Introducing agroforestry

a teaching guide for the technical level
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INTRODUCTION

Background

An age-old practice and a relatively new research approach, agroforestry is gradually finding its niche in agricultural and forestry research, training, education and development institutions in many countries. Throughout Africa, universities and technical colleges are getting involved in teaching agroforestry, but how they achieve this largely depends on the objectives of their existing educational curricula and programmes, human and financial resources, and infrastructure. Thus agroforestry teaching varies greatly among institutions.

ICRAF, through its training materials project, is assisting national institutions to develop their own agroforestry training materials based on available research and development information and adapted to suit the needs of individual institutions in various agroecological regions. One of the mechanisms to achieve this is through training materials workshops for trainers.

The first such workshop held in November 1993, proposed that a teaching manual for certificate and diploma levels be developed, coordinated by the African Network for Agroforestry Education (ANAFE). During 1994-1995 representatives of technical colleges in Kenya, Malawi, Tanzania, Uganda, Zambia and Zimbabwe produced draft contributions for the manual. However, the contributions were developed in the context of the approaches, opportunities and limitations of the institutions represented and their curricula, and they were often very different among the various colleges. Therefore, at the coordination level it became clear that the approach was unlikely to produce a standard manual that could be adopted by all the technical colleges in the region.

In July 1995 the contributing authors and ICRAF staff met and recommended that the focus should be on producing a course outline and teaching guidelines rather than on 'cut-and-dried' teaching material for teaching agroforestry in the different technical colleges. The main advantage of this was that individual institutions were left the flexibility to adapt the course outline and guidelines to their own curricula and to develop appropriate teaching materials to support it. This guide is an outcome of such an approach.
Technical-level training

Technical-level training has a major role in producing middle-level workers and in generating useful academic experiences for developing tertiary level education. It is effective training for producing frontline extension and development workers, teachers, technical assistants, research assistants, agribusiness workers, field supervisors, etc. Technical programmes are the first entry points from secondary school systems to the tertiary level and more focused professional education and training. In fact many universities and higher level educational programmes initially started as technical colleges or technical-level training programmes.

The content of technical-level training programmes is mostly applied science, and the teaching strategy is practical in orientation.

Aspects that distinguish technical training programmes from other programmes include (tables 1 and 2):

- entry requirements for the programme
- minimum duration of the programmes
- courses offered, their content and teaching strategy
- minimum requirements for graduation
- minimum qualifications required for the teaching staff

Table 1. Entry requirements for and duration of technical college programmes in anglophone countries

<table>
<thead>
<tr>
<th>Award</th>
<th>Intake category</th>
<th>Prerequisite (years of formal education)</th>
<th>Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certificate</td>
<td>Preservice</td>
<td>11-12</td>
<td>2-3</td>
</tr>
<tr>
<td>Diploma</td>
<td>Inservice/Preservice</td>
<td>12-14</td>
<td>1.5-3</td>
</tr>
</tbody>
</table>

Table 2. Entry requirements and duration of technical college programmes in francophone countries (Zoungrana and Temu 1996)

<table>
<thead>
<tr>
<th>Award</th>
<th>Prerequisite (years of formal education)</th>
<th>Duration (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certificat d’aptitude professionnelle</td>
<td>8-9</td>
<td>1-3</td>
</tr>
<tr>
<td>Brevet de technicien</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>Brevet de technicien superieur</td>
<td>13</td>
<td>3</td>
</tr>
</tbody>
</table>
Three types of courses are generally offered at the technical level:

• pre-service and in-service diploma course lasting from one-and-half to three years. Candidates for the in-service diploma course are required to have a certificate in the specific field of study and minimum working experience of up to three years.

• pre-service certificate courses lasting two to three years. Candidates for this course should have attained credit passes in all science subjects at O-levels

• short in-service courses lasting up to six months tailored to specific needs

Technical level training programmes are offered in both technical colleges and in several university systems alongside degree level programmes. What are described here as technical colleges are institutions that offer only certificate or diploma courses as their highest level training programmes. Most of the technical colleges in land husbandry disciplines are established and administered by government ministries of agriculture, environment or natural resources to meet specific human resource needs of the respective ministries. A few are administered under the ministry of education.

The role of technical level colleges in agroforestry teaching is significant, and their potential has become increasingly apparent. Presently, agroforestry is taught as a separate course in over 60% of the technical colleges of agriculture, forestry and natural resources in Africa. The majority of graduates from these institutions are involved in rural development activities. An appropriate agroforestry course in the curricula will, therefore, have a direct impact on rural extension and will ultimately contribute to improve the living conditions of the rural poor.

About this guide

The objective of this teaching guide and course outline is to provide a standard framework of content and a delivery strategy for teaching agroforestry. It addresses some essential elements that are commonly identified as major shortcomings of agroforestry curricula in some technical level colleges with respect to (Kasolo and Temu 1995):

• statements of course and learning objectives

• range of topics cutting across the fundamental disciplines in agroforestry (crop science, animal science, forestry, etc.)
functional categories within which the various topics on related aspects can broadly be grouped
logical sequencing of topics
balance between theory and practical sessions

This guide provides a foundation on subject matter coverage (course outline), teaching strategy, and information on resource materials. Model examples are provided in most cases.

Course outline

The course outline section contains a guide on the content and organization of subject matter that is considered appropriate for agroforestry teaching at the technical level. It is organized into six chapters within which topics on related aspects could broadly be grouped:

Chapter 1 Concepts and principles
Chapter 2 Agroforestry components
Chapter 3 Agroforestry technologies
Chapter 4 Social and economic aspects
Chapter 5 Developing agroforestry interventions
Chapter 6 Agroforestry extension

Chapter 1 is designed to provide a broad framework for the course. It introduces basic concepts and principles in agroforestry that are reinforced and dealt with in more detail in subsequent presentations.

Chapter 2 deals with the basic components and fundamental interactions that take place in agroforestry systems. It provides an important basis for the remaining parts of the course — agroforestry technologies, socioeconomics, interventions, and extension.

Chapter 3 focuses on technical improvements of traditional systems or practices. Building on agroforestry concepts introduced in the preceding chapters, this chapter reinforces the concept of classification of agroforestry technologies, extension potentials and constraints.

Chapter 4 introduces the basic concepts of tenure, gender, culture, and economic evaluation of agroforestry systems. It dwells on the social, economic and cultural backgrounds of the farming communities. This is essential to produce trainees who can develop socially and economically appropriate agroforestry technologies as alternative and sustainable land-use systems, particularly for resource-poor farmers.
Chapter 5 presents the subjects of land-use and farming-household characterization and diagnosis, which are tools and approaches used to design and develop agroforestry interventions suitable for a given land-use system and adoptable by farmers. It combines information about the concepts and principles of agroforestry, as well as sociological and economic aspects of agroforestry.

Chapter 6 introduces the concepts and principles of general extension, project monitoring, and evaluation and their applicability to agroforestry extension. This is an essential subject in producing extension staff who can take the right messages of agroforestry techniques to farmers in a simple way.

Teaching objectives

Teaching objectives are expressions — in terms of behavioural change — of the desired impact of the teaching on the learner; particularly the skills the learner would need in the world of work.

In this guide, objectives are listed for each chapter (module) in relation to the relevant knowledge, skills, and attitude that the trainee should acquire to be able to perform specified duties in agroforestry. The given objectives may be modified depending on specific subject areas that require emphasis to address specific local needs. However, one has to always make sure that the stated objectives are achievable within the limits of the course content and the teaching strategy.

Teaching strategies

These are guidelines on how to conduct and manage the teaching and learning process to satisfactorily achieve the intended objectives of each module. The teaching strategies section outlines activities that should be conducted both by the instructor and the students in terms of classroom lectures, practical work, case studies, seminars, etc. It guides on logical development of the subject, sequencing of activities, use of teaching aids and use of resources.

Teaching outline

This part contains details of the suggested topics to be covered under each chapter. It also provides direction on how the subject should logically be developed in the teaching-learning process.
Source materials

Relevant and fairly recent publications are listed at the end of each chapter. The instructors are encouraged to enrich the list with materials that are up to date and appropriate to their specific ecoregional zones.

In most colleges and universities, agroforestry is currently offered as a separate course with its own course number and contact time. In some institutions it is taught as a component of another course in agriculture, forestry, natural resources, etc. For all the arrangements in which agroforestry is offered, the material covered by this teaching guide is estimated to require at least 60 contact hours (40% theory, and 60% practical).

