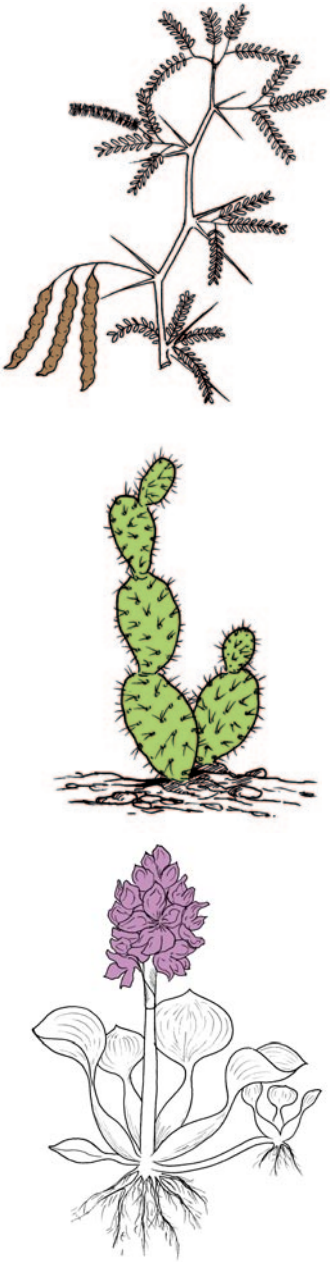
Alien invasive species

Alien invasive species are plants or animals that are not naturally found in an area, the accidental or deliberate introduction of which has or is likely to cause economic or environmental harm.

The case of *Prosopis juliflora* and several closely related species in Kenya illustrates some of the problems that invasive species can cause.

Prosopis are thorny shrubs or trees which grow up to 10 metres tall, are salt- and drought-tolerant and can grow in areas receiving as little as 50 mm of rainfall per year. Originally native to the Americas, it is believed they were first introduced to Kenya in 1973 for use in rehabilitation of quarries with saline soils in Mombasa. Since then they have been planted in many dryland areas of Kenya, rapidly spreading to create large, dense, impenetrable thickets where livestock can no longer graze. There is also concern about the detrimental impact of this aggressive invader on local biodiversity as they displace indigenous species. Many residents of areas where Prosopis has become established regard them as weeds and have called for them to be removed, but this would be very expensive and is probably impossible. However, Prosopis also has some useful characteristics: it grows rapidly and produces biomass that can be used as excellent fuelwood or can be made into charcoal and its timber can be used for carvings, furniture and other useful products.

The lesson to be learned from *Prosopis* in Kenya is that great care needs to be taken before species not native to an area are introduced. Ecosystems are complex and it is very difficult to guess what impacts – good or bad – such an introduction may have. Experience from *Prosopis* in Kenya – and also from water hyacinth in Kenya's lakes and rivers **(see Module 5 "Inland aquatic biodiversity")**, prickly pear (*Opuntia* spp) on rangeland and lantana (a shrub) throughout much of the country - and for many other species throughout the world, is that in most cases introduction of alien species is detrimental and should be avoided. Once these invasive species become established it is often impossible to eradicate them.



Alien invasive species: Prosopis juliflora (top); prickly pear (middle); hyacinth (bottom)

Season-long trial

Woodlot for timber with agricultural crops[1]

Introduction

This trial compares the performance of two timber species planted with agricultural crops at a moderate spacing and also the crop yields during the first two years

Materials

- implements for land preparation and cultivation
- maize / sorghum / millet and pigeon peas seeds
- tree seedlings of two different species, as chosen by the group
- sticks, tape measure, ruler, string, note books and pencil

[1] **Adapted from: Farm Forestry and Nursery Establishment (2004). Compiled by Jane N. Ndeti, Shinji Ogawa, J. M. Kimondo, P. M. Kariuki. Intensified Social Forestry Project in Semiarid Areas**

Steps

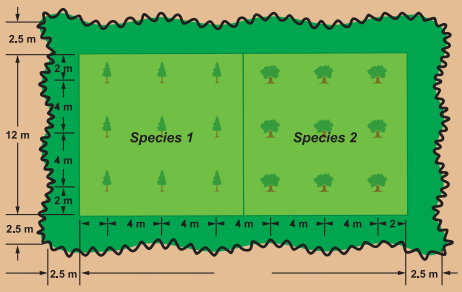
Year 1

1 Select a piece of land, 29 metres by 17 metres, with similar soil characteristics throughout and which is flat or gently sloping. This plot should be provided by one member of the group and be available for at least 2 years, preferably longer.

2 Prepare the land by clearing any bushes and shrubs before the rainy season starts. The land should also be ripped using an oxen plough to increase infiltration of rain water.

3 Divide the plot into two equal plots, each 12 metres by 12 metres.

4 Mark the sites for tree planting spaced at 4 metre intervals, as shown in the layout below:



5 Dig tree planting holes measuring at least 30 cm by 30 cm wide and 30 cm deep.

6 Before the onset of the rains, identify where seedlings of the selected species are available, purchase and transport them near to the planting site.

7. In both plots sow the maize, sorghum or millet varieties that are normally grown, using the normal spacing and density recommended for the area.

8. Plant pigeon peas in the strip 2.5 metres wide surrounding the plot. This is to ensure that the plot is protected from animals.

9 After the onset of the rains, plant the tree seedlings of the two species selected as early as possible so that they can take full advantage of the rains.

10 Weed the plot according to normal farming practice. Oxen ploughs should be used to plough the land between crops to improve water infiltration.

11 At regular intervals during the season, monitor crop and tree growth, i.e. tree survival, tree damage, tree height, crop height, number of live and dead leaves, and record the number of cobs on at least five maize plants (or other crops as grown) in each plot. Observe pest and disease both in trees and crops.

12 When the crops are ready, the group should meet and agree on the day to harvest.

13 From each of the two plots harvest carefully each plot separately, measure the yields from each of plot and comparing the yields.

14 Compare the survival and height of the two tree species selected.

Year 2

15 Remark and prepare the same two plots before the rainy season starts. The land should also be ripped using oxen plough. Extreme care should be taken to ensure that the young trees are not damaged.

16 Plant the same maize/ sorghum / millet varieties as in year one at the recommended spacing.

17 Again, plant pigeon peas in the 2.5m-wide strip surrounding the plot.

18 Weed the plot according to normal farming practice. Oxen ploughs should be used to plough the land between crops to improve water infiltration and its subsequent conservation.

19 At regular intervals during the season, monitor crop and tree growth, i.e. tree survival, tree damage, tree height, crop length, number of life and dead leaves and record the number of cobs on at least five maize plants in each plot of 12m by 12m. Observe pest and disease both in trees and crops.

20 When the crops are ready for harvesting, harvest each plot separately, measure carefully and compare the yields from both plots.

21 Do a cost-benefit analysis to evaluate the advantages and disadvantages of growing tree species together with agricultural crops.

The facilitator should lead a discussion:

- Was there a crop yield difference between the two different plots?
- Was there difference in tree height and survival between the two selected species in year one and year two?
- Were there any advantages and disadvantages of intercropping each tree species with food crops?
- What problems were encountered in the establishment and management of the

Season-long trial

Woodlot for poles and firewood[1]

Introduction

In this trial the growth of planted wood fuel species in a woodlot and native wood fuel species in natural stands of a firewood collection area are compared

Materials

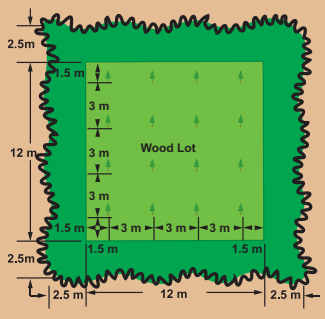
- implements for land preparation and cultivation
- pigeon peas and beans / green grams seeds
- seedlings of one selected tree for wood fuel as chosen by the group
- sticks, string, tape measure, ruler, pencil, gloss paint and note books

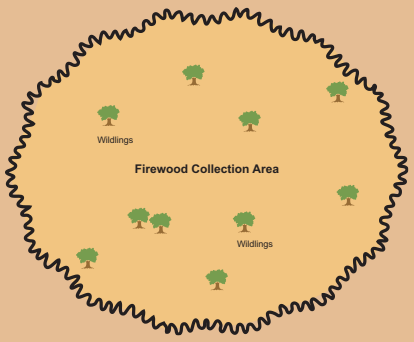
[1] **Adapted from: Farm Forestry and Nursery Establishment (2004). Compiled by Jane N. Ndeti, Shinji Ogawa, J. M. Kimondo, P. M. Kariuki. Intensified Social Forestry Project in Semiarid Areas**

Steps

Year 1

1. Select a piece of land measuring 17m by 17m with relatively uniform soil throughout on a flat or gently sloping area. This land should be provided by one of group member and be available for at least 2 years, preferably longer.
2. Prepare the land by clearing of bushes and shrubs before the rainy season starts. The land should also be ripped using oxen plough to increase infiltration of rain water.
3. Mark the inner plot of 12 metres by 12 metres.
4. Stake out the sites for tree planting at 3 metre intervals, before the rains start, as shown in the layout below:
5. Dig tree planting holes measuring at least 30 cm by 30 cm wide and 30 cm deep.
6. Before the onset of the rains, identify where seedlings of the selected species are available, purchase and transport them near to the planting site.
7. Before the onset of rain go to a nearby firewood collecting site. Find the small wildlings (about one foot (30 cm) tall or the same size as the seedlings to be planted in the wood lot) of commonly used firewood species and mark using gloss paint at least 10 wildlings so their growth can be monitored over the coming years.
8. In the woodlot, sow the selected beans/ green grams varieties at the spacing recommended in the area.





