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FARMERS OR FORESTERS

The use of trees in the sylvopastoral systems of the Atlantic Zone of Costa Rica

P.F. Paap

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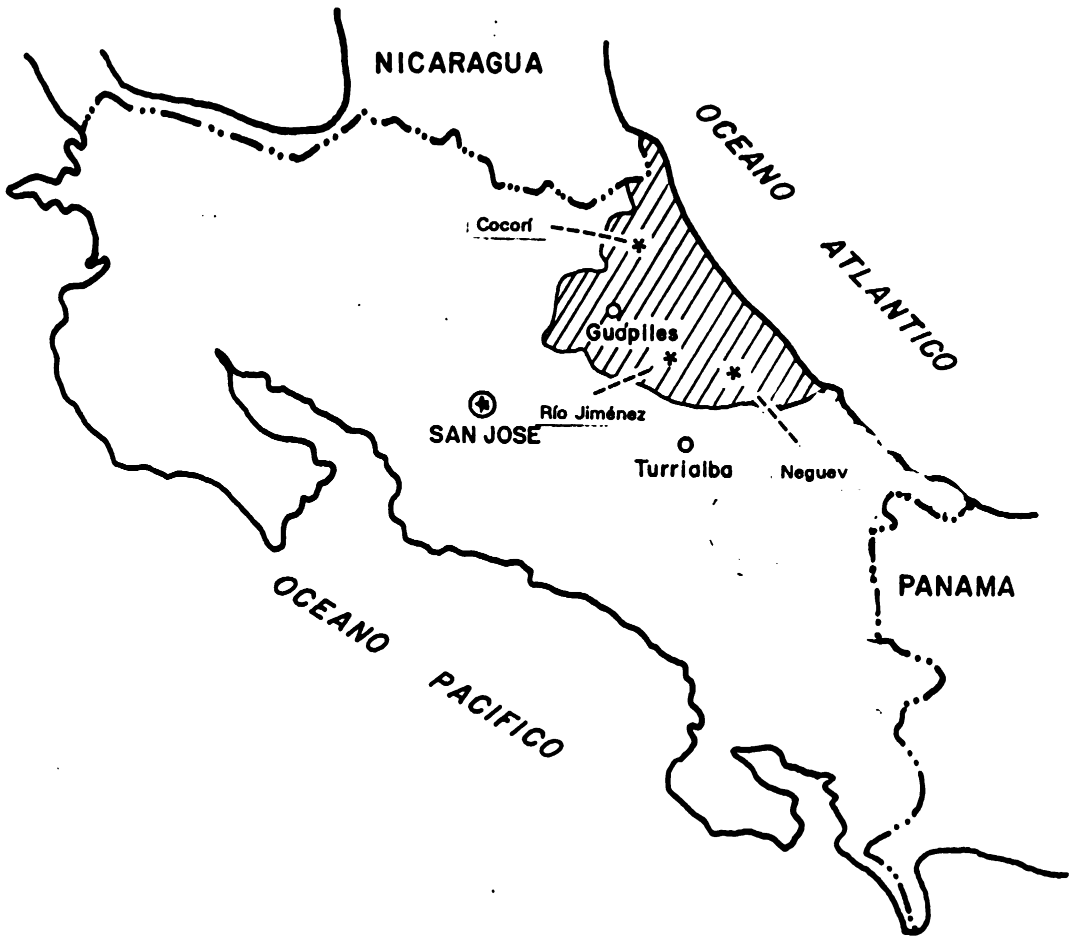

Figure 1. Location of the study area.

PREFACE

General description of the research programme on sustainable Landuse.

The research programme is based on the document "elaboration of the VF research programme in Costa Rica" prepared by the Working Group Costa Rica (WCR) in 1990. The document can be summarized as follows:
To develop a methodology to analyze ecologicaly sustainable and economically feasible land use, three hierarchical levels of analysis can be distinguished.
1. The Land Use System (LUS) analyses the relations between soil type and crops as well as technology and yield.
2. The Farm System (FS) analyses the decisions made at the farm household regarding the generation of income and on farm activities.
3. The Regional System (RS) analyses the agroecological and socio-economic boundary conditions and the incentives presented by development oriented activities.

Ecological aspects of the analysis comprise comparison of the effects of different crops and production techniques on the soil as ecological resource. For this comparision the chemical and physical qualities of the soil are examined as well as the polution by agrochemicals. Evaluation of the groundwater condition is included in the ecological approach. Criterions for sustainability have a relative character. The question of what is in time a more sustainable land use will be answered on the three different levels for three major soil groups and nine important land use types.

Combinations of crops and soils

	Maiz	Yuca	Platano	Piña	Palmito	Pasto	Forestal I II III
Soil I	x	x	x		x	x	x
Soil II						x	x
Soil III	x			x	x	x	x

As landuse is realized in the socio-economic context of the farm or region, feasibility criterions at corresponding levels are to be taken in consideration. MGP models on farm scale and regional scale are developed to evaluate the different ecological criterions in economical terms or visa-versa.

Different scenarios will be tested in close cooperation with the counter parts.