Training materials

Even though the list of agroforestry training materials is steadily growing, their number is much smaller than what is available for other related sciences such as agriculture, forestry and livestock. This is because agroforestry as a science is in its early stages of development.

Through its training materials project, ICRAF has produced a series of agroforestry training materials to support its introductory course on 'Agroforestry research for integrated land use' and other more specialized group training activities. These publications and audiovisual materials are listed in ICRAF's annual publications list and in a catalogue of ICRAF training materials. ICRAF has also produced a catalogue of the materials available in its library, one of the leading agroforestry documentation centres in the world.

Needless to say, there are probably very few agroforestry materials that can be readily used in any teaching context without some form of adaptation. This is so because no single individual or institution is competent enough to produce such universally usable materials for agroforestry, as agroforestry is a rapidly developing area of scientific research.
1 Concepts and principles

TEACHING OBJECTIVES

The objectives of this module are to enable students to:

• define agroforestry and explain its basic concepts and principles
• explain the role of agroforestry in a land-use system
TEACHING STRATEGIES

Classroom lecture

A general introduction covering common land uses and their classification is essential. The subject of agroforestry can be developed as a theoretical classroom presentation focusing on its definition, concepts and principles. A brief introduction of the other chapters might be given here to give the students a general picture of what agroforestry is, and to give them an overview of the subject matter they are going to cover in the course. Adequate coverage should be made of traditional agroforestry practices found in the vicinity of the institution.

Use slides, pictures, drawings, overhead transparencies, posters, etc. to illustrate land-use and farming systems, trees on farm land, uses of trees by farming communities, etc.

Demonstration

Where possible, agroforestry demonstration plots may be established on the college farm (see chapter 3 — Agrofotestry technologies). Such plots may consist of a collection of important useful trees of the region (in an arboretum), some agroforestry systems or technologies, student research plots, etc.

Field visits

A field visit may be organized to observe various land-use systems that deliberately incorporate a tree component, e.g., farmers' fields, extension projects, forest buffer zones, marginal lands, soil conservation projects, or research stations dealing with agroforestry. However, not much time should be spent on this field trip. It should be limited to an introductory visit to a nearby area that has adequate models to give the students a general picture of agroforestry in the field. Extended and more elaborate field visits should rather be conducted in an integrated manner in the latter part of the course, after the students have covered broad subject matter.

Provide a handout to the students that summarizes the most important observations that will be made during the field visit (land-use systems, types of land ownership patterns, agroforestry components, type of technology,
expected benefits to the farmers or the community, farmers' and community opinion on agroforestry, etc.).

Remind the students to observe common courtesy rules when visiting farmers' fields or research farms.

**TEACHING OUTLINE**

**Introduction**

This initial presentation on agroforestry will set the scene for future presentations, and thus needs to be developed in close collaboration with all resource persons involved in the related subjects. These people may be drawn from both within and outside the college, involving people who are trained in and/or are working on areas of agriculture, forestry, animal science, soils, socioeconomics, etc.

This chapter will provide the broad framework for the rest of the course and will introduce definitions, concepts and principles that will be reinforced and dealt with in more detail in subsequent presentations.

Make sure that there will be no contradictions between this and future presentations. A glossary of common agroforestry terminology can be useful.

Give a brief historical overview of the role of trees in land-use systems and describe some well-known agroforestry systems or practices in your region. (Clarify what the term 'region' means in your context, and other related terms — 'ecoregion', 'administrative region', 'surrounding area', etc.)

Describe the various land-use systems and the interdependence of the different systems. Explain how a farming-systems approach can be used to better understand interactions within a farming household and with the outside world. Highlight some of the important systems concepts such as 'boundary', 'structure', 'function', 'state', 'hierarchy', 'inputs', 'outputs', 'productivity', and 'stability'. List and describe some tools (diagrams, calendars, maps, transects, etc; see also Chapter 5 — Designing agroforestry interventions) that can be used to illustrate and promote understand of how farming systems work.

Introduce the concept of 'sustainability'. Give a brief and simplified explanation of it in the context of farming systems. What are the requirements for sustainable agriculture (environmental concerns, soil conservation, efficient use and conservation of natural resources, optimizing biological interactions on farm, availability of internal inputs, energy and subsistence needs, etc.)? What are the external requirements that contribute to sustainable agriculture
(infrastructure, marketing, policy, credit facilities, etc.)? When can a farming system be considered sustainable? How can agroforestry contribute to sustainable land use?

Highlight the need for specialists from different fields (agronomists, foresters, livestock and soil specialists, economists, anthropologists, etc.) to work together in the development of a multidisciplinary field such as agroforestry.

Highlight the common problems and constraints (population growth, environmental degradation, land shortage, urbanization, etc.) facing numerous countries in the developing world in general, and your country, region, or locality in particular, and indicate how agroforestry can contribute to their alleviation. Discuss the potential of agroforestry for different land-use systems with respect to the livelihood in your region.

Definition

Having described agroforestry in its present and historical contexts, use some traditional systems and practices as examples to develop a definition of agroforestry. Definitions can go from the very simple ones such as "trees on farms", to the more complex ones such as the following:

"Agroforestry is a collective name for all land-use systems and practices where woody perennial plants are deliberately grown on the same land management unit as agricultural crops and/or animals, either in a spatial mixture or in temporal sequence. There must be significant ecological and economic interactions between the woody and non-woody components". (Lundgren 1987)

or

"Agroforestry is a dynamic, ecologically based, natural resource management system that, through the integration of trees in farm- and rangeland, diversifies and sustains smallholder production for increased social, economic and environmental benefits." (Leakey 1996)
Define the keywords of the definition of agroforestry — 'deliberately
grown', 'components', 'spatial mixture', 'temporal sequence', and 'ecological
and economic interactions'.

Explain what makes agroforestry different from traditional forestry,
agriculture or other related disciplines. Distinguish between the concepts of
agroforestry and social forestry or community forestry.

**Classification**

Describe how the term 'agroforestry system' differs from the terms 'agroforestry
practice', 'agroforestry intervention' and 'agroforestry technology'.

Point out that there are many ways in which trees can be combined with
crops and/or animals for the benefit of sustainable agricultural land use.
Highlight the need to classify agroforestry systems in order to have a common
understanding about them and to be able to evaluate and improve them.
Explain that agroforestry systems have been classified in many different ways.
Point out that there are only two functionally different types — simultaneous
and sequential systems. Describe each of them giving examples.

Stress the need for a practical classification in the context of a given
situation. For example, a hedgerow intercropping technology can be
considered an agrisilvicultural system (trees and crops), a linear technology
(tree or shrub hedges), a simultaneous technology (trees together with crops), a
soil conservation technology (trees or shrubs on contours).

Looking at the definition of agroforestry and some of the concepts
outlined in the introduction, indicate how agricultural land-use systems
incorporating trees can be classified using different criteria such as their
structure, function, socioeconomic or ecological basis. Highlight some
strengths and limitations of the classification systems.

**Structure**

Classify systems according to the composition of their components — into
agrisilvicultural, silvopastoral, or agrosilvopastoral systems — or according to
their arrangement in time and space — into multistrata, linear, or sequential
systems.
Function

Identify the production and service roles of agroforestry and use these criteria to propose other possible classifications for agroforestry systems (wood, poles, fruits, fodder, etc., as production roles, and soil conservation, microclimate improvement and soil fertility enhancement as service roles).

Ecology

Explain why agroforestry classifications are based on agroecological conditions (geographical regions such as highlands or semi-arid lowlands; specific conditions such as degraded lands, acid or saline soils; cropping conditions such as coffee or tea production zones, etc.. Give some examples of the sort of categories that can be identified using these criteria. Explain how such classification can be useful to extrapolate information between similar agroecological zones.

Socioeconomics

Explain how socioeconomic criteria such as scale of production (large- or small-scale farming) or level of technology input and management (commercial, intermediate, or subsistence) can be used to classify agroforestry systems. Highlight the relativity of these classification criteria, e.g. a 25-ha farm is considered small in the Amazon but enormous in the Kenya highlands where 2- to 3-ha farms are the norm. Likewise explain that the production scale of a commodity will be considered commercial in the context of one land-use system and subsistence in another.

Examples

Identify suitable agroforestry classification criteria for the land use, agroecological and socioeconomic conditions in your area and explain the basis of this classification, its strengths and weaknesses. Look for traditional, research and/or development examples to illustrate your classification.
References and further reading

Indicate what references you have used to develop your presentation, as well as relevant publications that students may consult for more information about the subject.