9. Plant pigeon peas in the strip 2.5 metres wide surrounding the plot. This is to ensure that the whole plot is protected from animals for a long period.
10 After the onset of the rains, plant the tree seedlings in the woodlot as early as possible so that they can take advantage of the rains for a long period
11 Weed the plot according to normal farming practice. Oxen ploughs should be used to plough the land between crops to improve water infiltration and its subsequent conservation
12 At regular intervals during the season, monitor growth of the crop, seedlings and wildlings, i.e. seedling survival, seedling damage, seedling height, wildling survival, wildling damage, wildling height, record the number of pods and height of at least five beans/green grams plants in the woodlot. Observe pests and diseases in both trees and crops.
13 When the crops are ready, the group should meet and agree on the day to harvest.
14 From the woodlot plot, harvest carefully the bean/green grams, measure the yields from the plot.
15 Compare the survival and height of the trees in the woodlot and wildlings in the field.

Year 2

16 Remark and prepare the plot of 12 metres by 12 metres before the rainy season starts. The land should also be ripped using oxen plough. Extreme care should be taken to ensure that the young trees are not damaged.
17 Remark the wildling and monitor continuously.
18 Plant the common beans / green grams variety, as in year 1, using the recommended spacing.
19 Plant pigeon peas in the 2.5 meter-wide strip surrounding the plot.
20 Weed the plot according to normal farming practice. Oxen ploughs should be used to plough the land between crops to improve water infiltration and its subsequent conservation
21 At regular intervals during the season, monitor growth of the crop, seedlings and wildlings, i.e. seedling survival, seedling damage, seedling height, wildling survival, wildling damage, wildling height, record the number of pods and height of at least five beans/green grams plants in the woodlot. Observe pests and diseases in both trees and crops.
22 When the crops are ready for harvesting, harvest the plot, measure carefully and compare the yields between year 1 and year 2.
23 Compare the survival and height of the trees in the wood lot and wildling in the field.
24 Do the costs benefit analysis to evaluate the advantages and disadvantages of growing tree species together with agricultural crops.

The facilitator should guide a discussion:

- Was there a crop yield difference between the first and second year?
- Was there difference in tree height and survival between trees in the woodlot and wildlings in the field after one and two years?
- What were some of the problems encountered in the establishment and management of the woodlot and in monitoring wildling in the field?
- Were there any advantages and disadvantages of managing the woodlot and the trees in the field?

MODULE 7
soil and water management

This module:

- **Places soil and water into a larger context and shows how the management of water and soil are linked to agricultural biodiversity and the functioning of the ecosystem**
- **Explains how the water cycle operates**
- **Explains why forests play an important role in the water cycle**
- **Explains how water limits what can grow and how available water can be used more efficiently**
- **Introduces the concept of healthy soils and the role played by soil life**
- **Explains the role of organic matter and humus in soils**
- **Introduces Conservation Agriculture practices and discusses their application to the local context**

Water – essential to life!

Without water, no living thing can survive for very long and water is essential to any farming activity.

In Kenya, production of most crops and livestock depends entirely on rainfall to supply the necessary water: very few farmers, especially resource-poor farmers, are able to irrigate their crops. Many low-income farmers live in dry areas where low and unreliable rainfall is a major cause of food insecurity.

Water and soil management are linked to agrobiodiversity and ecosystem function

Although the amount of rain falling in any area cannot be easily changed, it is relatively simple to make better use of the rain that does fall. Soil and water management go hand-in-hand: if soils are well managed, water falling as rain can be more effectively absorbed, less will be lost through evaporation, runoff will be reduced and there will be less risk of soil erosion. Well managed soils are healthy soils, which make the best use of available water, and support the growing of crops and rearing of livestock and the conservation of agrobiodiversity.

The water cycle

The total amount of water on the Earth is fixed and the vast majority of it is in the oceans. The Earth's water can, however, exist in different forms – frozen as ice and snow, as liquid water or as water vapour (steam).

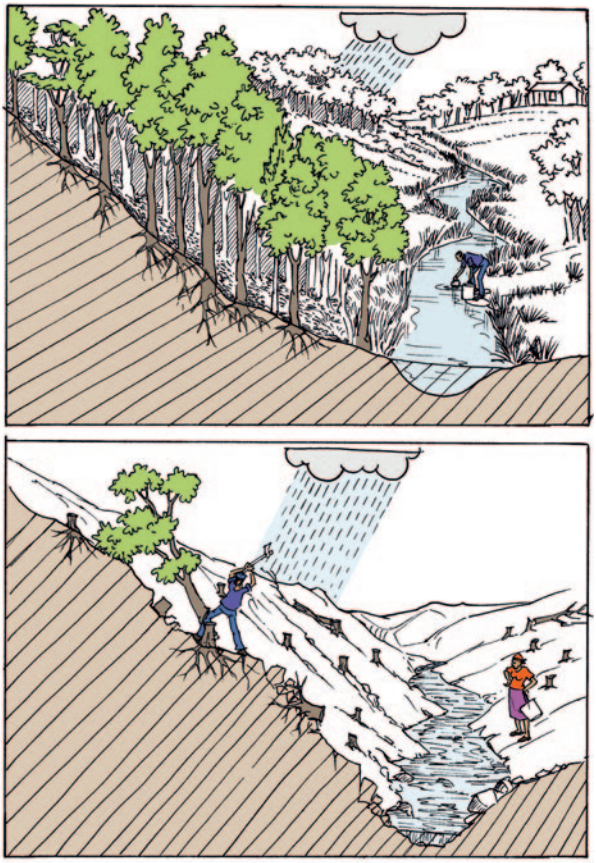
Ice and snow on the top of Mount Kilimanjaro melts in the heat of the mid-day sun to form water, which flows down the mountain into streams. The streams feed into larger rivers, lakes and swamps, in and around which a wide variety of plants grow, which in turn support a vast range of animals – from the smallest micro-organisms to the largest land animals, such as elephants. Some of the water in the lakes, rivers and swamps is also used by people to water their crops and livestock and for domestic use.

As plants grow, they take up water through their roots and release it back into the atmosphere as water vapour through tiny holes in their leaves. Some water evaporates from the surface of streams, rivers, lakes and swamps and rises as water vapour into the air. As water vapour rises higher into the atmosphere it cools and forms clouds. When the clouds are saturated, the water falls as rain (or snow on high mountain tops), refilling the streams, rivers, lakes and swamps and soaking into the soil, where it is taken up by plants' roots, endlessly repeating the cycle: this is called the hydrological cycle, or more simply the water cycle.

Trees and the water cycle

Trees play an important part in the water cycle. Trees, other forest plants and forest litter (mostly dead leaves) absorb rainwater, reducing soil erosion and runoff. When rain falls on bare ground, the force of raindrops can wash soil into streams, making them muddy. But when rain falls in the forest, it drips down through leaves and branches to the forest floor. The forest canopy and the layer of litter under trees, protect the soil from the full force of rain. Tree roots hold the soil in place, stopping it washing away. In this way, forests act like sponges, soaking up water and then gradually releasing it. Forests also help improve water quality by filtering out impurities that could be potentially harmful in streams or groundwater.

Human activities, such as cutting down trees for logging or farming, will increase the rate of soil erosion, increase the risk of flash-floods or landslides and can reduce water quality.



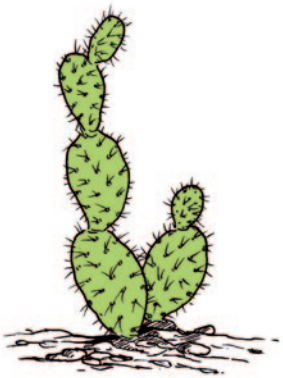
Water and farming

The amount of water that is reliably available in an area determines the type of wild plants that grow naturally, or those that can be grown by people in fields or forests.

In very dry parts of the Earth, such as in deserts, few plants can survive. Those that do, which include spiny cacti, tough, clump-forming grasses and small, hardy shrubs, have special features to enable them to survive in dry conditions, including:

- small leaves
- leaves covered with a waxy layer to reduce water loss
- leaves covered with small hairs to reflect back sunlight (leaves are often a silvery-grey colour)
- stems covered with thorns to protect them from browsing animals
- special parts of the plant that can store water
- few tiny holes in their leaves that release water vapour back into the air: sometimes the holes only open at night when it is cooler
- deep tap-roots to reach deep water.

Similarly, the plants that can be grown in fields and forests depend on the amount of water available. In drier areas, crops with a high water requirement, such as maize, will not do well. Other crops, such as bulrush millet, sorghum and cassava, which are more drought-tolerant, are better choices in drier areas: crop failures will be less common if crops that are more tolerant of low rainfall are grown and food security will be improved.



Water harvesting and soil water retention

A number of simple, proven techniques – such as the use of mulch, construction of terraces along contours with grass strips or stones lines, or digging planting pits - can be used in dry areas to increase soil moisture and water retention and reduce runoff and soil erosion. All these methods aim to trap rainwater more effectively and reduce losses through runoff and evaporation. These techniques can improve food security and income levels and enhance agrobiodiversity by supporting higher and more reliable crop yields, better tree growth and through reduced runoff and reduced risk of soil erosion.