The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW), The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

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SUMMARY

In the Atlantic Zone of Costa Rica, farmers are mostly involved in animal husbandry practices. As their farm systems often contain a lot of woody perennials, either as dispersed trees in the pastures or as trees in living fences, it could be said that large parts of the farming systems occurring in the Zone apply to the definition of sylvopastoral systems.

The methodology used in this research to arrive at a description of the sylvopastoral system, the LUTs and the sylvopastoral practices that are important in the research areas Río Jiménez, Neguev and Cocorí, encompasses a combination of the diagnostic phases of Land Evaluation and Agroforestry Diagnosis & Design. From these tools for land use planning, a checklist was derived, that included inputs, outputs, components and activities. This checklist was the basis for a structured interview with farmers in the research areas (9 in each area) about the importance of trees in their farming systems. A further insight in the farming systems that occur in the research areas and the use of trees within them was gained in three case studies on farms with different Land Use Types.

In this research it has been shown, that farmers like to have trees in their farming systems, as long as these trees do not hinder animal production. So their priorities rest on animal husbandry.

Requirements for further involvement in the use of trees in the sylvopastoral systems are not fulfilled. Time, labour and capital are scarce and laws and infrastructure do not stimulate income generating activities involving trees. Furthermore, the farmers' knowledge about the production functions of trees is often extensive, but knowledge about the interactions between the trees and other components of the systems (service functions) lacks deeper understanding.

What is needed, is appropriate research and extension about labour extensive and income generating activities with trees, that can diversify the farm production.

PREFACE

This thesis has been written as a contribution to the AIO-forestry research project within the VF-program "A methodology for planning of sustainable land use: a case study in Costa Rica". The general aim of the AIO research is to contribute to the process of rural development, based on sustainable land use, in the Atlantic Zone of Costa Rica, by studying the conditions under which trees and forest can be viable components of the farming system. The information gathered from field research will be incorporated in a Linear Programming Model (LPM) for land use planning. The results of this LPM will be used in regional land use planning. The three land use types that are included in the forestry research are: natural forests, plantation forestry and agroforestry.

The study area is the northern part of the Atlantic Zone of Costa Rica. Three research areas were chosen in this Zone, because they were considered as representative for the Zone. These areas are Neguev, Cocorí and Río Jiménez. In these areas a number of farms have been selected in a previous study. These farms have been exposed to a quantitative and a qualitative analysis. The information which this analysis provides, will be incorporated into the LPM. To contribute to the purpose of the LMP within the Atlantic Zone Program, the research conducted as basis of the presented report, analyses a subsystem of one of the forestry land use types, namely the sylvopastoral system.

The supervisor for this thesis in Costa Rica was Ir. A.C.J. van Leeuwen, AIO at the Department of Forestry of the Wageningen Agricultural University. The supervisor in the Netherlands was Drs. A.M. Filius of the same department. The duration of the MSc research project was 5 months (840 sbu.) of which three months field work in Costa Rica (from 13 June - 10 September), and 3 months literature research in the Netherlands.

Pieter F. Paap

1. INTRODUCTION

This first chapter will give an outline of the problem (in section 1.1 and 1.2). Furthermore it will give the context (in section 1.3 and 1.4) in which this report has to be viewed by the reader, by setting the objectives and demarcating the subject.

1.1 Problem analysis

Animal husbandry is an important source of foreign currency for Costa Rica. Within agricultural products, it accounts for the third place after banana and coffee. In the Atlantic Zone of Costa Rica, animal husbandry is a common component of the farming system. The area of pastures in this zone, increased from 35.000 ha in 1963, to 308.482 ha in 1988 (Aragon, 1992).

An evident relationship between animal husbandry and deforestation exists (Weide, 1986). The tropical rainforest of the Atlantic Zone has been reduced from 60 % of all land use in 1960, to 25 % in 1984. This deforestation was strengthened by another phenomena: "tree-reduction". For instance, in the same period of time, the percentage of pastures with trees reduced from 80% to 60% of the total area of pastures (Smits, 1988). This might be an ongoing process.

Still, forests and trees are an important component in land use. Due to the rapid deforestation, forests no longer occur in extensive areas of the Atlantic Zone, but they can still be found in smaller areas on private farms and trees are mixed in systems with agricultural crops and livestock. Trees and forest may be an important part of the farm household, either as a source of land (conversion), a stabilizing element in land use, or as a source of timber, fuelwood, fruits and cash-income. However, the problem is, that many forests/trees disappear due to a wide range of reasons, e.g. intensification of land use, colonization schemes, etc. The dissappearing of forests/trees can bring along certain negative consequences for the region, of which decrease in production capacity of the land, and a lack of timber- and non-timber products in the near future. This may ultimately not only cause a decrease in welfare and well-being of the farming community, but also a major ecological drawback (Leeuwen, 1991).

The integration of trees (or better, woody perennials, as palms, bambu, etc. are also included), pastures and livestock is better known as a sylvopastoral system. A considerable amount of knowledge and information about such systems exists in Costa Rica. For example, organizations like CATIE and MAG are investigating the use of these sylvopastoral systems.

For instance, the utility of fodder producing tree species, planted in lines around the fields, better known as living fences, has been investigated by Smits (1988), Benavides (1985), and others. The use of the guayava tree (*Psidium guayava*) in pastures has been investigated by Somarriba (1987). However, these systems have predominantly been investigated on plots near research stations, or through on-farm experiments.