SOURCE MATERIALS


The objectives of this module are to enable students to:

- identify the functional components of an agroforestry system
- describe below- and above-ground interactions in a given agroforestry practice and explain how these interactions affect the trees and the crop
- explain how the process of basic resource capture and flow functions in an agroforestry system
TEACHING STRATEGIES

Classroom lecture

This chapter may be developed as a theoretical classroom presentation explaining and discussing the subject matter of agroforestry components and interactions.

Explain how the main growth elements — light, water and nutrients — are captured by the components of an agroforestry system. Discuss the basics of nutrient cycling and nutrient supply in the soil-plant system. Elaborate on the role of animals in an agroforestry system. Discussion should deal with fodder species and use of animal manure. Introduce the subject of pests and diseases in agroforestry.

Use slides, pictures, drawings, models, overhead transparencies, video, objects, etc. to illustrate the components — agroforestry trees and shrubs, crops, and animals in agroforestry management, the basic processes of nutrient cycling in agroforestry systems, etc.

Field visits

Field visits can be organized to observe some major agroforestry components and their interactions; agroforestry trees and shrubs (those in use as well as those with potential value); management practices; most important food and cash crops; animal husbandry; the physical, chemical and geological aspects of soil, etc. Discuss with the farmers their tree, crop, and animal management practices, yields, problems, etc.

Provide the students a handout that summarizes the most important observations they are expected to make, especially pertaining to the issue of competition for growth resources (mutualism, commensalism, parasitism, etc.). Students should develop a nutrient cycling model based on a system incorporating trees, crops and animals.

Group exercise

Let the students analyse a given farm in terms of its major components, management practices, yield, and nutrient flow. They should identify the constants and suggest improvements.
TEACHING OUTLINE

Introduction

This chapter deals with the basic components and fundamental interactions that take place in agroforestry systems. It will provide an important basis to develop the remaining parts of the course — agroforestry technology, socioeconomics, interventions, and extension.

Highlight what will be covered in this chapter in the context of what the students have studied previously and make the link with relevant aspects that will be covered in future presentations.

Components

Introduce the basic components of agroforestry (agricultural crops, trees and shrubs, and livestock) in general and those specific to the ecoregion. Give an overview of the most important components:

- food and cash crops in the region, their requirements, cultivation practices — inputs such as fertilizers, pesticides, etc. — and yield
- tree growing and management practices, tree species, yield, etc.
- domestic animals and their management, fodder requirement, and yield

Discuss about agroforestry trees and shrubs (AFTS). Describe their characteristics and production and service functions on farms.

Talk about how AFPS and crops are selected for compatibility. List and explain the tools for identification and the criteria for selection of appropriate species for different agroforestry practices. Consider technical, ecological, and socioeconomic aspects.

Discuss the management aspects for AFTS. Explain the propagation mechanisms, and establishment and silvicultural management practices required for good performance. Provide students with species fact sheets.

Discuss tree nursery development, management and problems.

Introduce the students to major crops, animals and other components (bees, fish, etc.) of the farming systems in the region. Explain the basic concepts and characteristics. List the most important food and cash crops and farm animals in the region, and discuss their requirements, cultivation practices, including inputs, and yields. Provide fact sheets on important crops and animals.
Introduce this section by giving a brief explanation of the concept of interaction — the mechanisms and components involved in each interaction, and the biophysical and socioeconomic implications of it. Point out that the term 'agroforestry system' is primarily about interaction of components (tree and crop and/or animal) with each other, and that there must be discrete boundaries separating the system from others on a farm.

Point out that interactions within components are determining factors for outputs from the component mixtures, and that the biophysical bottomline of agroforestry is how to manage the competition between the tree and the crop and/or livestock components for light, water and nutrients for the benefit of the farmer. Explain how these interactions are site and management dependent.

Highlight the role of soil in the interactions and give an overview of the physical and chemical aspects of soils. Describe the composition of soil with respect to its organic and non-organic components and explain how these influence the characteristics of the soil. Explain how organic matter affects soil moisture content and infiltration capacity, as well as the general nutrient level of soils.

Introduce the students to the basics of nutrient flow in a plant-soil system. Explain the process of nutrient flow through:

- uptake of nutrients from the soil by living plants; the ability of a tree to absorb nutrients from outside the soil volume exploited by roots of annual crops, and how this could depend upon its spatial distribution and temporal patterns of root growth
- accumulation and decomposition of litter from plants; note the role of soil micro-organisms
- nutrient removal from the system (by crop harvesting, soil leaching, etc.); export of nutrients through harvesting parts of the perennial component, and consequent decline in soil fertility; potential of agroforestry systems to reduce leaching losses
- nutrient input (by applying fertilizer or manure, tree litter and pruning, N-fixing species, etc.)

Discuss tree-crop and tree-animal interactions in either a spatial association or a temporal sequence with annual crops or pastures. Describe the main types of tree-crop interactions and their effects. Discuss the interactions in terms of:
• below-ground and above-ground interaction — competition, decomposition, symbiosis, and microclimate change
• positive and negative interaction — nutrient cycling, amelioration of climatic conditions, fodder, weed control, competition, toxic chemicals in fodder, allelopathy, etc.

You may give the main effects of tree-crop interactions given in table 2.1 as an example.

Discuss some of the main effects of tree-crop interactions given in table 2.1 plus others in more detail, using specific examples of agroforestry systems. Highlight the importance of site condition/physical environment, species, and arrangement of the components in space and time on the effect of the interaction.

Table 2.1. Main effects of tree-crop interactions (Ong 1996)

<table>
<thead>
<tr>
<th>Effects</th>
<th>Evidence</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Increased productivity</td>
<td>+</td>
<td>Ong 1991</td>
</tr>
<tr>
<td>2. Improved soil fertility</td>
<td></td>
<td>Kang et al. 1990</td>
</tr>
<tr>
<td>3. Nutrient cycling</td>
<td>+</td>
<td>Szott et al. 1991</td>
</tr>
<tr>
<td>5. Microclimate improvements</td>
<td>+</td>
<td>Monteith et al. 1991</td>
</tr>
<tr>
<td>8. Weed control</td>
<td>0</td>
<td>Rizvi 1991</td>
</tr>
<tr>
<td>9. Sustainability and stability</td>
<td>0</td>
<td>Sanchez 1987, Young 1991</td>
</tr>
<tr>
<td>10. Pests and diseases</td>
<td>-,+</td>
<td>Zhao 1991</td>
</tr>
</tbody>
</table>

+ is used for positive effects, — for negative ones, and 0 for instances without evidence. Only key or recent sources are quoted.

Productivity

Evidence shows that the overall (biomass) productivity of an agroforestry system is generally greater than that of an annual system (Ong 1996). Discuss the basis for the potentially higher productivity of an agroforestry system.

Soil fertility improvement

Explain how trees affect microsite enrichment. Discuss the extent of their effect in relation to differences in their growth rate (fast-growing vs. slow-growing trees), the type of agroforestry system, site condition, ecoregion (fertile vs. acid, infertile soils, humid tropics vs. arid or semi-arid environment), etc.
Soil conservation

Identify and describe appropriate agroforestry systems that have beneficial effects in controlling soil erosion: Explain the mechanisms by which the systems work.

Microclimate improvements

Explain how trees can be used for improving the microclimate and crop yield. Discuss the significance of their effect in relation to the amount of soil water available, and the favourability of environmental conditions, e.g. areas of high wind or sand movement, and favourable areas for crop growth. Discuss how the effect of shade trees depends on the nature of the understorey crops.

Competition

Describe competition between crops and trees and explain its significance, particularly in simultaneous agroforestry systems. Explain the concepts of below- and above-ground competition and the importance of the soil and aerial environment in these phenomena. Discuss the complications encountered in assessing the extent of competition.

Pests and diseases

Discuss pests and diseases in agroforestry. Highlight their importance with respect to loss in crop yield and research data to farmers and researchers, respectively. Relate this to agroforestry systems, pointing out favourable and unfavourable effects of combining trees and crops. Point out that trees can introduce new pests and diseases, or create a favourable microclimate for their development. Explain how trees can also reduce the incidence of certain pests and diseases. Highlight the importance of diversity.

In winding up this chapter, highlight the complexity of the interactions and their potential problems and risks in agroforestry. Highlight the importance of making appropriate selection of species and management system to fully exploit the soil volume for growth resources with the minimum possible competition, problems and risks.
Beniest J. Plant protection and pesticide use. Technician Training Note. Nairobi: ICRAF.