Exercise **Choice of water harvesting and soil moisture retention methods**

Learning objective	Timing	Time	Materials
To establish to what extent water and soil erosion are limiting factors in farming in the area; to compare the relative advantages and disadvantages associated with the different water harvesting and soil moisture retention methods and select those most suited to local needs	Any time but preferably before the onset of rains	3 hours	flip-chart paper and marker pens

Steps

1 Participants are asked to form groups of around six people. Each group brainstorms on the following issues:
- What factors limit crop yields in this area?
- Which factors are the biggest problems? The group ranks the factors in order of importance.
- What techniques or solutions have the group members seen or heard about which could help overcome the priority problems?
- For the most important three problems list possible techniques or approaches that could help overcome the problem.

2 The groups record their findings in a table on a sheet of flipchart paper using words or drawings, such as:

Problem	Technique needed to correct the situation
Soil erosion	Terracing, water harvesting
	Retention ditch

3 The groups then present their findings back in plenary and the facilitator leads a discussion;
- Did problems to do with soil and water rank highly in the groups' lists?
- Did different groups come up with different solutions to the same problems?
- Were different problems and/or solutions suggested by men and women? If so, why might this have been?
- What techniques were listed and by which gender? Did these include water capture, water retention and water use?
- Who would benefit from the different solutions?
- What problems might be associated with implementing the different solutions?
- Are they appropriate for resource-poor farmers?
- How much labour would be needed to establish and maintain the solutions? Do the farmers have the necessary skills, tools and knowledge? If not, where could they turn to for help?
- What role can farmer group play in helping members address the priority problems?

The facilitator should prompt the group to discuss issues of:
- land tenure and water rights - and how to enhance security of tenure and access to land and water
- catchment management – the need to manage areas beyond the farm because of upstream-downstream effects
- the need for community organization and support by districts for larger-scale land and water management.

Life in soil[1]

Soils are often considered as simply a medium for growing plants, providing physical support, water and essential nutrients. And organisms that live in soils are often regarded as being nothing more than pests, such as some types of termites and nematodes (types of small worms).

A good soil generally consists of:
- 45% mineral fraction (sand, silt, clay)
- 5% organic matter
- 25% air (oxygen)
- 25% water

Soils are thus made up for 50 percent of empty spaces (pores), which are filled up with water and air. Everything that happens in soils, happens in the pores. This includes functions that are important to plants directly, such as water draining and storage, and to soil micro-organisms, which find habitat in the pores. The share of components that make up soils varies, including due to management practices. For example, if soil is compacted, this results in less air; if it is flooded, in more water and less air. With no water and air in the soil, nothing grows. Healthy soils are thus soils where physical, chemical and biological health of their components is maintained.

[1] This section is based on: *Discovery-based Learning on Land and Water Management: Practical Guide for Farmer Field Schools*. Food and Agriculture Organization of the United Nations and International Institute of Rural Reconstruction, Nairobi (2017). Available at: www.fao.org/3/a-i6897e.pdf

Exercise **Soil types**

Learning objective	Timing	Preparations by group	Time	Materials
Soils are made up of a mixture of clay, sand, silt and organic matter. This exercise demonstrates in a very clear way what sort of soil you have	Any time but preferably early in the training cycle	Each member is asked to bring 4 handfuls of top soil sample from their farms	2 hours	several drinking glasses, soil samples collected from different areas, clean water and a small stick

Steps

1 The farmers are first asked to form groups of around six people. Each group categorizes the different soil samples using their own criteria.

2 The facilitator then guides the groups to classify using the procedure below:

- First remove any stones, leaves and seeds from the soil sample
- Next take a handful of soil, moisten with a little water, adding more water gradually until the soil begins to stick to the fingers and is uniformly moist (not wet)
- Try to form the soil into a ball and then a long, thin cylinder
- Depending on how the soil responds, it can be classified as sandy, silty or clay:

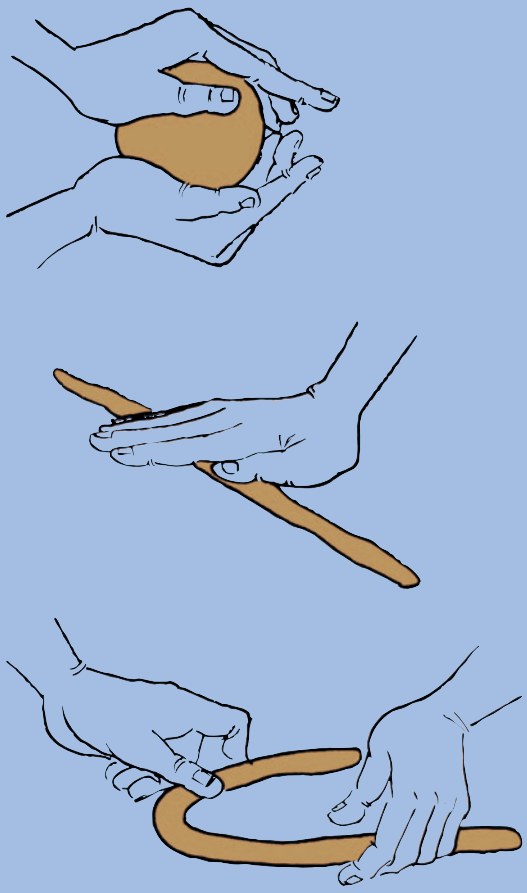
Response of moist soil	Soil type
Does not stick together Rough gritty feel Ball falls apart easily Cylinder of around 5 cm long and 1.5 cm wide can be formed but it cracks easily Soil does not stick to fingers	Sandy
Soil sticks together Can be formed into smooth ball Can be formed into a cylinder about 13 cm long and 0.5 cm wide: cylinder can be bent into a U-shape but cracks appear	Silty
Moist soil feels soft and smooth Easily formed into a ball that feels like plastic Can be rolled into a thin cylinder which can be bent without cracking Wet soil is very sticky and has a soapy feel	Clay

3 Each group selects two different types of soil, either based on the previous test or samples that have been collected from different locations, such as valley bottoms, hill tops and slopes:
   - Place some of the soil sample in a glass, filling it one-third full
   - Fill the glass with clean water and stir well
   - Leave for 5 minutes and then stir again
   - Then leave for one hour (the hour can be used for another activity).

4 After one hour, what do you see? The soil will have settled and the water will have become clear. The particles in the soil will settle out according to their size: biggest at bottom of glass, next smaller particles of sand, with small particles of clay at the top. Floating on top is organic matter, including roots, seeds and leaves. You may also see some small insects and other small animals.

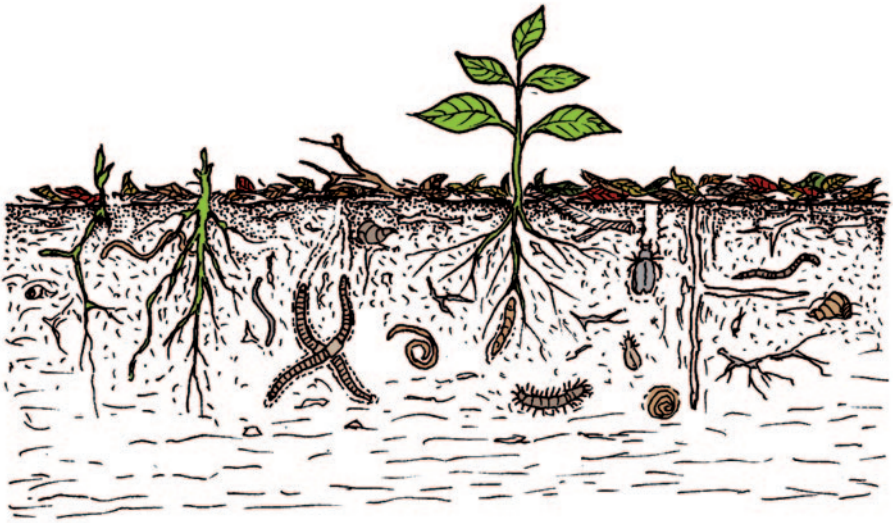
5 Each group makes a drawing of their soil samples, labelling the layers and stating where it was collected:
   - What sort of soil is the sample?
   - What impact will this have on their farming?
   - What can be done to improve the soil?

6 The groups present their findings back in plenary and the facilitator guides a discussion;
   - What types of soil are present in the area?
   - Which types of soil are associated with which locations?
   - What impact might the soil type have on farming in the area?
   - What can be done to improve the different types of soil? Have these methods been tried before – what problems are associated with them?
   - What help do the farmers need in improving their soils – do they have all the information they need?
   - Where could additional information be obtained?
   - What role could the training group play in helping farmers improve their soils?



Simple tests to classify soil types as sandy, silty or clay

But soil is much more than a mixture of organic matter, sand, silt and clay – it is also full of living things. Most life in the soil is too small to see with the eye – we would need a magnifying lens or microscope to see it – but it still makes major contributions to soil fertility, structure and stability, contributing to productivity of land and preventing its degradation. Healthy, living soils are very important for our environment and livelihoods.



'Soil health' refers to the ability of soils to carry out important functions that support agriculture. In healthy soils:

- rainwater easily soaks into the soil and is held there for use by plants
- water passing through the soil is filtered and results in clean water in streams and rivers, and safe drinking water
- there are many air spaces that allow roots and soil organisms to breath and grow
- soil is soft and easy to till and enables roots to easily access moisture and nutrients and produce healthy plants
- there is less risk of weeds and invasive species being a problem: such as *Striga*, that is difficult to control and associated with infertile soils; weeds associated with acid or other problems soils; spreading weeds like couch grass; or grasses and other plants that are unpalatable for livestock
- some chemicals may break down more easily, and some harmful bacteria present in animal and human excreta are rapidly destroyed
- the soil is well structured: the crumb-like structure and well-developed

plant roots help resist erosion by wind or running water, processes that can remove the fertile topsoil and create a hard surface that restricts entry of rainwater.