Investigation upon the way in which the farmers use the trees in their pastures and the problems they encounter while using trees, is a very important precondition for research on how the problems can be alleviated on small (farm) and larger (regional or higher) scale. The services and research institutes, that frequent the research areas in the Atlantic Zone and that occupy themselves with designing new agroforestry systems, have underestimated this importance. Yet, such information is necessary for designing a LP-model, for which the presented research can supply data.

1.2 Problem statement & research objective

The report presented here has to contribute to solve part of the problem field mentioned above. This part of the problem field is described in the following problem statement.

Problem-statement: Which sylvopastoral practices are applied by the farmers of the research areas Río Jiménez, Neguev, and Cocorí in Atlantic Zone of Costa Rica and what is the importance of these practices within the farming systems.

From the problem statement, the following research objectives can be derived:

Research-objective: The general aim of the research is to develop a manner of describing the sylvopastoral land use type in the Atlantic zone of Costa Rica.
The research objective can be split into five basic questions, which are:

- How can the sylvopastoral land use types be described in a structured manner, so that they can be used in land use planning.
- Which sylvopastoral practices do farmers in the Atlantic Zone apply and to what extent?
- What is the role of the tree-element in the sylvopastoral system of a farm, in relation to the other elements (grasses and livestock)?
- What requirements (management, inputs, etc.) are needed to reach the current level of output of trees on the farms?
- What are constraints in the sylvopastoral system of the farm?
- What are possible improvements regarding sylvopastoral practices; are such improvements desired by the farmers and can the constraints be controlled to such extent that the improvements become feasible?

1.3 Methodology

The main purpose of this report is to come to a description of the land use that includes trees, pastures and cattle on the farms of the research areas Río Jiménez, Neguev and Cocorí in the Atlantic Zone of Costa Rica.
To discover the importance of the sylvopastoral system within the farming system, first it is necessary to get information about the research areas (as will be done in Chapter 2). When the important features of land use had been derived from literature, a general idea will be formed about the importance of the use of trees on pasture land for the farmers in the research areas. The management of this sylvopastoral system by the farmers, and in particular

the practices involving trees, must be compared with findings in literature about these practices in general. Therefore, a description of common sylvopastoral practices out of literature is included in the report in Chapter 3.

The result of this research should be a description of types of land use, occuring in the research areas, and involving trees on pasture. Several methods have been developed by large organisations, like FAO, ICRAF, etc., that include a description of land use in their strategy. These methods aim at providing a logical framework for land use planning. Two methods have been chosen to be included in this report: ICRAF's Agroforestry Diagnosis & Design (D&D) and FAO's Land Evaluation (LE). They will be compared in this report in Chapter 4, and useful elements will be extracted to provide a type of standardized way to look at the sylvopastoral systems in the research areas, and to provide a basis for comparing and evaluating these systems.

The field work consists of two elements. The first element was a general interview with farmers. The interview consisted of a stuctured set of open ended questions (there was an order in which they were asked), that left space for answers (a list of alternatives was mentioned and specification could be added). The questions of the interview are stated in Appendix I. The questions dealt with the components of the sylvopastoral system on the farm, including cattle, pasture, dispersed trees and living fences. Furthermore, the farmers were asked if they perceived any interactions between the different components and if they managed the system according to these interactions. The researcher was not able to carry out on-farm measurements, within the restricted time available for the research. That means that things like soil composition, hydrology and yield of tree products cannot be measured. On basis of the information given by the farmers, a type of average sylvopastoral system can be outlined, with components, interactions and management.

For a more detailed study of the importance of trees within the farming system, three farms (one in each research area) were taken as case study. The farms were selected on basis of the animal husbandry practice present (see chapter 2), and on a remarkable sylvopastoral practice. A week was spent on each farm, to work with the farmer (getting to know the farmer and the farming practice) and to conduct a detailed interview about his farming practice. On basis of the case study, a Land Utilization Type description of each farming practice is made, with more specific description of the sylvopastoral practices (a detailed way of tackling the gathered material from the interviews and the case studies is presented in Chapter 5). All results have been stated in Chapter 6. To get to know the farmer behind the sylvopastoral systems, the farmers of the case studies were asked about their opinion on certain subjects. The result of these interviews were used, together with information from literature to state the farmer's opinion about their farming practices, and the influence of research and extension organizations on these practices (see Chapter 7).

In the last phase of the research (Chapter 8), conclusions will be drawn about the importance of trees in the farming systems of the Atlantic Zone. The research results will be compared with available information in literature about similar research conducted in the past. In the recommendations, no clearcut solutions for the observed problems will be given, but only suggestions. So this research will not lead to a new kind of 'wonder' sylvopastoral system, but it will give recommendations about the way in which the existing systems may be improved, within the context of the systems.