TEACHING OBJECTIVES

The objectives of this module are to enable students to:

• list different agroforestry technologies and identify ways to classify them into relevant groups
• describe the components, management and objectives of the most common technologies
• explain how and establish where farmers can use appropriate agroforestry technologies to improve their farming systems (understanding the limits of technologies)
• identify existing traditional agroforestry practices and assist farmers to develop them further with improved technologies
TEACHING STRATEGIES

Classroom lecture

The subject may be developed as one or a series of theoretical classroom presentations on technologies and their possible classifications, emphasizing the important ones for a specific region.

Use slide series, videos, pictures, drawings, models, etc. to illustrate the technologies (see Source materials).

Demonstration

Where possible, demonstration plots of the most important agroforestry technologies in the region can be established on the college farm. As research experience and capacity in technical colleges is in most cases inadequate, it is useful to get technical advice from external resource persons on the design and management of the demonstration plot, species to be planted, as well as the collection and use of the information obtained from it.

The purpose and design of a college agroforestry demonstration plot should not be seen in terms of an agroforestry course only. It should be intended to serve demonstration purposes of related disciplines — agronomy, animal science, soil conservation, etc. Therefore, there is need for interdepartmental coordination and multidisciplinary input in the design, establishment, and management of the plots.

Students should participate in the establishment and management of the demonstration plots as part of their practical work. Where appropriate, students may carry out special projects in such plots as part of their study requirements.

Make sure that the plots retain their 'demonstration' value throughout their useful life (put up a board that gives details of the demonstration plot, date of establishment, names of the different components, a plan of the plot, etc.). Control pests, diseases and weeds, and manage the plot as needed. Organize a field day in the demonstration plot for an important event such as a tree-planting day.
Field visits

Field visits to observe important agroforestry technologies may be organized to farmers' fields, extension projects or research stations dealing with agroforestry. Provide the students with a handout that summarizes the most important observations that will be made during the field visit (type of technology, components and their names, their arrangement and management, expected benefits to the farmers, etc.). The students should be required to write a short report about their field observations.

TEACHING OUTLINE

Introduction

Highlight what will be covered in this chapter in the context of what the students have studied previously and make the link with relevant aspects that will be covered in future presentations.

For this chapter, students are expected to be conversant with what agroforestry is all about and how the components in agroforestry systems interact. Later on in the course they will study the socioeconomic aspects related to the technologies, and learn how to design agroforestry interventions and technologies to suit the needs of farmers, and to extend them to farming communities.

General overview

In previous presentations students will have become familiar with the most common agroforestry terminology (system, practice, technology, and classification based on structure of the components, time, expected benefits, etc.). Emphasize the fact that the concept 'technology' refers to a 'package' of technical recommendations (components, arrangement, management, place on the farm, expected benefits, etc.) that is expected to be an improvement over a traditional system or practice.

It is important to cover all levels of technology classification, from the very simple (e.g. simultaneous technologies where all components are in the field at the same time, or sequential technologies where the components are present at different times, or where the maximum growth rates of the components occur at different times) to the most complicated (classifications using the structure of the system, function or other criteria). Where possible relate the given
technologies to some existing physical examples or practices that the students are familiar with. Stress the fact that a classification method is often developed for a specific purpose, and as such there is no single ideal way to classify technologies.

Select an appropriate classification method for technologies that suits the needs of the farming communities in the area, e.g., if most of the farmers in the area raise livestock, you may want to focus on a 'livestock technologies' group subdivided into alley-farming, fodder banks, live fences, trees in pastures, and other technologies. If crop production is more important, you may want to use a classification system that distinguishes between technologies that improve production and those that protect production resources (e.g., better soil fertility, windbreak, terracing, etc.) and those that directly contribute to production (e.g. fruits, leaves).

If you want to develop your own classification for agroforestry systems, use or adapt one that has been described in the literature. You may, for example, use the following classification that*is often used in training courses (table 3.1):

Table 3.1. Classification of agroforestry systems

| Crops under tree cover | • Farmed parklands or scattered trees in cropland  
|                        | • Mixed tree-crop plantations (rubber, coffee, coconuts, cocoa, fruits)  
|                        | • Shade trees in crop land  
| Animal production     | • Grazing under tree cover or in forests  
|                        | • Trees for pasture improvement  
|                        | • Animal production in woodland (browsing)  
|                        | • Fodder trees on farm  
| Agroforests            | • Tree home gardens  
|                        | • Village forest gardens  
|                        | • Woodlots and other block planting of trees on farm land  
| Linear agroforestry arrangements | • Windbreaks and shelterbelts  
|                                | • Boundary planting  
|                                | • Tree hedges  
|                                | • Living fences  
|                                | • Woody strips  
|                                | • Trees on contours (soil conservation)  
|                                | • Hedgerow intercropping or alley cropping  
|                                | • Alley farming  
| Sequential agroforestry arrangements | • Sustainable shifting cultivation  
|                                     | • Improved tree fallows  
|                                     | • 'Taungya' or 'shamba' system  
| Other technologies              | • Trees and aquatic animals (aquaforestry)  
|                                | • Trees and insects (entomoforestry)  

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Explain how this classification mostly uses the structure of the tree component mixed with elements of function to distinguish between technologies. Develop a 'critique' of this classification with your students. For each group of technologies provide a general overview to expound what the technologies are about.

**Specific technologies**

Using an appropriate classification system, select the most relevant technologies in the context of your teaching and your intervention area and provide a detailed overview of each technology, covering the following aspects:

**Introduction**

Where possible, give some historical background on the technology. Has it been a practice in the region? Where did it originate? When was it introduced? How? Identify similarities and differences between its region of origin and your intervention area to justify its usefulness for farmers in your region. What research and/or development activities have taken place in the region?

**Definition**

Develop a concise definition of the technology and discuss it with the students to make it clear to them what that specific technology represents.

**Description**

- Describe the technology in its most common form — Where can it be found on the farm (niche)? How are the components (crops, trees and eventually animals) arranged vis-a-vis one another? What are the characteristics of the tree component?

- Describe the benefits of the technology (mostly products such as fodder, mulch, wood, fruits and medicine, or services such as soil fertility improvement, erosion control, boundary marking, and protection of crops from free-roaming animals). What are the primary and secondary benefits?
• Describe the variations of the technology and discuss how farmers have adapted it to suit their own specific needs; for example, research may have developed specific recommendations for the technology but farmers may have changed these as a result of certain constraints or opportunities (species, spacing, arrangement, niche, management, etc.) Explain how this may affect the performance of the technology.

Current knowledge

Various research institutions and development organizations will have information about the different technologies you are interested in. Ideally, this knowledge will be available within the region where you teach, but you may also have to consult the literature for information on research and development experiences gained in other parts of the world. Within the limits of the level of this course and the time available, summarize data on relevant experiences to provide an overview of the current knowledge about:

• the different types of components that have been studied or used in a technology (which tree or crop species or varieties; why were they selected and what are their advantages over others?)

• the arrangement of these components in the technology (place on the farm, position of each component versus the others, structure and spacing of individual components)

• the management of each component — with a focus on the trees — in the context of the technology (nursery, planting, pruning, harvesting, etc.)

• the positive or negative interactions that can be experienced with the technology (above-ground competition for light and shade, below-ground competition for water and nutrients, support for climbing plants, protection from rain and wind, destruction of crops, etc.)

• inputs, outputs and performance of the technology (what is needed to establish the technology and to maintain it? what can be expected in terms of products or services? can these be quantified? how does the technology perform when inputs are compared with outputs? how does it compare with other alternatives?)
• social and economic aspects (what is known about the economics of the technology? what are the social opportunities or obstacles that may improve or limit its extension, e.g., tenure, gender, cultural beliefs, etc.)

• environmental and ecological aspects — suitable niches and limits, benefits and risks

Illustrate all of these aspects with appropriate research and development examples, preferably from your own region or area.

Extension potential and constraints

Introduce the students to the system and institutional set-up of extension in your country — from the national to the grassroots or farmers' community level. Describe the land-use characteristics and farming conditions (problems, constraints and opportunities) for which a specific technology may be appropriate.

For example: hedgerow intercropping can address a soil fertility problem in regions with the following characteristics: 1) fertile soils without major nutrient limitations, 2) adequate rainfall during the cropping season, 3) sloping land with an erosion hazard, 4) an ample supply of labour, 5) scarce supply of land, and 6) secure land tenure.

Looking at the land-use characteristics and farming conditions, find out what other agroforestry or non-agroforestry alternatives exist. What is the comparative advantage of one alternative over the others?