Soils under natural vegetation, such as in forests or fallows, often have these properties but they can be lost after a few years of cultivation. As with human health, soil health depends on how it is cared for and nourished: soils that are starved and mistreated will not be healthy and productive.

The farmer's choice of land use and management practices affect not only the different types and number of organisms living in the soil, but also their functions, which determine both the health and productivity of the soil. The two most important things that maintain a healthy soil are the amount of organic matter (the more the better) and the living organisms it contains.

Properties of healthy and poor soils

Healthy soil	Poor soil
Plant fragments and crop residues on the soil surface	Bare and compacted soil surface
Dark colour due to presence of organic matter (humus)	Light colour because soil is starved of organic matter
An open structure with spaces and channels for air and water entry and drainage through the soil	A compact, solid soil with few pore spaces and poor aeration and poor drainage
Lots of fine roots holding the soil together	Few roots or only roots of problem weeds, such as couch grass
Many visible organisms of different species (and the different structures they make)	Few visible organisms, or sometimes many visible organisms of just one or two species, e.g. many white grubs, which are pests
Channels (small burrows) formed by burrowing earthworms and/or termites	Few channels

Exercise **Comparison of healthy and poor soils**

Learning objective	Timing	Preparations by group	Time	Materials
To appreciate the characteristics of healthy soils and the role of soil organisms	Any time but preferably before the onset of rains	None	3 hours	Spades, plastic bags and large sheets of plastic, knives, teaspoons

Steps

1 Participants visit one of the farmer group members' farm and the facilitator asks them to brainstorm on what characteristics they associate with a healthy soil and a poor soil. Based on these initial suggestions, the members then select two areas on the farm, one that they consider has healthy soil and one that has poor soil. The farmer should be asked whether in his/her experience of growing crops in these two areas, there is a difference in soil quality.

2 Once the two sites have been agreed upon, collect two blocks of soil, each the width of a spade, and as deep as practical, one being 'healthy soil' and the other poor/unproductive soil.

3 Place the two blocks separately in large bowls (or polythene bags) to collect any animals that could escape.

4 Place the two blocks in the bowls side by side and ask the group to investigate the structure and any biological features with a couple of small knives. Assist in identifying any of the properties shown in the table, above.

5 Tip out the soil onto two large white plastic sheets and ask some volunteers (children may be interested to help) to carefully sort through the material and collect any animals they can see – look carefully, some may be very small. Separate roots, stems, leaves, seeds, stones etc. and soil organisms and compare the amounts found in each of the two soils. Place animals from the two soils in separate bowls (if possible white in colour so they can more easily be seen) - use a spoon to collect very small animals. Also try to identify those structures (such as tiny burrows) that you think have been produced by soil organisms and compare them to the rest of the soil.

6 Ask the group to identify any of the animals found and discuss with them what they think these organisms are doing in the soil.

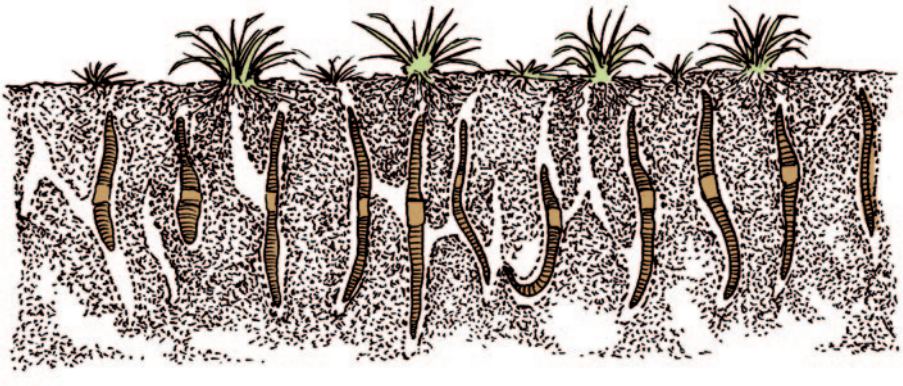
- Do they consider that the soil selected as 'healthy' is in fact healthier and why?
- What differences are there between the two soil samples? What impact might these differences have on crops grown on them?
- Does the types and numbers of organisms differ in the two samples? Why might this be?
- What roles might the different types of soil organisms play? Are they helpful or harmful or a mixture of the two?
- What lessons has this exercise provided in how soils should be managed?

What do soil organisms do?

The enormously complex and varied life in soil (soil biodiversity) performs key functions that maintain plant growth and production in all ecosystems.

Many of the tiny animals, fungi and bacteria do not have distinct or unique roles in maintaining soil, but are part of a very complex community. Many different sorts of soil animals feed on dead plant materials (herbivores), other animals feed on the herbivores (predators), and others are parasites - just like life above ground!

The larger, visible soil animals, such as worms and termites, can change the structure of the soil, and consequently have effects on many soil properties and processes. Plant roots are also vital for maintaining the structure of soils, as well as for taking up water and nutrients.



Earthworm's burrows in soil help improve drainage and allow penetration of water

An important job of soil organisms is the decomposition of dead plants, animals and dung, which is essential not only for the release of nutrients for continued plant growth, but it is also important to keep the environment healthy. Through their activity, soil organisms create the physical structure of soil; they break down organic materials releasing nutrients and forming humus.

Nutrients provided to crops by the decomposition of dead plant materials and manures are not their only sources of nutrients. In addition, some soil bacteria help legumes to fix nitrogen from the air, and some soil fungi form partnerships with plant roots that enable them to gain nutrients, such as phosphorus, even from nutrient-poor soils.

Role of organic matter and humus

Soil organic matter is material that originates from plant and animal remains, such as crop residues, leaves, stems, roots and manure. When these materials rot, they are broken down by micro-organisms and the final product is called humus.

Humus is dark in colour, rich in plant nutrients and usually found in the top layer of soil – healthy soils that contain humus are therefore usually also dark in colour.

Organic matter – or humus – plays important roles in soil, including:

- increasing soil fertility as it slowly releases nutrients for plants
- binding the soil particles together and improving soil structure and aeration
- acting as a sponge and retaining more soil moisture than soils low in organic matter
- providing food for soil micro-organisms.

Sources of organic matter

Farmers can use a wide range of organic material to improve the fertility and structure of their soil.

Sources of organic materials and their qualities

Organic material	Quality	What is contains	How to use it
Tithonia Gliricidia Leucaena Manure from animals fed on high-quality feeds	High	High in nitrogen Low in lignin* Low in phenols**	Incorporate directly into the soil for annual crops
Legume green manure	High	High in nitrogen Lupins also high in phosphorus	Grow as intercrop and splash and dig-in during or after growing season
Home-made compost	Varies depending on material composted	Varies depending on material composted	Apply direct to soil: 1 cm deep
Calliandra	Fairly high	High in nitrogen High in lignin and phenols	Mix with fertilizer or one of the high-quality organic materials in row above before incorporating into the soil
Maize stalks Manure from animals fed poor-quality diets Manure that has been exposed to sun/rain for more than six months	Medium	Low in nitrogen Low in lignin	Mix with fertilizer or add to compost
Twigs	Low	Low in nitrogen High in lignin	Leave on field surface to help control erosion and retain water

*Lignin is the woody material found in all plants. Some plants have more lignin than others, and older plants tend to have more than younger ones. A good indication of how much lignin is contained in a leaf can be obtained by tearing it: the harder the leaf is to tear, the more lignin it contains and the longer the leaf will take to breakdown and release its nutrients. Plants with high lignin levels therefore are not good sources of organic material.

** Phenols are chemicals found in plants that slow down the rate at which they rot: the more phenol, the lower its quality as a source of organic material.

Soil health management practices

Traditionally, agriculture has involved tilling soils to prepare seed beds and control weeds using hoes, ploughs and other implements. However, this traditional approach can damage the structure of soil, destroy soil organisms and can lead to soil erosion.

Alternative approaches exist that offer many attractive benefits:

- reduced tillage – no, or minimal soil turning
- mulching: maintaining soil cover at all times with mulches, e.g. by leaving crop residues on the soil surface, or growing cover crops
- practicing crop rotation – for example by alternating cash crops with perennial pastures.

The combination of these practices avoids the destruction of beneficial soil organisms which occur when soil is turned-over, such as by ploughing, and exposed to heat, solar radiation and predators. Soil organisms take over the role of the plough, which allows saving to be made in both labour and money. Crop rotation helps to prevent pests and diseases that are present in one crop from affecting the following crop. Increased soil biodiversity results in a wider variety and larger numbers of soil organisms, which in turn may improve yields, including through a reduced need for agrochemicals.

The following table compares conventional with agro-ecological management practices:

Conventional agriculture	Agro-ecological practice
Tilling: Soil turned over by ploughing prior to planting soil structure destroyed and soil compacted, reduces aeration, root development and water infiltration, and in turn negatively affects crops	Reduced tillage: No/minimal soil turning: soil structure preserved, soil moisture availability increased, runoff and erosion reduced. Reduces wear-and-tear on farm machinery and labour and energy requirements
Removal of crop residue for off-field use: Soil is bare after crops are harvested and before new crop is established: risk of soil erosion	Cover crop: Soil is permanently covered; reduces soil erosion
Crops sown in bare ground: soil exposed to splash erosion, soil erosion and high temperatures	Mulching: Crops sown into mulch (such as stovers) from previous crop or cover crops: protects soil from splash erosion, soil erosion and high temperatures
Crop rotation not always practiced	Crop rotation usually practiced: helps to control diseases and pests without pesticides and uses nutrients in the soil efficiently

Conservation agriculture

Conservation agriculture (CA) is an approach to production that combines the three soil management practices outlined above: minimal soil disturbance (reduced or no till), permanent soil cover (e.g. through mulching) and crop rotation.