1.4 Demarcation

Of course, it is not possible to obtain all information about the sylvopastoral land use systems, as used by the farmers of the Atlantic zone, in a research period of 3 months. Therefore a demarcation is necessary. The research is restricted to:

- the case study area's: Río Jiménez, Neguev and Cocorí.
- a selection of farms: already some interviews have been held about the role of forest/trees in the farming household. The information from these interviews has lead to the formation of groups of farms that are supposed to represent a 'typical' sylvopastoral system.
- sylvopastoral systems: As animal husbandry appears to be a rather important form of land use in the research areas, sylvopastoral systems have been taken as subject, more specifically living fences and dispersed trees. There is even some evidence of the occurrence of protein banks in the region: if there are farmers that apply this technique among the case study farmers, this technique will be incorporated into the research.
- animal husbandry practices involving cattle. This means that the breeding of horses, goats, sheep, poultry, etc. will not be dealt with in this research.

2 LAND USE IN THE RESEARCH AREAS

In this chapter, land use in the research areas Río Jiménez, Neguev and Cocorí of the Atlantic Zone of Costa Rica will be outlined, to give an idea of the relevance of agroforestry in the research areas.

2.1 The Atlantic Zone

The Atlantic Zone of Costa Rica is situated in the east of the country. The climate is permanently humid, with a high precipitation (3000 - 6000 mm/y)(Hermsen, 1989), distributed almost equally over year. The relative humidity is high; an average of 87 % (CATIE, 1990). The average yearly temperature is about 26 degree Celsius, without real difference in monthly temperature (app. 3 degree) (Hermsen, 1989). The Zone is part of the "humid to very humid rain forest region" according to Holdridge's classification (CATIE, 1991).

Table 2.1 shows the development and importance of the major types of land use.

	1963	1973	1982
Land use category	Limon Province	Huetar Atlantica	Huetar Atlantica
Annual crops	?	ca. 7600	19000
Arable land	36000	21300	?
Permanent crops	39100	44400	78300
Grazing land	35000	71800	232900
Forest, shrub, etc.	91600	140800	?
Total farm area	205200	278200	652200
Non-farm area (mostly forest)	767500	728200	352500
Total area	972700	1004700	1004700

Table 2.1: Land use (ha) in the Limon Province/Huetar Atlantica, 1963 - 1982. Source: Sluys et al., 1987.

A tremendous (over six-fold) increase in the area under pastures, has taken place in the last 40 years. The increase results from forest conversion for extensive beef production, with the incentive of favourable export prices, and for colonization schemes (Borel & Romero, 1991), which the government uses as a means for developing the country. However, expansion of the area under banana plantation is also taking its toll: between 1985 and 1991, Costa Rica's banana growing area increased from 20,500 to 32,000 ha, and it is expected to reach 45,000 ha by 1995. This expansion of banana cultivation is occuring mainly in the Atlantic Zone, partly through the purchase of unprofitable cattle ranches and partly through widespread clearcutting of forests (Gaupp, 1992).

2.2 Deforestation in the Atlantic Zone

At present, much of the original forest cover has been destroyed by wood extraction and by conversion into pasture and crop land (Sluys et al., 1987). Since 1970, the rate of deforestation in Costa Rica has been between 1.2 and 1.8 % annually, two or three times the estimated worldwide average for tropical countries (Gaupp, 1992). It is not unreasonable to believe that deforestation rates in the Atlantic Zone are even higher, considering the fact that it is a recent colonization area. Especially serious is the fact that only about one third of the approximately 35,000 hectares of forest cleared in Costa Rica each year, has been suitable for grazing or farm land (Gaupp, 1992). Research by Veldkamp et al. (1992) on deforestation in the Atlantic Zone has shown, that until 1972, there was a preference to clear fertile soils. Clearing rates on fertile soils decreased after 1972, while the deforestation rates of moderately and even more on unfertile soils continued to increase. As land is becoming scarce, more and more poor soils are being cleared (Veldkamp et al., 1992). These areas, that are not realy appropriate for grazing or agriculture, must be dedicated to uses, like protection forest, protection-production forest, tree plantations or agroforestry associations (Martinez, 1989).

2.3 The research areas

The Atlantic Zone Programme, for which the research presented here has been carried out, has chosen three areas of the Atlantic Zone as research areas. Some general data will be given about the research areas. More detailed information is given in Appendices II, III and IV. The research areas are (Anonimous, 1987):

- The Lomas of Cocorí and surroundings, 50 km north of Guapiles, covering about 120 km^2, with about 150 households. In this area the land is deforested by precaristas, bought by urban landlords and subsequently used as grazing land for beef cattle.
- The western half of Río Jiménez district, 20 km ENE of Guapiles, 55 km2 in surface, with about 200 farm households. The subarea has a relatively long settlement history. Railway remnants witness that large parts were once used for plantation agriculture (banana, abaca). Nowadays, the land is used by small and medium scale farmers for milk and beef production, and maize, rice, cassava, cocoa, and fruittree growing. Increasing scarcety of land and changes in marketing possibilities force farmers towards intensification and specialization.
- The IDA settlement scheme Neguev, 25 km ESE of Guapiles, about 55 km^2. Neguev was once a large extensive cattle estate and has been subdivided into 310 farms for

settlers of various origins. Intensification processes in Neguev, amongst others from pasture to annual crops, are guided by IDA.

As was concluded in § 2.1, the pasture area is expanding in the Atlantic Zone, and the research areas will not be an exception in this matter.