For example: A soil fertility problem may be solved through the use of compost or chemical fertilizers, or tree or crop fallows, or hedgerow intercropping. Why would hedgerow intercropping be the best solution in a certain case?

List the possible knowledge gaps that may be encountered while developing a technology. How can they be addressed? What is the role of research?

List possible extension constraints to the successful dissemination of the technology (inadequencies in nurseries, farmer training, markets, agricultural
and forestry policies, land and tree tenure). How can they be addressed? What is the role of development organizations (the government, NGOs) in this?

References and further reading

Indicate what references you have used to develop your presentations as well as some relevant publications that students could consult to learn more about the subject.

SOURCE MATERIALS


4

Socioeconomic aspects of agroforestry

TEACHING OBJECTIVES

The objectives of this module are to enable students to:

• appreciate farmers' views, values, traditions, etc.
• describe socioeconomic factors to be considered in agroforestry interventions
  . describe the legal framework of land and tree tenure, and policy issues relevant to agroforestry
• explain how gender and culture relate to agroforestry
  . determine the costs and benefits of agroforestry enterprises
TEACHING STRATEGIES

Classroom lecture

This chapter will largely be based on classroom lectures, introducing the students to the basic elements of tenure, gender, culture and economic evaluation of agroforestry systems. Pertinent government policies on land, and socioeconomic aspects may be discussed. Use slide series, films, videos, etc. to illustrate these, for many students these are new aspects.

Case studies

Case studies may be developed to demonstrate the economic aspects of agroforestry interventions. For instance you may develop a simple cost-benefit analysis of an agroforestry project in a suitable environment.

Field visits,

Organize field activities to undertake a basic socioeconomic survey in the farming communities. Assess the farming systems and production factors — household energy sources, population, state of the environment, etc. — that are of importance in agroforestry intervention. Certain aspects of land tenure, culture and gender — such as labour issues and traditional values and how they affect decisions about agroforestry — can be included in discussions with farmers during the field visits.

Make sure that the students observe common courtesy rules when visiting farmers' fields or research farms.

TEACHING OUTLINE

Introduction

For most students in natural sciences, socioeconomic issues are a rather new concept. The introduction to this chapter is therefore very important in setting the scene for the whole chapter chapter.
In the previous chapters the students covered the basics of agroforestry components and systems, and agroforestry technologies. In this chapter we show how that knowledge links with the user of the agroforestry technologies — the farmer. We will look at the factors that affect farmers' decisions in agroforestry. Keywords are 'tenure', 'gender' and 'culture'. We will also examine the economic aspects of agroforestry activities and how they are influenced by production resources — land, labour and capital — to be able to do a cost-benefit analysis. Explain the terms 'cost' and 'benefit' in terms of their broader economics context.

To understand these socioeconomic aspects, the students need to learn about the different spheres or levels in which the farmer lives and works — the household, the village or community and the national sphere. Understanding how these spheres relate to and influence the farmers' day-to-day activities is very important.

Basic socioeconomic factors that have impact on agroforestry, such as population density and growth rate, land holding, level and means of income, source of energy for domestic use, uses of trees, etc., are important subjects for this stage.

The historical perspective of the changes in land-use and household systems is another aspect in this chapter. What has happened in the past affects today's decisions, and traditional knowledge is often very useful in new activities.

Finally, aspects of sociological and economic evaluation should be discussed. Understanding how evaluation tools are used is essential in the process of introducing or improving agroforestry interventions.

This information will provide a foundation for the next chapter about agroforestry interventions.

**Social factors affecting agroforestry adoption**

**Tenure**

Introduce the students to the concept of 'tenure' — the nature and distribution of rights to land, trees or other resources. There are many types of rights related to resources, but most fall under one of the following four categories:

- right of use — to cultivate crops, cut branches or trees, etc.
- right of transfer — to rent, sell, bequeath, mortgage, or pledge, etc., land or trees
• right of exclusion — to forbid others from using trees or land
• right of administration — to allocate land or to alter rights to land or trees

Explain to the students the different levels or spheres under which these rights are distributed — individual, household, groups, organizations, or governments.

Introduce the concept of 'security of tenure'. This means "to have sufficient quantity, duration and assurance of rights to resources". More specifically the term refers to:
• quantity — having sufficient number of certain key rights to resources
• duration — having the rights for a sufficient time
• assurance — having certainty of existing rights

**Land tenure at community and household levels**

Explain what the following basic property ownership categories entail:
• state ownership — all rights of transfer extension and administration are vested in the state
• private ownership — all use, transfer, and exclusion rights are vested in private citizens
• common property — there is a clearly defined group of rules for users
• open access — resource is accessible to everyone, and there are no rules governing use rate or maintenance

Discuss the main land tenure aspects in your region or area at community and household levels and relate them to the basic property ownership systems. Also clarify how they interrelate. Observe that traditional and formal rights might contradict.

Highlight the factors that influence tenure systems in your region or area (population, economic, climatic factors, government interventions and local customs).

Explain how tenure rights at household and individual levels are influenced by:
• process of land acquisition
• local cultural factors
• socioeconomic status of households
• gender issues within a household
At the household level, point out that different members of the household may have different rights.

Discuss the above aspects with students, from local and regional perspectives, and establish an overview of the land tenure situation.

*Tree tenure at community and household levels*

Explain the main components of tree tenure — the right to own, inherit, plant, manage, cut, use or sell a tree or its products. Discuss the implications of tree tenure components to agroforestry development.

Explain the differences in tenure between indigenous and planted trees, and between different species. Highlight the importance of these differences in the context of agroforestry extension, using local examples.

*Land-use policies and legislation*

Give an overview of the current land-use policies and legislation as they relate to agroforestry development. Discuss conflicts and agreements between the established policies and legislation, and traditional land and tree tenure practices.

*Gender*

Observe that the term 'gender' does not refer to just women but to men, women and children and how they relate to one another. Gender refers to the different roles for women and men as defined by culture and society. Explain how gender issues deal with information about men and women and their roles, resources, labour, preferences, incentives, etc.

Discuss with students the differences in entitlements and rights among men, women and children in sample or chosen areas, covering:

- responsibilities
- user rights
- legal rights
- division of labour
- decision-making systems
Rural livelihood systems — norms and influences

Highlight the effect of external influences on traditional norms. Explain the implications of conflicts in gender issues (traditional norms versus external influences) to agroforestry development.

Gender analysis and framework

Explain how gender roles are defined by the society and highlight how the definition of roles is often based on a society's value judgment and stereotypic conceptions.

Introduce students to a gender analysis framework that can be applied to sample situations and in the context of agroforestry extension activities.

Discuss the aspects to be considered in the gender framework analysis. They should include the following:

- who does what
- who has access to what
- who controls
- who benefits
- who is the decision maker

Develop profiles on community activities and resource access and control. Use the profiles to explain the framework process in gender analysis. The examples in tables 4.1 and 4.2 can be modified to fit local situations.

Table 4.1. Analysis framework for activity profile

<table>
<thead>
<tr>
<th>Activities</th>
<th>Female adult</th>
<th>Male adult</th>
<th>Female child</th>
<th>Male child</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-farm employment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grazing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marketing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash crop management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food crop management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collecting firewood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fetching water, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4.2. Analysis framework for access and control profile

<table>
<thead>
<tr>
<th>Resource</th>
<th>Access</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Female adult</td>
<td>Male adult</td>
</tr>
<tr>
<td>Land</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Money</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash crops</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tree</td>
<td></td>
<td></td>
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<tr>
<td>Labour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Role of gender in agroforestry issues

Explain the importance of the results of gender analysis and their influence on agroforestry extension programmes. Guide students through a discussion about the gender analysis exercise, in the context of agroforestry extension activities. Explain the advantages of gender analysis in programme development, highlighting the following uses:

- identification of factors likely to constrain agroforestry extension
- facilitation of early adjustments and adaptation
- identification of specific needs and correct responses

Determinant analysis

Explain the term 'determinant analysis', pointing out how the method is used in identifying factors to be addressed to minimize their influence on agroforestry extension programmes. Discuss the factors involved in the determinant analysis — culture, environment, economy, government policy, land and tree tenure, and labour — highlighting their implication in agroforestry extension programmes.
Traditional values and indigenous technology knowledge

*Social values of users*

Bring to the attention of the students the traditional values system (religion, traditional beliefs, taboos, etc.), so that they can identify and understand local perceptions and attitudes that have implications on agroforestry interventions.