CA has the potential to yield both environmental and economic benefits, as it enhances soil biodiversity and thus benefits natural ecosystems while at the same time potentially reducing the need to employ chemical fertilisers.

However, it must be noted that some disadvantages exist in the application of the CA package, and that the implementation of single soil management practices, as best adapted to the context of each farm system, should be considered. Some disadvantages may include:

- Problems with weed control, as reduced or no till systems alter the efficacy of herbicides and mechanical weed control, and needs devising of alternative control strategies
- Issues with nutrient management, as surface cover crops may influence nitrogen uptake by plants (N immobilization)
- Issues with competing use of crop residues for example, as forage or fuel
- May increase work load for women, who are often responsible for weeding
- May need new agricultural tools (e.g. direct seeders), hence financial investments
- Possible yield drop in the first (3-5) years, including due to issues with weed and nutrients control
- Possible poor germination
- Water logging in poorly drained soils.

Exercise **Conservation Agriculture - advantages and disadvantages**

Learning objective	Timing	Preparations by group	Time	Materials
To introduce Conservation Agriculture (CA), to compare CA to conventional agriculture and to enable participants to consider the associated advantages and disadvantages associated with each approach.	Any time but preferably early in the training cycle; consider inclusion as season-long experiment	Each member is asked to bring 4 handfuls of top soil sample.	2 hours	none

Steps

1 The facilitator asks the group members whether they have heard of Conservation Agriculture. If some have, they are asked to share with the other members what they understand by the term. If none have, or to help summarize the members' understanding/experience, the facilitator explains the three cornerstones of Conservation Agriculture:
   - minimal or no soil turning
   - maintaining permanent soil cover, with either crop residues or cover crops remaining on the soil between crops
   - crop rotation.

2 The members are the asked to form groups of around six people. Each group considers the possible benefits and difficulties associated with Conservation Agriculture:
   - How does it differ from their current practices?
   - What advantages might it offer in terms of labour/cost of land preparation?
   - What effect might permanent soil cover have?
   - What effect might crop rotation have – and which crops should follow each other in the rotation?
   - What do farmers currently do with their crop residues? If crop residues were left in the field, what impact might this have elsewhere on the farm or household?
   - Does the group have questions about Conservation Agriculture? If so what?

3 The groups record their findings on flip-chart paper, using either words or drawings.

4 Participants then reconvene and each group presents their findings and the facilitator leads a discussion:
   - Overall, were there more advantages than disadvantages with Conservation Agriculture?
   - Might there be problems in the short-term as farmers changed over from conventional to Conservation Agriculture? What might these be?
   - How could any disadvantages be overcome?
   - In case of seasons-long trial, soil samples can be re-assessed periodically, to discuss whether participants think the advantages are sufficiently attractive to make them want to find out more about Conservation Agriculture? And if so, how might they do this?

Water harvesting and soil moisture retention methods

There are many methods of water harvesting and soil moisture retention methods, some of which are described below:

Retention ditches are dug along the contour to catch and retain incoming runoff and hold the water so that it can seep into the soil. They are usually 0.3 to 0.6 metres deep and 0.5 to 1 metre wide, with rounded or sloping sides. On flat land the ditches are spaced at 20 metre intervals and have closed ends so rainwater is trapped. On sloping land the ditches are spaced at 10 to 15 metre intervals and have open ends so excess water can drain away. When digging the ditches on sloping land, the soil is heaped on the lower side to form an embankment and stop soil from falling back in: planting grass on the embankment helps stabilize the structure. In semi-arid areas, retention ditches are used to grown plants with high water requirement, such as bananas.

In **contour farming** operations such as ploughing, furrowing and planting are all carried out along the contours, not up and down the slope. Contour farming can involve construction of soil traps, bench furrows or bunds, planting grass strips or hedgerows or simply the laying of trashlines made by laying crop residues in lines along the contour: all slow down runoff and trap soil, gradually building up terraces. The first step is to determine a contour guide line, on which all the other structures are based.

Water harvesting from external catchments involves transferring water from an area that is not cropped to fields or plots, where it supplements water received directly on the cropping area. Simple storage structures can be constructed to store water until it is needed. In areas with low rainfall, a larger catchment area is needed.

Contour furrows are small banks made of earth on gently sloping land. A furrow is dug on the higher side – this collects runoff from the catchment area above, between parallel furrows. The catchment areas are left uncultivated with the crops planted either on the ridges or sides of the furrow: beans and peas which need more water are usually planted on the side of the furrow and maize and millet on the ridges. The spacing between furrows is usually 1 to 2 metres, depending on the slope and available rainfall: the drier the area, the wider the spacing.

Stone lines are laid out along contours to slow down runoff, increasing seepage into the ground and reducing soil erosion. Stone lines are spaced at 15 to 30 metre intervals. First a shallow trench is dug along the contour. Large stones are placed on the downhill side of the trench and smaller stones used to build up a bund, which can be reinforced with soil or crop residues. When it rains, the stone lines will naturally catch soil washed downhill, in time creating terraces.

Grass strips are a cheaper alternative to terracing. Strips of grass up to 1 metre wide are planted along the contour: these catch silt and over time benches are formed. Spacing between strips is 20 to 30 metres on gently sloping land, 10 to 15 metres on steeper slopes. The grass needs to be cut regularly to prevent shading of crops and spreading. Suitable grasses include: Vetiver, Napier, Guinea and Guatemala grass or a local veld grass. Cut grass can be used as livestock feed or as mulch.

Planting pits are the simplest form of water harvesting. Pits are dug 15 to 30 cm in diameter and 5 to 15 cm deep with a spacing of about 1 metre; there is no need to follow contour lines. Crops, such as sorghum and millet, are planted in the pits and, if available, compost or manure is dug-in before planting.

Semi-circular bunds are raised soil structures, formed in a semi-circular shape with their tips aligned to the contour. Size varies from a radius of 2 metres to 30 metres. Smaller ones are used for planting fruit trees, whilst larger ones can be used for rehabilitating rangeland or growing fodder. The bunds are laid-out in a staggered arrangement.

Earth basins are square or diamond shaped micro-catchments which capture and retain rainwater as it falls. They consist of a grid of low earth ridges, which can be reinforced with grass, and are especially useful for fruit trees. The basins can be from 1 to 2 metres across, up to 30 metres across. On sloping land, the downhill side of the basin will receive most water and it here that the seedling should be grown. Manure or compost can be applied to the basins.

Mulching involves covering the soil between crop rows or around individual trees and plants with plant material, such as cut grass, straw and other crop residues and shrub or tree trimmings. This helps to retain soil moisture, prevent weeds, enhance soil structure, protects soil from splash erosion and prevents formation of crust. Sometimes the mulch is covered with soil to prevent it blowing away.

Cover crops are usually types of legume that grow in a creeping manner. They are used to cover the bare soil surface in between rows of crops, such as maize, fruit trees or coffee. They protect the soil from erosion, add organic matter, and improve soil structure. As they can fix nitrogen, they improve further soil fertility and enable recycling of atmospheric nitrogen fixed in the plant tissue into the soil.

Relative suitability, advantages and limitations of the methods are spelled out in the table below.

Comparison of soil and water conservation techniques

Method	Conditions	Advantages	Limitations
Retention ditches	Semi-arid areas Need flat or gently sloping land Permeable, deep and stable Not suited to shallow soils or areas prone to landslide	Retains runoff and improves soil moisture Reduces soil erosion Can grow water-demanding crops in dry areas	Heavy rainfall may overfill and break ditches High labour requirement for construction Need regular maintenance and de-silting On unstable, risk of landslides
Contour farming	Gradient of less than 10% On steeper slopes, combine with terracing or strip cropping Field needs even slope, otherwise very time-consuming to follow contours when ploughing	Reduces runoff and soil erosion Reduces nutrient loss Quicker when ploughing with draft animals as move along the contour	Improperly laid-out contours can increase risk of soil erosion Labour-intensive maintenance On heavy soils, a lot of water can collect, which can break the contours Trashlines are only temporary, eventually being eaten by termites etc
Water harvesting, external catchment	Low rainfall areas (300 to 800 mm) Open, uncultivated land adjacent to field Gentle slope from external catchment to field If open land communally owned, need to share benefits equitably	Improves yield security: crops can be irrigated during dry spells Increases available water for crops Irrigation by gravity: no power costs Low investment per acre	Water storage structure is labour-intensive to build Large runoff volumes can break the reservoir Losses due to evaporation and seepage can be high Poor design and management can lead to erosion and flooding Reservoir takes up valuable land Some engineering knowledge is needed Water harvesting on communally owned land may cause conflicts