2.4 Animal husbandry in the research areas

Animal husbandry seems to be the most widespread types of land use in the research areas. Weide (1986) recognizes five cattle herding practices in the Atlantic zone of Costa Rica:
1) Dual purpose cattle farming with sale of meat and on farm consumption of milk;
2) Dual purpose cattle farming with sale of both meat and milk (dairy products);
3) Specialized dairy farming;
4) Beef production (A cow-calf operations, B fattening);
5) Cow-calf operations.

In the following part of the report, three of the most occuring cattle herding practices in the research areas will be explained. These are the first, the second and the fourth practice. According to Sluys et al. (1987), these can be described as:

1) Dual purpose cattle farming with sale of meat and on farm consumption of milk: most of these farms are small, also grow annual (maize, beans) and some perennial crops (cocoa, plantain), may have some pigs or chicken. Often part of the income is derived from off farm work. Productivity generally is low; lack of cash (no sale) and credit preclude improvements.

2) Dual purpose cattle farming with sale of both meat and milk (dairy products): These farms sell milk or cheese on the local market and so generate a regular income which may enable investments (specialization) in pasture, minerals, better breeds. Common breeds are Brahman, Indo Brasil, Holstein-Friesian, Jersey.

3) Beef Production (A Cow-calf operation, B fattening): Group A rears calves up to 150 kg (8 months) and sells them to B to be fattened to about 500 kg (an additional 2 - 2.5 years). Often A and B are found on the same farm. Such farms require improved pastures on fertile, well drained soils and are often found in recently opened areas, where land is still cheap.

Forest is dissappearing rapidly in the Atlantic Zone of Costa Rica, resulting in more and more land being conversed into pastures. Even on these pastures, the amount of trees is being reduced. But generally, the soil does not lend itself for any form of farming. The land is often only suitable for some form of forestry. A dilemma for the farmers exists: on the one hand they need land for their farming practices (which in the area are mostly related to animal husbandry), but on the other hand, land uses other than forestry may decrease the production capacity of the land. A compromise can be found in some form of agroforestry. The importance of agroforestry systems in the research areas can be expected to increase.

The focus in this thesis is on agroforestry; to be more specific, the integration of trees in the pastures in a certain way, which is commonly known as a sylvopastoral practice. More information about agroforestry and, in particular, sylvopastoral practices, will be given in the next chapter.

3 SYLVOPASTORAL PRACTICES: THEORY

The former chapter gave some insight in how the land in the Atlantic Zone of Costa Rica is used. Also, it was mentioned that forest and trees on farm land are often occurring elements in the land use. In this chapter, agroforestry is explained, to give more background on the investigation of sylvopastoral systems in the research areas.

3.1 Definition of agroforestry

There are numerous definitions of the term agroforestry. They all define agroforestry as a specific kind of land use. Land use can be defined as the utilization and demarcation of any piece of land by man, in order to meet a certain objective (Overmars, 1990). To achieve these objectives, inputs are required. Livestock breeding, rainfed agriculture and forestry are examples of land use; agroforestry is another example.

To clarify the concept and scope of agroforestry, it may be useful to review the definition used by ICRAF (Raintree, 1987b; Young, 1987):

> *Agroforestry is a collective name for land use systems and technologies in which woody perennial (trees, shrubs, palms, bamboos, etc.) are deliberately combined on the same management unit with herbaceous plants (crops, pastures) and/or animals, either in some form of spatial arrangement or temporal sequence, and in which there are both ecological and economic interactions among the different components.*

The definition of agroforestry by ICRAF is nowadays widely accepted, but several authors have useful additions to this definition. For instance, Torres (1980) also includes growing multipurpose woody species. Khosla and Toky (1986) add to the definition that agroforestry is accomplished by management practices suiting the socio-economic conditions of the people. Prasad (1985) furthermore mentions the need for compatibility with the cultural practices of the local population. It is certainly important, to take these remarks into consideration when discussing the subject of agroforestry, but the definition by ICRAF will be at issue in this report, when agroforestry is mentioned.

Agroforestry practices, systems and technology are discerned within the concept of agroforestry. Often these terms are confused which each other. Here, they can be explained in the following way:

Agroforestry practices: An agroforestry practice is a distinctive arrangement of components in space and time, and the management of these components. Agroforestry practices should accomplish a synergy between the elements involved, that provides in the needs of the user.

One essential point to note is, that an agroforestry practice can exist even in non-agroforestry land use (Nair, 1989; Young, 1989). An example of an agroforestry practice is a home garden.

Agroforestry systems: Difference should be made between agroforestry major systems and agroforestry systems. An agroforestry major system is a general division between groups of agroforestry practices on account of their components (see paragraph 3.2). An agroforestry system is a specific local example of a practice, characterized by environment, plant species and arrangement, management, and social and economic functioning. But a system can only be defined as such, when it is often occurring in a specific area (with more or less similar environmental conditions). This specific occurrence of agroforestry systems, is often referred to as "site-specific" (Nair, 1989; Young, 1989; Beer et al., 1989; Nair & Dagar, 1991). An example is the use of *Erythrina poeppigiana* as a shade-tree and mulch producer above *Coffea arabica* on coffee farms near Turrialba, Central Valley of Costa Rica.