*Traditional agroforestry concepts*

Discuss the nature of the indigenous knowledge about trees and tree products and how trees and crops interact in an agroforestry system. This is important in the planning process, and affects adoption of the technologies.

*Social evaluation of agroforestry*

Explain how agroforestry activities are evaluated, focusing on social and economic evaluation. Discuss the characteristics of social evaluation, particularly as they relate to the acceptability of agroforestry technologies. The evaluation should look at both the demand for and the supply of the technologies. Key questions concerning the demand are:

- Who is adopting the technology?
- What aspects of the technology do they like or dislike, and why?
- What is the impact?

The supply side deals with questions such as:

- What are the best communication methods?
- How are existing institutions to be used or improved in extending technologies?
- How are seeds and planting material to be obtained?

*Methods*

Social data can be collected in a number of ways; describe the most relevant ones for your conditions. Some methods are:

- open dialogue with individuals and groups
- use of plays, games and other local communication means
- case studies
- informal surveys
• formal surveys
• farmer visits to trials
• farmer-designed trials
• village-level workshops

Economic evaluation of agroforestry

Assess the economics knowledge of the students. How much on the concepts outlined here has been covered in other courses such as Introduction to economics, Agricultural economics, Forestry economics, or Natural resources economics? Build from what the students know, concentrating mainly on the evaluation of agroforestry using those concepts and criteria.

Support this topic with simple and practical economics examples, such as one that compares economic returns from different cropping practices with and without an agroforestry component.

Framework

Economic evaluation deals with the feasibility (whether the required resources and infrastructure are available) and the profitability of an agroforestry activity. This section should provide the fundamentals for economic evaluation of agroforestry technologies.

Types of economic evaluation

Describe the different types of economic evaluation — the public and the private economic evaluations. Explain the differences in ex-ante (before) and post-ante (after) evaluation, and highlight their application in planning (for ex-ante evaluation) and monitoring (post-ante evaluation).

Costs and benefits

Describe the different costs (inputs, opportunity costs) and benefits (positive outputs) associated with evaluating agroforestry systems. Distinguish between tangible (measurable in physical units) and intangible costs and benefits, and highlight their importance in the economic evaluation of agroforestry activities.

Explain the approaches for quantifying tangible and intangible costs and benefits in economic evaluation. Explain the process of valuation of inputs and benefits in economic evaluation.
outputs. Point out the differences in private economic valuation — use of market prices and opportunity cost prices — and public economic valuation — use of shadow prices and the society's willingness to pay.

Discuss the effects of the following on the valuation of costs and benefits on agroforestry activities:
- time
- risk and uncertainty
- government policies

**Principles and methods of economic evaluation**

Discuss the basic issues to be addressed by cost-benefit analysis: what to produce, how to produce, and how much to produce.

Discuss the use of budgets in comparing options — whole-farm budgets for analysing the whole farm, and partial budgets for analyses where there are differences in inputs and outputs. Highlight the use of the cost-benefit analysis method in comparing budgets.

Explain how economic evaluation is used in planning agroforestry activities, highlighting the use of linear programming (selection of the most optimal of available resources over the different possible options) and sensitivity analysis (responses to changes in key variables like prices and discount rates) as planning tools.

**Measures of economic worth**

Explain the meaning of 'economic worthiness' of an activity. Explain the importance of discounting in comparing different alternatives, and describe the following economic evaluation criteria in the context of agroforestry activities:
- net present value (NPV)
- internal rate of return (IRR)
- benefit-cost ratio (BCR)

**Information needs and collection**

List some important methods for collecting economic data.
Developing agroforestry interventions

TEACHING OBJECTIVES

The objectives of this module are to enable students to:

- list and describe the basic concepts, principles, tools and methods of land-use characterization and diagnosis
- conduct a characterization and diagnosis exercise for a farming community/household
- develop and design appropriate agroforestry interventions based on land-use characterization and diagnosis
TEACHING STRATEGIES

Classroom lecture and case-study presentations

The topic may be developed as a series of theoretical classroom presentations on the subjects of 1) land-use and farming household characterization and diagnosis, 2) tools and methods for characterization and diagnosis, and 3) the approach used to design and develop agroforestry interventions aimed at alleviating farmer-identified problems and constraints.

The best way to illustrate the theoretical concepts is through a case study on characterization, diagnosis and intervention design in a relevant agroecological region. Ideally, such a case study presentation will be illustrated with slides.

Demonstrations and practicals

Where possible, some of the tools and methods that facilitate land-use characterization (aerial photography, remote sensing, geographical information systems or their outputs) can be demonstrated to students and become the subject of some practical work (data collection, analysis and interpretation) in the preparation of a field exercise. Develop a farming household survey questionnaire and practise the use of participatory diagnostic tools.

Field visits

A field visit may be organized to identify, observe or verify important land-use characteristics (topography, vegetation, soils, land-use systems, socioeconomic aspects, etc.) and diagnosed problems and constraints (deforestation, erosion, soil fertility decline, land degradation, low farming income, population pressure, etc.). Clearly explain how these affect land use and farming systems and highlight how agroforestry interventions can potentially be of help to farming communities in the area.

Field exercise

The most important teaching strategy to reinforce the theoretical concepts and principles of land-use characterization, diagnosis and agroforestry intervention design is a practical field exercise.
The organization and implementation of such an exercise is described in detail in the ICRAF field exercise book *Characterization, diagnosis and design training exercise book for Embu, Kenya* (Beniest et al. 1995). Even though that exercise book has been developed for a specific land-use system, most of it is applicable to a wide range of land-use systems. The main parts that will need to be developed for a specific land-use system are those on characterization and extension. Ideally this exercise should be implemented towards the end of the course so that students will apply all the knowledge acquired during the course. The exercise comprises the following activities:

1. **Characterization and extension information**

   For the exercise, students and/or resource persons collect relevant biophysical (location, climate, soils, vegetation, topography, land use, etc.) and socioeconomic (population, labour, marketing, infrastructure, tenure, policies, etc.) characterization and extension information on the targeted land-use system.

2. **Use of diagnostic tools**

   During a practical session, students and resource persons familiarize themselves with the diagnostic tools that will be used to conduct a farming household survey for identifying farmers' perception of problems and constraints.

3. **Data verification and collection**

   Students verify characterization and extension information and, using appropriate diagnostic tools, collect data on individual farming objectives, enterprises, problems and constraints.

4. **Hypothesis formulation and testing**

   Using available data and information, students identify and prioritize major land-use problems and constraints and develop a method to confirm and test their hypotheses with the farmers in the targeted land-use system.

5. **Intervention design**

   For one or several priority problems or constraints, students identify a potential agroforestry solution and specify it in terms of its components and their management. This part of the exercise will identify a series of knowledge gaps that may need to be addressed through research, and the problems related to extension and farmer adoption of the proposed intervention.
TEACHING OUTLINE

Introduction

Explain the importance of this chapter in the context of this course in the sense that it will require students to apply all their knowledge about the concepts and principles of agroforestry, components, systems and technologies as well as sociological and economic aspects of agroforestry, to design agroforestry interventions and technologies that are suitable for a given land-use system and will be adoptable to farmers. At the end of this chapter students will be able to develop and design interventions and technologies using available characterization and diagnosis information.

Characterization

Define and describe land use or agroecosystem characterization and diagnosis and highlight the differences between them. Explain the concepts and importance of spatial (geographical) boundaries, and scales or units of observations in the context of characterization. List and describe the elements that need to be considered in the analysis of agroecosystems as they relate to the interactions between components and the classification of systems. Explain the terms 'georeferencing' and 'quantification' as important attributes of characterization.

Explain the concept of hierarchy of agroecosystems and the relationships among the different scales.

List and explain the significant objectives of characterization as they relate to the extrapolation of recommendation domains, site selection, diagnostic studies, extrapolation of research results, information for technology development, and impact analysis.

List the important biophysical (location, climate, soils, vegetation) and socioeconomic (demography, economy, infrastructure, policy) variables that may constitute a minimum characterization data set at a given scale. Focus on the usefulness of data at one or several scales and on the quality of data as they relate to reliability and currency.

List and describe some important tools that can be used for characterization at different scales (secondary information, geographical information systems, remote sensing, aerial photography, surveys and interviews).
Give examples of the use of characterization information to examine interactions among variables and to understand fundamental processes, to select sites for development or research, to identify the importance of combinations of variables or to extrapolate research results.

**Diagnosis**

Define the place of 'diagnosis' in the context of land-use and agroecosystems characterization. What are the main differences between the two in terms of scale, resolution of data arid focus?.