Method	Conditions	Advantages	Limitations
Contour furrows – a component of contour farming	Annual rainfall of 350 to 700 mm Slope should be even so water is distributed evenly Slope should be gentle: 0.5 to 3% Light soils	Improved soil moisture and water availability Reduced risk of erosion Easy to make and manage Labour requirements low	Not suited for very dry areas Heavy rainfall may break the furrows Land preparation with draft animals is difficult Bunds and furrows need regular maintenance
Stone lines	Annual rainfall 200 to 750 mm Gentle slopes Need stones to be available locally Any soils	Good for rehabilitating eroded land by trapping silt Slows runoff and increases soil moisture Causes terraces to develop naturally Reduces erosion Easy to design and build	Stones may not be available Stones act as refuges for rodents and reptiles Labour-intensive to construct
Grass strips	Need for grass for fodder or as mulch Grasses needs to survive during droughts	Controls erosion and runoff Increases soil moisture Provides cut grass for fodder and mulching	Not suited to steep slopes in dry areas where grasses won't survive drought Grass can spread and become a weed Requires labour Grass can act as refuge for rodents Suitable grasses may not be available locally
Planting pits	Annual rainfall 200 to 750 mm Gentle slopes, less than 2% Deep soils: if soils shallow, plant on top of ridge not in pit to maximize rooting depth Good for rehabilitating barren, crusted soils and clay slopes where infiltration is limited and tillage difficult	Traps runoff, increases soil moisture Reduces erosion	Digging pits is labour-intensive Land can not be prepared using draft animals
Semi-circular bunds	Gentle slopes, less than 2% Annual rainfall 200 to 750 mm Soils not too shallow or saline	Easy to construct Suitable for uneven terrain Increases soil moisture Reduces soil erosion	Difficult to construct with draft animals Requires regular maintenance

Method	Conditions	Advantages	Limitations
Earth basins	Arid and semi-arid areas: annual rainfall of 150 mm and above Deep soils, preferably at least 1.5 metres Flat to gentle slope, up to 5%: if used on steeper slopes, basins should be smaller	Basins are easy to construct by hand Improves soil moisture No rainwater is lost from runoff; risk of erosion decreased Manure and compost can be applied to basins to improve soil fertility and water-holding capacity	Labour-intensive Heavy rainfall will cause basins to overflow
Mulching	Low rainfall areas respond well to mulching Well drained soils Not too steep slopes	Increases soil moisture Reduces evaporation Suppresses weeds: reduces weeding Reduces fluctuations in soil temperature: improved conditions for micro-organisms Increases soil organic matter and improves structure Protects soil from splash erosion and runoff. Can act as a barrier against the spread of pests and diseases	Some grass species used as mulch can root and become weeds Mulching material may not be available Mulching may compete with fodder needs of livestock Dry grass mulch may be a fire hazard Mulch can be a habitat for pests and diseases Difficult to mulch on steep slopes Can increase nitrogen immobilization, thereby reducing quantity available to crops
Cover crops	Not suited to dry areas with annual rainfall below 500 mm	Improves soil structure and fertility Reduces soil erosion and runoff Suppresses weeds Cover crop an provides food for people, fodder for animals and cash income Improves soil moisture and reduces surface crusting Reduces fluctuations in soil temperature Cover crops can be an alternative to mulching, especially in semi-arid areas where crop residues are needed for livestock Can act as a physical barrier that halts the spreading of pests and diseases	Cover crops often need to be fertilized with phosphorus Cover crop competes with main crop for water and nutrients Serves a refuge for rodents Requires additional labour and inputs Legumes are prone to some diseases Reduces cropping area

MODULE 8

agrobiodiversity, natural pest control and pollination services[1]

This module:

- **Illustrates the role of agro-biodiversity in controlling pests**
- **Considers the role of pollinators in crop production**
- **Outlines strategies to enhance pollinator communities and protect them from pesticides**
- **Discusses sustainable honey production in dryland Kenya**

[1] This module is based on:
FAO. 2008. Participatory training and curriculum development for farmer field schools in Guyana and Suriname. A field guide on integrated pest management and aquaculture in rice. FAO, Rome. Available at: www.fao.org/3/a-ba0031e.pdf
FAO. 2014. Gestion intégrée de la production et des déprédateurs du coton. Guide du facilitateur pour les Champs écoles des producteurs. FAO, Rome.
Martins, D. J. 2014. Our friends the pollinators. A handbook of pollinator diversity and conservation in East Africa. Nature Kenya – the East Africa Natural History Society, Nairobi, Kenya, 102 pp.
FAO. 2016. Mainstreaming biodiversity and ecosystem services into agricultural production and management in East Africa. FAO, Rome. Available at: www.fao.org/3/a-i5603e.pdf
FAO. 2017. Integrated pest management of major pests and diseases in eastern Europe and the Caucasus. FAO, Rome. Available at: www.fao.org/3/a-i5475e.pdf

Agrobiodiversity and natural pest control

"Biodiversity offers great potential for managing pests. It provides resistant genes and anti-insect compounds; a huge range of predatory and parasitic natural enemies of pests; and community ecology-level effects operating at the local and landscape scales to check pest build-up"[2]

Natural pest control largely relies on the ecosystem services provided by natural enemies – predators and parasites – to control the build-up of pest populations and prevent the spreading of diseases. Natural enemies, also called beneficial organisms, include, among many others: birds, spiders, wasps, flies, ladybugs and fungi.

Farming systems can be designed and managed to reinforce the natural process of pest regulation. Examples of good practices in the design of the farm are:

- **selection of crops and varieties** that have natural defenses against pests. Crops have traits that may make them more or less attractive to pests, and this feature has long been used in plant breeding
- **use of plant genetic diversity:** growing different varieties of the same crop at once can help reducing pest problems
- **use of mixed-cropping systems:** the strategy of growing multiple crops at the same time, to reduce overreliance on a single crop, can also help minimising impact from pests, who find it more difficult to find their preferred host plants in the system
- **crop rotation:** helps avoiding the building up of pest populations
- **providing on farm food and shelter to beneficial insects** to build up their population
- **manage the habitat to enhance natural pest control:** remove alternative food sources to discourage pests, plant hedgerows and conserve natural and semi-natural habitats, to offer refuge to beneficial insects
- **building up soil fertility** to support healthy crops that can better withstand pest pressure
- **avoid harming beneficial insects** by avoiding improper pesticide applications.

[2] Quote adapted from the book: Gurr, G. M, Wratten, S. D, Snyder, W. E. eds. 2012. Biodiversity and Insect Pests: Key Issues for Sustainable Management, Wiley-Blackwell.

An example of this is the push-pull system. This entails the planting of specific crops in proximity to each other, to push pests out of the main crop and pull them towards others that do not facilitate pests' establishment, while at the same time attracting natural enemies. This strategy has been successfully tested in East Africa and Kenya, and is particularly attractive because it employs locally available plants, and fits well with the traditionally mixed cropping systems in the region.

By considering interactions across the agroecosystem, natural pest control can rely on other strategies to limit the establishment and spreading of pests. For example, with regards to the management of soils, it is known that cover crops that are used to enhance soil fertility can also serve as habitat to natural enemy populations. If the cover is removed from the land, these natural enemies may be unable to survive or build up sufficient numbers to be effective.

Negative effects from pesticide use

Misuse of pesticides has negative impacts on crop production, human health and the environment.

Economic issues:

- development of resistance by pests, due to frequent and prolonged exposure to specific chemicals
- increased costs of production due to reduced pesticide efficiency, which may lead to pest outbreaks and in turn yield damage
- lack of compliance with market standards in case of crop pesticide residues.

Environmental issues:

- contamination of over- and underground water bodies
- consequent poisoning of fish and other aquatic organisms
- long-term persistence in soils impacting rotational crops and beneficial soil organisms
- poisoning of wildlife
- poisoning or contamination of livestock
- reduced populations of pollinating insects
- air pollution.

Social issues:

- direct and indirect pesticide poisoning
- food safety concerns associated with crop pesticide residues.

Exercise **Insect zoo**

Insect zoos serve as a good facility for looking closely at insect pests and natural enemies, thereby deepening participants' knowledge about their population dynamics and feeding behaviour, and their functioning as part of the bigger ecosystem.

Learning objective	Timing	Preparations by group	Time	Materials
To understand how different natural enemies, such as predators and parasites, work to control insect pests, by rearing them inside a cage or vial. To understand the bio-ecology of pests and defenders. To identify the potential crop defenders and understand the symptoms caused by different pests	Early morning	None	2 hours to set up, plus regular observations	Mesh net, stakes, vials and buckets

Predator zoo

1 Cover one square meter of the crop with a mesh net cage erected with sticks approximately one meter high
2 Remove insects from inside the cage, as well as a spider. Do not feed for up to two days
3 Put some insects inside the cage as prey, with a predator spider
4 Observe the cage twice a day morning and afternoon to examine the remaining prey. Record prey consumed during observation. This zoo is only for predator insects or hunting spiders. For small predators like lady bird beetles, follow the same procedure using a vial or a discarded mineral water bottle.

Parasites zoo

1 Collect larva, pupa, nymphs or eggs found from the field and put inside vials or transparent plastic bags/cups
2 Place wetted cotton inside to maintain moisture
3 Cover with a mesh net and tie with a rubber band. Put them in the same place
4 Observe twice a day to examine hatching insects and take notes on individuals inside the vials. Each vial or plastic bag should be used only once.

Discussion:

- Discuss in group the notes taken on organisms inside the cages of vials.

Exercise **Beneficial insects**

Learning objective	Timing	Preparations by group	Time	Materials
To understand the role of beneficial insects in regulating pest populations	Any time	None	2 hours	Bamboo sticks, muslin cloth, thread, needle

1 Participants divide in groups

2 Each group establishes one closed and one open cage, as detailed below:

a Closed cage method:
One healthy plant is selected and the aphids present on the plant are left undisturbed. All the defenders and others are manually removed. The field cage is erected using 4 bamboo sticks all around the plant. The plant is totally covered with white cloth on all 4 sides and on the top. The cloth is inserted into the soil to prevent the movement of aphids and defenders. Participants record the aphid population, both nymph and adult.

b Open cage method:
Similar to the above case, another healthy plant is selected and the aphids present on the plant are left undisturbed. The defender population and other pests are removed. The cage is closed on the top of the plant, leaving all sides open 1 foot above ground level, to facilitate the free movement of defenders

Discussion:

- Participants discuss in their groups the role of defenders in the ecosystem based on what observed in the study:
  - What happened to the pest population in the controlled condition, where the defenders were not allowed in the ecosystem? Did the population increase?
  - Were the results different in the cage that was left partially open?
- Participants report the results of their group discussions to the other groups.