Agroforestry technologies: Technologies here indicate the accumulated knowledge about the working of the relations between the components of an agroforestry system and the way in which land use managers (in most cases farmers) can influence these relations to produce and control the desired outputs on their specific piece of land, with or without scientific intervention. The definition encompasses both 'hardware' (tools, equipment, seeds, buildings, etc.), i.e. the physical forms of technology, and 'software' (methods, practices and strategies, including forms of social organization) (adapted from Reijntjes et al., 1992; Koningsveld, 1987). An example of an agroforestry technology is the application of the principle that trees can reduce wind velocity and thereby crop damage in windy areas, by using trees in shelterbelts in the vicinity of crops.

Often, no distinction is made between technologies and practices. In this report, distinction is made between agroforestry practices, systems and technologies. They are perceived as parts of a whole (which is land use), that can occur simultaneously, but are not interchangeable. For instance, when agroforestry practices are being imported into a specific area, proper technology to manage these practices should be imported simultaneously. Otherwise, the chance of success is limited.

3.2 Agroforestry major systems and practices

Agroforestry is generally divided into three major systems, depending on the components they encompass (see figure 3.1). If the system includes all possible components mentioned in figure 3.1, it is known as a agro-silvo-pastoral system. The second system, which only includes the tree- and livestock-element, is called a sylvopastoral system. The third system is one that combines the tree- and crop-element, and is called an agro-silvicultural system (Combe, 1982).

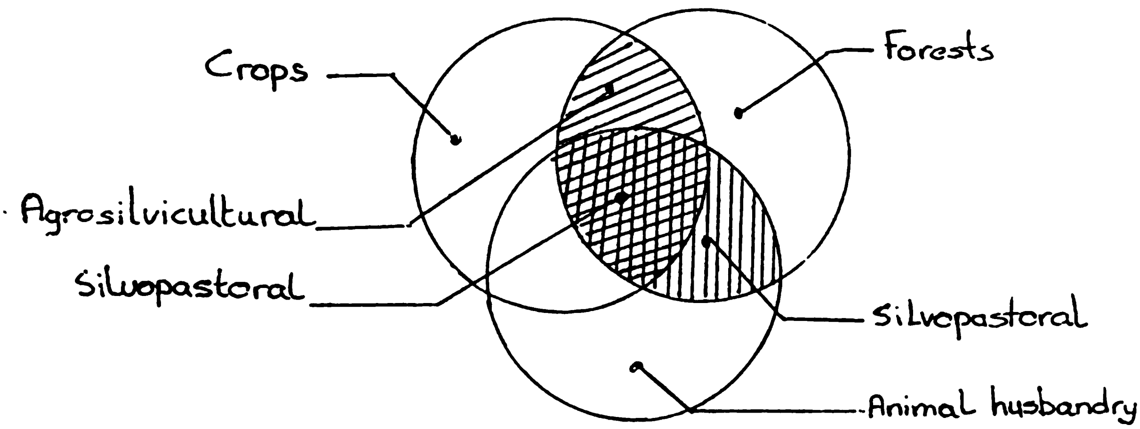

Figure 3.1: Land use and agroforestry systems. Source: Combe, 1982.

Within each major system, a set of practices can be discerned. Table 3.1 is a classification of agroforestry practices, in which different approaches towards the division of the major systems into practices have been explained. This table can be used to give a detailed description for the agroforestry systems in a certain area, without loosing comparability with other systems, in the same or in other areas.

As cattle holding is a very common practice in the research areas on which this report focuses, the choice was made to regard only the major system, that involves trees and cattle: the sylvopastoral system.

3.3 The sylvopastoral major system

The systems, that are part of the sylvopastoral major system, encompass the combination of pastures, with or without animals, with trees on a certain piece of land. A schematic example has been given in Figure 3.2. The principal inputs of the sylvopastoral system are: solar radiation, precipitation, seeds, labour and veterinary products (Russo, 1984). The principal outputs are animal and tree products and services, that depend on the components and the interactions between them.

Table 3.1: Major approaches to classification of Agroforestry systems and practices. Source: Nair, 1989.

Categorization of systems (based on their structure and functions)			Grouping of systems (according to their spread and management)	
Structure (nature and arrangement of components, especially woody ones)		Function (role and/or output of components, especially woody ones)	Agro-ecological environmental adaptability	Socio-economic and management level
Nature of components	Arrangement of components			
Agrisilviculture (crops and trees incl. shrubs trees and trees)	*In space* (spatial) Mixed dense (e.g., homegarden)	*Productive function* Food Fodder	*Systems in/for* Lowland humid tropics	*Based on level of technology input* Low input (marginal)
Silvopastoral (pasture animals and trees)	Mixed sparce (e.g., most systems of trees in pastures)	Fuelwood Other woods Other products	Highland humid tropics (above 1,200 m a.s.l., e.g., Andes, India, Malaysia)	Medium input High input
Agrosilvopastoral (crops, pasture animals, and trees)	Strip (width of strip to be more than one tree)	*Protective function* Windbreak	Lowland subhumid tropics (e.g., savanna zone of Africa, Cerrado of South America)	*Based on cost-benefit relations* Commercial Intermediate
Others (multipurpose tree lots, apiculture with trees, aquaculture with trees, etc.)	Boundary (trees on edges of plots fields)	Shelterbelt		Subsistence
	In time (temporal) Coincident	Soil conservation Moisture conservation	Highland subhumid tropics (tropical highlands) (e.g., in Kenya, Ethiopia)	
	Concomitant	Soil improvement		
	Overlapping	Shade (for crop, animal, and man)		
	Sequential (separate)			
	Interpolated			