Define 'farming household diagnosis' as an approach to understanding farmers' problems and constraints, and explain how this facilitates designing of technologies or interventions that address farmer-identified problems and constraints and that are be attractive to farmers.

Explain the key features of farming household diagnosis — flexibility, iterativeness and a combination of the use of formal and informal methods to obtain reliable information on land use and farming systems.

Define who the key players are in a farming household diagnostic exercise (farmers, extensionists, researchers, policy makers, key informants) and explain why it is necessary to have multidisciplinary teams in conducting such surveys.

List and compare different approaches that can be used to understand and troubleshoot agricultural production systems (diagnosis and design — D&.D, farming systems research — FSR, rapid/participatory rural appraisal — RRA/PRA, etc).

List and elaborate the stages and steps in farming household diagnosis and subsequent agroforestry intervention design and highlight the iterative nature of this process (characterization or pre-diagnostic information gathering; diagnostic field work at the farm level; data analysis; hypotheses formulation; prioritization of problems, constraints and potential solutions; hypothesis testing; and intervention and/or technology design.

List some participatory took that can be used to conduct a farming household survey (formal and informal farmer interviews, maps, transects, calendars, labour and resources charts, conceptual diagrams, ranking, etc.), and explain how they are used in the process.

What are the outputs or end products of farming household diagnosis (system description; assessment of farmers' problems and constraints; prescreening of potential interventions such as technologies, components, policies; assessment of information gaps; and design of appropriate interventions)? Give examples of hypotheses regarding farmer resources, target
groups, farmers' problems and interventions, etc., and suggest ways to prioritize, differentiate and verify these.

**Technology-intervention design**

The product of characterization and diagnosis exercises should be sufficient information to design priority interventions that will address farmer-identified land-use problems and constraints. Stress the importance and the iterative nature of the overall characterization, diagnosis and design process, and give examples of how they will influence each other over time.

List and describe some important considerations in intervention design (agroecological suitability, adoption potential, influence on the farming system as a whole, sustainability, etc.).

List and describe some possible agroforestry or non-agroforestry interventions (policies, technologies, extension, etc.) that may address a specific problem or constraint. Give some examples showing instances where interventions can be considered appropriate and show why a specific one is chosen over others. What biophysical and/or socioeconomic criteria can be used to compare, and thus prioritize, different interventions? Describe some participatory tools (e.g. matrix ranking) that can help confirm the ranking of alternatives.

If the proposed intervention is an agroforestry technology or an improvement of a system, explain that one needs to specify this in terms of the components and their arrangement and management. What would be the expected inputs and outputs and how can performance be quantified or qualified?

Develop a technology design framework that will allow the identification of possible knowledge (to be addressed through research) and dissemination (to be addressed through extension) gaps. Highlight the need for biophysical (e.g. ecological, agronomic, soil-related considerations) and socioeconomic (cost-benefit analysis, labour, tenure, etc.) technology evaluation to determine the potential adoption of the technology.

If knowledge gaps are identified that need to be addressed through research, what sort of basic questions will need to be addressed to allow improved intervention design? What factors need investigating or rating for importance (effect on biological performance, potential for modification and adoption, interaction with other farming enterprises, researchability)? What hypotheses are to be tested? What experiments should be designed? List, describe and give some examples of the types of research that may be needed to
address knowledge gaps (adoption, on-farm, on-station, strategic, applied, or adaptive research).

List and explain some important factors that may affect technology transfer and impact: logistic infrastructure, marketing, nurseries, extension, farmer training, etc.

SOURCE MATERIALS


Scherr SJ. 1990. The *diagnosis and design approach to agroforestry project planning and implementation: examples from western Kenya.* Nairobi: ICRAF.
TEACHING OBJECTIVES

The objectives of this module are to enable students to:

• analyse and compare the basic concepts and methods of agricultural and forestry extension in the context of their application to agroforestry

• explain and apply the various steps involved in planning and managing agroforestry extension activities

• implement agroforestry extension activities with farmers

• monitor and evaluate agroforestry activities, and the effectiveness of the extension approaches used
TEACHING STRATEGIES

Classroom lecture

The subject may be developed as a series of theoretical classroom presentations on the concepts and principles of general extension, project monitoring and evaluation and their applicability to agroforestry. The students should also be introduced to the existing institutional set-up and system of agricultural or forestry extension in the country, and the status of agroforestry extension in the system.

Relevant extension case studies, using slides and other audio-visual teaching aids, maybe used to illustrate theoretical aspects of the subject.

Practicals and exercises

Practicals and mock exercises can be used to teach appropriate extension methods and tools. Groups of students may develop an extension, monitoring and evaluation plan for a given agroforestry technology in the region. They could develop simple extension materials using available research information on an intervention or technology.

Field visits and discussion sessions

Field visits to relevant extension projects, followed by discussion sessions with farmers and extensionists can be organized to better comprehend the realities of agroforestry extension, monitoring and evaluation.

TEACHING OUTLINE

Introduction

Based on their understanding of the concepts and principles of agroforestry, students should by now be able to develop and design agroforestry interventions and technologies that are suited to local agroecological conditions and have potential for adoption by farmers.
The next important step is the larger scale dissemination of these interventions and technologies through the planning and implementation of extension activities, followed by monitoring and evaluation of agroforestry projects or programmes to determine their impact on the overall development of the targeted area.

**Concepts and principles**

Explain the basic concepts and principles of extension in the context of agroforestry. What makes agroforestry extension different from agricultural or forestry extension? Develop a definition for agroforestry extension with students using the general concept that "extension is a non-formal educational process for transferring and sharing knowledge and skills between farmers and extension agents".

Highlight some important considerations that will affect agroforestry extension and adoption —

- traditional farmers' experiences, beliefs and expectations
- problems and constraints at different scales (farm, community, area, nation, region) in the areas of policy, infrastructure, marketing, resource availability, etc.
- the multidisciplinary character of agroforestry
- social and economic dynamics of the envisaged target groups
- linkages among farmers, extensionists and research
- non-agroforestry alternatives that address farmer-identified problems and constraints

Explain the importance of peoples' participation in extension activities and point out the need to clarify the role of the extensionist and the farmer. Some of the roles listed in table 6.1 can be used as a guide.

**Tools and methods**

List common extension approaches, tools and methods and how they can be used and/or adapted for agroforestry:

- individual, group and mass extension
- farmer-to-farmer extension
- demonstration plots
- field visits to research stations and development projects
• communication tools (mass media, posters, written materials, audio-visuals)

Table 6.1. Sample roles in participatory extension activities

<table>
<thead>
<tr>
<th>Extension workers</th>
<th>Farmers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Help farmers express and communicate their problems</td>
<td>Communicate needs and problems</td>
</tr>
<tr>
<td>Motivate farmers to participate in planning and implementation of agroforestry extension activities</td>
<td>Suggest possible solutions to perceived needs and problems</td>
</tr>
<tr>
<td>Guide the implementation of agroforestry activities</td>
<td>Participate in planning and implementation of extension programmes</td>
</tr>
<tr>
<td>Provide technical advice</td>
<td>Practise new skills and use new knowledge</td>
</tr>
<tr>
<td>Facilitate incorporation of farmer knowledge into new technologies</td>
<td>Provide feedback on new skills and knowledge</td>
</tr>
<tr>
<td>Organize meetings/programmes</td>
<td></td>
</tr>
<tr>
<td>Provide liaison with other organizations involved in similar activities</td>
<td></td>
</tr>
<tr>
<td>Make available information about extension programme</td>
<td></td>
</tr>
</tbody>
</table>

Extension methods

Point out that agroforestry extension can be implemented using many methods. Explain that the choice of methods and tools will, however, be largely determined by factors like:

• the extension approach adopted (bottom-up or top-down approach)
• goals and objectives of the extension programme
• available resources
• institutional capacity, infrastructure and organization
• socioeconomic considerations

Explain to the students what 'individual', 'group' and 'mass' extension methods involve, highlighting the advantages and disadvantages of each method. Table 6.2. may be used as a guide. Point out that a combination of two or more methods is often better than one method.
Table 6.2. Sample description of different extension methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| Individual | • Communication is easy and simple  
• Confidence, trust and cooperation are easy to build  
• Feedback can be received immediately  
• Enables individual participation | • It is expensive  
• Requires many staff  
• Few farmers may be reached  
• Area coverage is small |
| Group     | • Cheaper than individual approach  
• More farmers are reached  
• Exchange of experiences and ideas is possible within the group | • Decision making is difficult  
• Influential people tend to dominate and benefit  
• Individual problems are not easy to address  
• People who are not members to the groups are never reached |
| Mass      | • Facilitates rapid spread of information  
• Many people are reached in a short time | • Limited information can be transmitted  
• Most target groups may not have receivers (TVs or radios) or required literacy level  
• Impact is difficult to evaluate  
• Production of extension materials is costly and requires specialized skills |

**Extension tools**

Define extension tools — "means which can be used to communicate extension messages to people". Point out that the application of the different tools can be varied, depending on the extension method adopted. Describe the common extension tools and relate them to the extension methods (individual, group and mass methods). Table 6.3 below may be used as a guide. You can, however, discuss with the students the relationships between extension methods and tools, for better understanding.