Exercise **Pitfall trap**

Learning objective	Timing	Preparations by group	Time	Materials
To identify the presence of ground dwelling nocturnal insects. To compare the difference of population in sprayed and unsprayed fields	Any time	None	2 hours over 2 days	Plastic jars, water, detergent, sickle

1 Participants divide in groups

2 Each group prepares two plastic jars half-filled with water, and adds liquid detergent, to avoid the escape of insects from the jars. The jars are buried in sprayed and unsprayed fields up to the brim at ground level

3 The groups collect the jars after 48 hours and take notes on the number and types of organisms found in each.

Discussion:

- Participants discuss in their groups:
  - What type of soil dwelling nocturnal insects are there in the ecosystem (e.g. ground beetles, spiders, earwigs, others)? How many of each type?
  - Is there a difference in number and/or type of organisms between the jars left in the sprayed and unsprayed fields?
- Participants report the results of their group discussions to the other groups. All participants discuss on the role of the organisms found in regulating pest populations, and on the effects of chemicals on them.

Exercise **Spiders abundance**

Learning objective	Timing	Preparations by group	Time	Materials
To identify spider populations and abundance across different ecosystems	Any time	None	4 hours	Vials, polythene bags, rubber

1 Different ecosystems are selected prior to the study depending on the local environment (for example, 2-3 different types of crop land; bund; barren land; grass land; pond or another aquatic ecosystem)

2 Participants divide in groups. Each group observes and counts the spiders in three spots of 1 mt2, in each of the ecosystems identified

3 The total population of spiders per hectare is then estimated (see sample table below).

Ecosystem	Spider count (replications on three 1 mt² areas)			Total	Average	Total per ha.
	1	2	3			
Crop 1	10	8	6	24	8	80 000
Crop 2	…	…	…	…	…	…
Bund						
Barren land						
Grass land						
Pond						
…						

Discussion:

- Groups report back on the number of spiders found across the different ecosystems. Which ecosystem had the most, and which the least? What could be the reasons?
- The facilitator can then guide discussion on the role of spiders with questions and exercises, for example:
  - Draw one or more typical spiders and describe their morphology
  - What are the differences between a spider and an insect?
  - What are the natural enemies of spiders?
  - How can the spider populations be preserved and protected?

Integrated Pest Management

FAO defines IPM as "the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified, and reduce of minimize risks to human and animal health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agroecosystems and encourages natural pest control mechanisms".

Integrated pest management (IPM) strategies have long been studied and applied in East Africa as in other regions of the world to provide a viable solution to manage pests, without recurring to excessive use of chemicals.

The core concept of IPM is that all available control options should be considered and applied by farmers, and that these methods should be based on knowledge of the agroecosystem, and of the economic, environmental and social consequences of each intervention.

Principles of IPM

1 **Agroecosystem analysis.** The agroecosystem is composed of all the organisms present in the crop area together with the surrounding environment. Agro-ecosystem analysis is key to determine pest populations' dynamics and the mortality factors operating on them

2 **Biodiversity.** As complexity increases, particularly among trophic interactions, there is usually an increase in the stability of the agro-ecosystem

3 **Management versus control.** Levels or limits of tolerable damage are more important than pest population levels. Tolerable levels of damage vary with market conditions, stage of the crop, local conditions or grower economics, and the personal values of the people concerned

4 **Field scouting.** Individual fields should be surveyed for populations of pests, parasites, predators, and pathogens. On the basis of this information and a consideration of the time of the year, stage of growth of the crop, and weather conditions a prediction can be made of population trends and potential damage

5 **Preserve natural pest control.** Biotic control agents must be considered appropriately

6 **Adequate decision-making.** Based on the results of the monitoring and the specific local conditions, adequate decisions should be made with regards to the appropriate selection and timing of pest control methods

7 **Non-chemical plant protection methods.** Non-chemical methods should be preferred, and chemicals only applied if no adequate alternative control measure is available

8 **Evaluation.** The efficacy of the pest management measures should be evaluated, to improve future pest management methods based on experience gained.

A key factor for the successful implementation of IPM methods is the community's knowledge of local agro-ecosystems and of the biology of pests, natural enemies and their interactions. Farmers are encouraged to attend training sessions and prioritize information sharing within the community, to learn one from the other.

Exercise **Storage and disposal of pesticides**

Learning objective	Timing	Preparations by group	Time	Materials
To create awareness on unsafe pesticide storage and appropriate disposal practices	Any time	None	2 hours	Large paper sheets, colour marker pens

Steps

1 Participants are divided in groups
2 Each group is asked to draw the house of one of its members on a paper sheet, to represent the village situation. Group members then indicate, on the chart:
   a Where the farmer stores his/her pesticides and spraying tank
   b Where food is prepared, consumed, and store
   c Where the main water source and storage site are located
   d In which part of the house his/her pet animals and children usually move.
3 Each group is then invited to mark, on the drawing, whether the storage and disposal of pesticide is safe to the children, water, food and pet animals (green round mark for 'safe' and red round mark for 'unsafe')
4 Each group presents their drawings to all participants
5 The facilitator summarises information on safety according to each group's drawing in a single table (see example below).

Safe (+); unsafe (-)	Storage	Disposal
Children	+ + + -	+ + - -
Food	…	…
Water		
Animals		

Discussion:

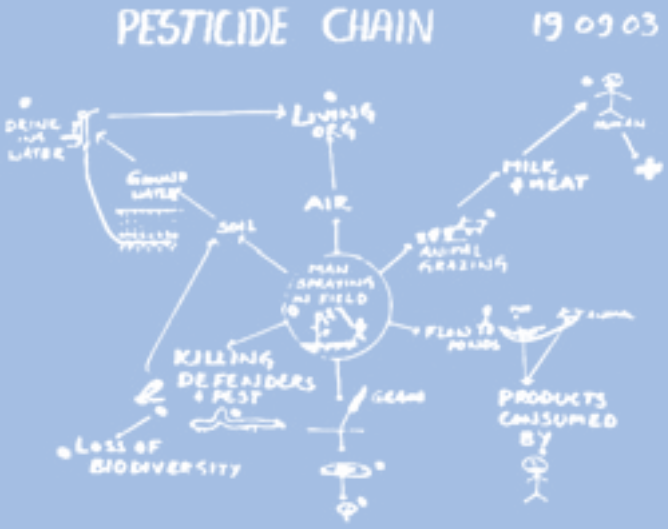
- The facilitator encourages discussion on the safety of storing and/or disposing of pesticides in or around the household.
- The main learning outcome of the simple exercise is to convince participants that **there is no safe place in the house to store and/or dispose of pesticides!**

Exercise **Pesticide chain**

Learning objective	Timing	Preparations by group	Time	Materials
To understand how pesticides residues persist and move along the ecosystem, and how they can ultimately damage human health	Any time	None	2 hours	Charts, markers

1 Participants divide into groups. Each group is invited to reflect on, and draw the cycle of pesticides flow in the ecosystem (see example below)
2 Each group presents to the other participants.

Discussion:
- In plenary, participants discuss the flow of pesticides, from the moment of application on the field.
- What are potential threats to the environment from pesticides? And to human health?
- The facilitator invites reflections on the importance of considering alternative methods for pest control.



Exercise **Exposure to pesticides during handling**

Learning objective	Timing	Preparations by group	Time	Materials
To visualize body contamination during handling and mixing of pesticides	Any time	None	2 hours	White clothes/dresses, sprayer, water, vegetable red colour dye

1 Two volunteer participants role play as farmers spraying pesticides. The volunteers are asked to wear white clothing for the activity
2 Vegetable red dye, to represent pesticide, is mixed in the water
3 After mixing one farmer sprays in the crop field, against the wind. The other farmer sprays along the wind
4 The two volunteers are encouraged to do all they would normally do while spraying, e.g. smoking, eating, rubbing eyes, sneezing, cleaning their face etc. All other participants observed these activities.

Discussion:

- In plenary, all participants discuss on what they have witnesses during the role-playing exercise.
  - What are the ways in which the pesticides can enter the body?
  - What is the most common way of pesticides entering the body during spraying?
  - Which step of the operation is most dangerous, and why?
  - How can contamination from pesticides be avoided? Is the use of personal protective equipment completely effective?
- The facilitator encourages discussion on the health effects of pesticides and the importance of considering alternative methods of pest control.

Exercise **The effect of insecticides on insects**

Learning objective	Timing	Preparations by group	Time	Materials
To understand the effects of narrow spectrum low-risk insecticides on insects and other non-target organisms.	Any time	None	2 hours	*Bacillus thuringensis* (Bt), plastic mosquito sprayer, plastic cup or discarded water bottle, mesh net, rubber band, insects and fish.

1 Participants form groups of about six people
2 Each group collects insects (harmful and beneficial), spiders, caterpillars and fish
3 Put harmful and beneficial insects in two cups each; divide also the other types of organism collected in two different plastic cups each. Cover each cup with mesh and tie with rubber bands
4 Dilute insecticide into water at the recommended rate and put into two different mosquito sprayers
5 Spray a cup with Bt; apply similar treatments to all cups
6 Examine the results after one hour
7 On a large paper, list how many organisms of each type died and how many remained alive
8 Present your results to the other groups.

Questions:

- Which insects were killed by the Bt application? As a last resort, why should we encourage farmers to use only narrow spectrum insecticides?