3.3.1 The main components of sylvopastoral systems

The main components of sylvopastoral systems are trees and shrubs, pastures, livestock and man, together with the environmental factors of climate, soils and landforms (Young, 1989; Russo, 1984). Figure 3.3 gives the components and the interactions between them. The driving variable(s) act directly on each of the components, hereby influencing the interactions between the components. The purpose of management is to fulfil the goal(s) of the farmer (Torres, 1980).

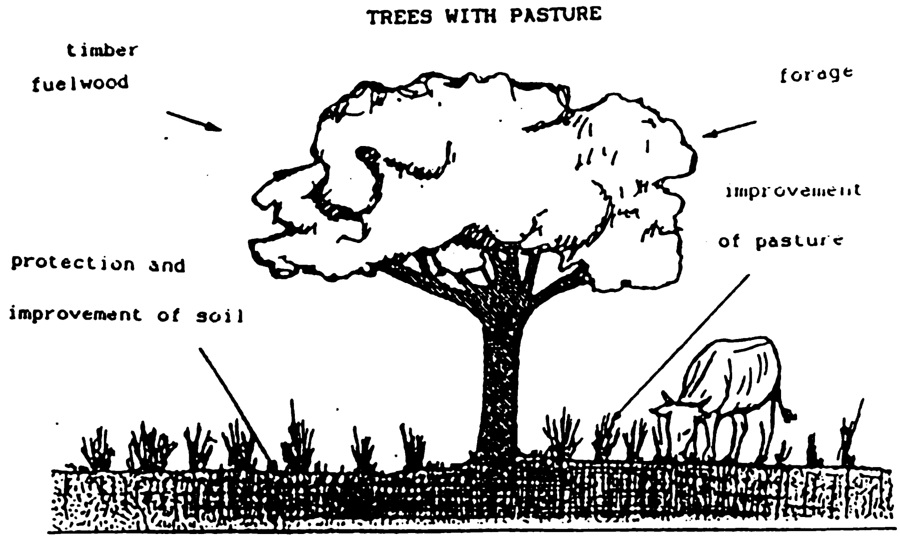

Figure 3.2: schematic example of a sylvopastoral system. Source: Geilfus, 1989.

The inputs invested in the components and the interactions between the components provides the person, that manages the system with outputs. From the definition of agroforestry, it can be concluded that it is the interactions (ecological and economic) between the components, that determine the image of a sylvopastoral system. Therefore, these interactions will be elaborated into further detail.

3.3.2 Interactions between components

There are many delicate interactions, of which the following is a rough outline.
The influences of the components on each other may be positive: The pasture is food for cattle; the excretes of cattle contain nutrients for the pasture. The trees interact with cattle, providing shade and forage, while they benefit from the fertilizing effect of the excretes, and at the same time produce fuelwood, timber or non-timber products (like fruits, nuts, tannins, etc.) (Russo, 1984). The presence of a stand of trees has several effects on the microclimate and soil of the immediate environment. Reduction of wind, decrease in solar