**Agroforestry education and training**

Explain the role of agroforestry education and training in extension. Highlight the current human resources capacity in agroforestry and the need for more training.
### Table 6.3. Some common extension tools to extension methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Tool</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual</td>
<td>Farm/household visits</td>
</tr>
<tr>
<td></td>
<td>Telephone calls</td>
</tr>
<tr>
<td></td>
<td>Personal letters</td>
</tr>
<tr>
<td></td>
<td>Informal contacts</td>
</tr>
<tr>
<td>Group</td>
<td>Films/videos with explanation from a competent person (guided)</td>
</tr>
<tr>
<td></td>
<td>Meetings</td>
</tr>
<tr>
<td></td>
<td>Demonstrations</td>
</tr>
<tr>
<td></td>
<td>Tours and field trips</td>
</tr>
<tr>
<td>Mass</td>
<td>Unguided video and films, television and radio</td>
</tr>
<tr>
<td></td>
<td>Exhibitions/displays and posters</td>
</tr>
<tr>
<td></td>
<td>Folders/leaflets and pamphlets</td>
</tr>
</tbody>
</table>

### Agroforestry extension and research

Discuss the importance of linking education with research and extension. Point out the vital link extensionists form between farmers and researchers, and the importance of research inputs into extension activities/packages. Highlight the role of research in technology generation and refinement.

### Planning and implementation of agroforestry extension

Describe the main approaches to extension planning —

- top-down approach
- bottom-up approach

List and discuss the advantages and disadvantages of each extension approach. Through discussion with the students, establish the best approach for planning agroforestry extension programmes in the local area. Highlight some relatively recent agroforestry innovations that require special consideration and environment when being passed on to farmers, as compared with traditional disciplines such as agriculture and forestry. For instance, introducing trees on farm can attract birds and other vermin that could damage crops. Discuss examples of such instances exhaustively.
Highlight the implications of the following considerations when planning agroforestry extension programmes, and their impact on the adoption of agroforestry:

- traditional farmers' experiences, beliefs, and expectations
- problems and constraints at different scales (farm, community, district, nation, region) in the areas of policy, infrastructure, marketing and resource availability
- the multidisciplinary character of agroforestry
- social and economic dynamics of the envisaged target groups
- linkages among farmers, extensionists and research
- non-agroforestry alternatives that address farmer-identified problems and constraints

Explain the importance of time in the process of technology adoption by farmers. Point out the 'transition element' in extension — from research or technology generation to the practical application of the technology by farmers. Highlight the need for careful planning in the 'transfer process', covering the 'what, when, how, and by whom' aspects of all the expected programme activities, if the desired impact is to be achieved. Give examples in each case.

Introduce the students to the use of weekly, monthly or quarterly extension plans. The example in table 6.4 below may be used as a guide.

Table 6.4. Nursery establishment seedling supply

<table>
<thead>
<tr>
<th>Activity</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed collection</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Nursery site preparation</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil collection</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construct nursery beds</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Seed sowing</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pot filling</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Watering</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Pricking out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Root pruning</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardening off</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Sale/supply seedlings</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Planting out</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

Note: This should be modified to fit local conditions and the nature of activities planned.
Students should work in groups to develop plans for identified extension activities, such as:

- seed collection
- tree establishment in the field
- field trips
- field demonstrations

**Monitoring and evaluation**

**Monitoring**

Establish, with student participation, the definition of 'monitoring'. A common definition is "monitoring is a continuous process of information collection, recording and reporting on an on-going extension programme". Explain the importance of establishing a common understanding for monitoring in the context of agroforestry extension activities, recognizing its multidisciplinary nature.

Highlight the importance of monitoring agroforestry extension programmes, particularly pointing out that its development is more recent than of traditional agricultural extension.

Discuss the advantages of monitoring —

- keeping track of the progress of the activities of the extension programmes as per set objectives
- facilitating timely forestalling and removal of constraints, and institution and implementation of corrective measures
- providing opportunity and data for redesigning activities
- keeping track of resource use

Explain the components of monitoring — indicators, methods and tools, and communication of monitoring findings.

**Indicators**

Describe what 'indicators' are and how they can be measured and expressed. Students should learn how to clearly determine and specifically define the indicators to be monitored. Distinction should be made between primary indicators (discrete indicators that can be measured directly) and secondary indicators (relative measures that can be derived from primary indicators).
Methods and tools for information gathering

It is important that students learn to identify suitable methods and tools used in information gathering for monitoring purposes and how to use them. They should therefore be introduced to various methods and tools (table 6.5.). Care should be taken to harmonize various methods and tools. This can be best done through discussion.

Table 6.5. Common methods and tools for gathering information

<table>
<thead>
<tr>
<th>Methods</th>
<th>Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surveys</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- formal</td>
</tr>
<tr>
<td></td>
<td>- informal</td>
</tr>
<tr>
<td>Field visits</td>
<td></td>
</tr>
<tr>
<td>Tours</td>
<td></td>
</tr>
<tr>
<td>Meetings</td>
<td></td>
</tr>
<tr>
<td>Random and spot checks</td>
<td></td>
</tr>
<tr>
<td>Reports</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Survey questions</th>
<th>Questionnaires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checklists and structured interviews</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>Checklists</td>
</tr>
<tr>
<td>Topics for reference</td>
<td></td>
</tr>
<tr>
<td>Questionnaires</td>
<td>Open-ended discussions</td>
</tr>
<tr>
<td>Checklists</td>
<td></td>
</tr>
<tr>
<td>Agenda</td>
<td>Discussions</td>
</tr>
<tr>
<td>Seasonal calendars and activity plans</td>
<td></td>
</tr>
<tr>
<td>Bar, line and trend graphs; pie charts and scatter diagrams</td>
<td></td>
</tr>
</tbody>
</table>

Communicating findings of monitoring

Students should be made aware of the need to promptly communicate in clear, simple and precise form to relevant people information generated during monitoring. Advantages and disadvantages of immediate or delayed responses should be established through discussion with students.

Evaluation

Explain the term 'evaluation' in the context of agroforestry extension programmes. Develop with students a definition for evaluation. Evaluation is commonly defined as "a process for assessing and monitoring results for:

- conformity with agreed plan
- improving on-going activities
- assisting management in future planning."
Relate evaluation to monitoring, and explain the differences and relationships between the two processes (table 6.6).

Table 6.6. Differences between evaluation and monitoring

<table>
<thead>
<tr>
<th>Monitoring</th>
<th>Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term</td>
<td>Long term</td>
</tr>
<tr>
<td>- considers activities</td>
<td>- considers effects of the activities as they relate to set objectives</td>
</tr>
<tr>
<td>Ensures that implementation goes on as planned</td>
<td>Impact oriented</td>
</tr>
<tr>
<td>Continuous</td>
<td>Periodic</td>
</tr>
</tbody>
</table>

List the different types of evaluation that can be used for agroforestry and highlight their characteristics:

- on-going evaluation (usually integrated with monitoring)
- terminal evaluation (carried out at the end of programmes)
- ex-post evaluation (carried out long after the end of a programme)

Discuss the need for evaluating agroforestry extension programmes, pointing out the importance of gathering information and analysing and presenting it accurately for decision making.

Explain the advantages of evaluation and identify the users of evaluation results —

Advantages of evaluation

- useful in assessing achievements against set goals of an extension programme
- facilitates informed decision making
- provides a good record of lessons learnt

Possible users of evaluation results

- collaborators (current and prospective)
- project staff
- other interested agencies
- donors
- general public


further reference materials


Hartmans EH. 1981. *Land development and management in tropical Africa.* Ibadan, Nigeria: *IITA.*


Hoekstra DA 1987. Species selection for the *food crop plots in the* eastern and *western plateau system, Burundi —. a case study. Nairobi: ICRAF.*


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