Exercise **Alternative to chemicals-based pest management**

Learning objective	Timing	Preparations by group	Time	Materials
To understand what alternative strategies to preventing, or managing pests can be applied in the local context.	Any time	None	1.5 hours	Large sheets of paper, marker pens.

1 Participants form groups of about six people
2 Each group discusses and lists on a large sheet of paper (following the sample table below):
   a the main pests and diseases that affect crops in the area
   b alternative (non-chemical) practices they use, on their farm, to control pests and disease. Particular attention should be given to those practices that make use of agricultural biodiversity (for example, planting different varieties, selecting landraces, protecting and enhancing natural enemies)
   c the effectiveness of each alternative practice on pests, based on their experience in their plots
   d the challenges in employing each alternative practice identified.
3 Each group presents the results to the other groups.

Crop: ..... **Location:** ..... **Season:** .....
Average cultivation area: .....

Pest/disease	Alternative practice	Effectiveness (-, +, ++, +++)	Challenges
Pest 1			
Pest 2			

Pollinators and pollination services

Pollinators are a vital element of agricultural production. Some crops are wind pollinated (such as maize) but many important crops rely on insects, such as bees, for pollination: without pollination crops cannot produce seeds and fruits. The majority of flowering plants only produce seeds if pollinators transfer pollen across different parts of their flowers. This means that, without pollinators, many ecosystem services on which humans depend – including food production – would be disrupted.

Around three-quarters of crops in Kenya benefit from pollination by bees; even people who do not keep bees themselves benefit from their neighbours' bees. Some crops – such as avocado, coffee, cowpeas, mangoes, pigeon peas, pumpkins, okra and tomatoes – benefit from pollination in terms of improved yield quantity and quality. Some others – for example passionfruit, cocoa, strawberry, eggplant, watermelon, cucumber and pumpkin – are entirely dependent on pollinators.

But it is not just bees that pollinate crops. Besides bees – of which, in many parts of Kenya alone, more than one hundred species can be found, including honey, stingless and carpenter bees – pollinators include other organisms, such as butterflies and moths, birds, bats, bush babies, wasps, flies, beetles and ants. Some plants can only be pollinated by one specie. By maintaining agrobiodiversity, a wide range of pollinators can flourish, helping to ensure both crops and wild plants are pollinated and fruits and seeds are produced. Conversely, careless use of pesticides and large-scale mono-cropping has a detrimental effect on useful pollinating species, reducing both the number and diversity of species.

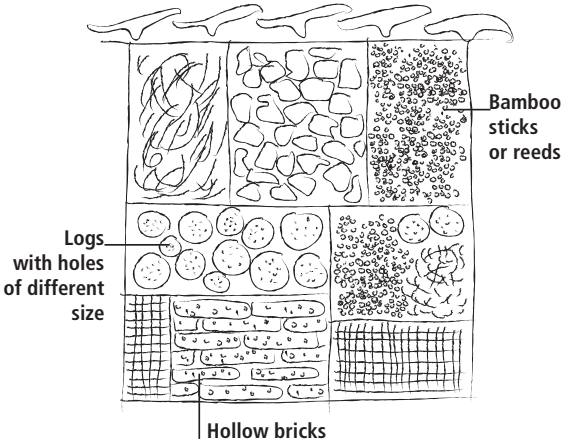
Pollination involves the transfer of pollen to the female part of the plant, thereby ensuring fertilization and development of seeds and fruits; pollination is the plant equivalent of animals mating and pollen plays a similar role to semen in animals. Pollination services benefit greatly human livelihoods, by improving the quantity and quality of pollination-dependent crops and, indirectly, by ensuring the preservation of a wide array of crop genetic resources.

The importance of pollinators to our livelihoods has been demonstrated, including by quantifying their value in agricultural production systems in economic terms. Nevertheless, pollinators are still under threat. This is due to habitat loss, caused for example by land clearing, but also to direct on-farm drivers, such as the overuse of pesticides that are damaging to beneficial insect communities, including pollinators.

The role of farmers in pollinators conservation

Farming is one of the key drivers of pollinators loss. With the increasing intensification of farming production across the world, the natural habitats that once sustained abundant and diverse pollinators communities are decreasing, or disappearing the in most heavily-intensified systems. However, at the same time farmers can play a key role in preserving healthy pollinator communities, by implementing specific management practices on, and around their farms.

A key aspect to which farmers can actively contribute is the preservation, and enhancement, of natural and semi-natural habitats on their farms, to ensure pollinators (and other beneficial insects) an appropriate environment in which to thrive. These habitats can include natural forest areas, hedgerows including different flowering plants, wild flowers (conserved, or planted, within the field). In addition, farmers may want to build specific structures that can attract, and offer shelter to pollinators. Bee hotels, for example, are structures that can be made of different materials, such as wood and bricks, and that contain cavities where certain types of bees can nest. Bee hotels can be placed around the farm, or in proximity of wildflower strips.



Besides the establishment of natural and semi-natural habitats, training sessions should emphasize that there are many other ways for farmers to contribute to the preservation of pollinators and other beneficial insect communities.

These include for example the application of non-chemical based methods for the control of pests. Pollinators are threatened by pesticides, especially those that have a broader spectrum of action and are likely to affect non-target insects. If after careful assessment, the use of pesticides is deemed essential, farmers must make sure that damage to beneficial insects is minimized. Steps to reduce threats to pollinator communities include, for example, finding out the toxicity to bees of specific products and

formulations, avoiding spraying when the crop is in flower, and protect known sites that host pollinators colonies, within the farm and on its edges, while spraying.

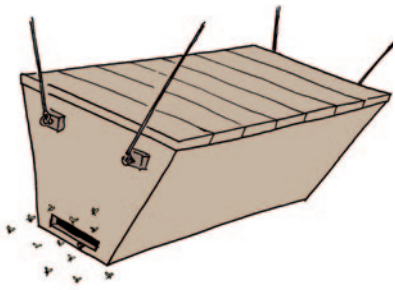
Other good practices that farmers can implement, and that can benefit pollinator communities, include the planting of multiple crops and crop varieties (see Module 2 "Crop diversity and food security") and the management and enhancement of soil fertility, (see Module 7 "Soil and water management").

Sustainable honey production in dryland kenya

In dryland areas of Kenya, honey is valuable both as a foodstuff and as a source of income. Sustainable production is threatened, however, by degradation of rangeland and subsequent loss of forest, shrub-land and other vegetation that supports bee keeping. Honey producers would also benefit from knowledge about and access to improved hives and processing equipment, better awareness of market requirements and stronger linkages to markets.

Traditional hives are simply hollow logs. Bees are attracted to these hives but take a long time to produce honey: they spend a long time building combs before they start to produce honey. Also, honey harvested tends to be of low quality, full of eggs, young and mature bees.

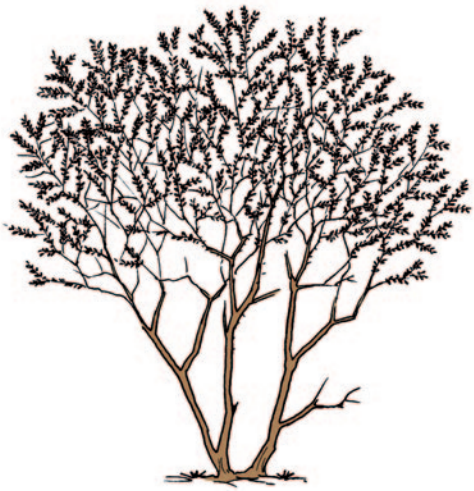
A solution is to use improved bee hives, such as the Kenya top-bar hive. This has the advantage of being more efficient and making it easier to harvest high-quality honey; however, it is more expensive than traditional hives and may not be readily available in the local area. Before honey producers invest in improved hives they need to be sure they have a market for the surplus honey they will produce.



The traditional way to process honey is to squeeze it through a piece of cloth, but this practice produces poor-quality honey that is contaminated with eggs and young bees. Simple equipment can be bought that enables honey producers to produce better quality honey, for example, by using hand-operated centrifuges and filters. Also, honey attracts better prices if it is packed in clean, glass containers.

The quality of honey also depends on the flowers that the bees are feeding on. Very good quality honey is produced by bees feeding on the thorny shrub or tree Acacia *mellifera*, also known as the hook thorn, *kikwata* in Swahili or *muthia* in Kamba, which is widespread in dryland Kenya. Planting Acacia *mellifera* and other fast-growing trees, as well as other plants such as aloes, can result in better tasting honey and also provide other benefits, such as shade, soil stability and fuelwood.

Individual honey producers may find it beneficial to form producer groups, which can share production equipment and jointly market their produce.



Farmers play a crucial role in the preservation and sustainable use of agrobiodiversity. In fact, the diversity of species that support our current agricultural production systems has been carefully managed and shaped by farming communities, over the course of the history of humankind. Farmers act as custodian of the Earth's agrobiodiversity resources, and play a big part in preserving traditional plant and animal varieties, and the knowledge associated with these.

FAO has long been working on promoting approaches to agriculture that enable both the sustainable use of biodiversity resources for food and agriculture, and their conservation, and on supporting farmers to make informed decisions on their farm management and production practices. This training manual fits in this broader commitment, to support a shift towards a paradigm of agricultural production that can sustain food and nutrition security while at the same time cause the least harm to natural ecosystems. The manual is intended as an introduction to agricultural biodiversity, and to its relevance to different aspects of agricultural production and management for smallholder farmers in Kenya. It includes eight different training modules, each covering a specific aspect related to agrobiodiversity. The modules are standalone and can be used independently one from the other, depending on the user's or project's aim.

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