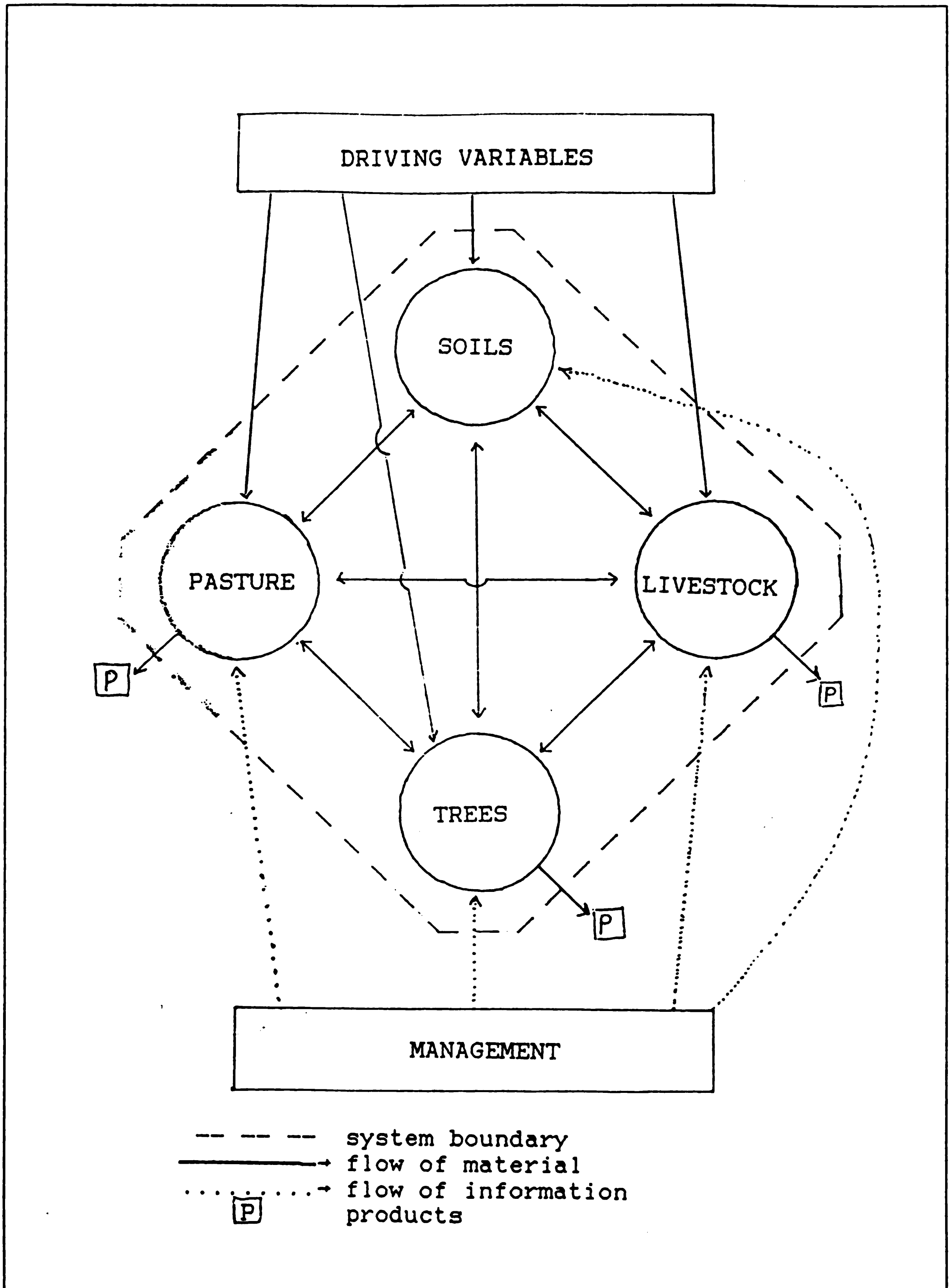

Figure 3.3: The components of a sylvopastoral system and the interactions between them. Source Torres, 1980.

radiation and the resultant decrease in evapotranspiration provides a more humid understorey microclimate, encouraging some vegetative growth and in certain cases, promoting a change in vegetative patterns (Garrison & Pita, 1992). Another beneficial effect is the addition of a leaf layer on the soil, that produces nutrients for the pasture, when incorporated (Russo, 1984).

But also negative influences of the components on each other exist: The tree roots compete with the roots of the herbaceous plants for water and nutrients in the soil, and the crown diminishes the necessary light for photosynthesis (Daccarett & Bleydenstein, 1984). The constant treading provokes the bearing of the surface soil, compaction of the soil, and destruction of the superficial roots, responsible for the adsorption of nutrients, damage the growth of the trees (Braggio, 1984).

Different studies done on soil compaction caused by animals, contradict each other on account of treading. Possibly, this is caused by differences in soil types and study conditions. However, they were unanimous on account of the increased time of water infiltration in grazing areas, compared with non-grazing areas (Braggio, 1984).

In the case of leguminose trees, the possibility exists, that the fixation of atmospheric nitrogen contributes to the enrichment of the soil of the pasture. And if the shade is not excessive, the development of the pasture is not much affected (Daccarett & Bleydenstein, 1984).

3.3.3 Multipurpose trees

From the advantages, mentioned above, it can be concluded that within sylvopastoral systems, woody perennials have productive functions and service functions within land use systems. The productive function could be characterized as the production of a material output (fuelwood, domestic timber, fodder, food, oils, fibers, etc.). The service (intangible) function of trees in land use systems can be seen as production of services (such as shade, shelter (from wind), soil conservation, fencing and water management) (Wessel, 1990). Most of the time the role of woody components in land management systems will not be limited to either production of materials or services, but will probably perform both functions (Torres, 1984). Trees that fulfil more than one function in a land use system, are called multipurpose trees.

The service functions of trees cannot easily be expressed in terms of financial benefit, and are therefore often underestimated. But they can be important for the farmers. For instance, trees in the pastures can be a partial substitute for livestock, whose role is sometimes "savings on the hoof". They can also support the livestock on the farm by enhancing the fodder-manure linkage and, if used as living fences, by providing an affordable means of reducing crop damage by uncontrolled grazing (Raintree, 1987a).

The fulfilment of functions, performed by trees in the sylvopastoral system depends on the way they are managed in their relation to the other components of the system. In turn, this management of trees is accomplished by applying sylvopastoral practices to both the trees and their interactions with the other components of the sylvopastoral system.

3.4 Different sylvopastoral practices

According to the purpose and place of trees in the sylvopastoral system, Nair (1985) discerns the following types of sylvopastoral practices:
1) protein bank (cut-and-carry fodder production)
2) living fences of fodder trees and hedges
3) trees and shrubs on pastures.

These three types will be discussed below.

3.4.1 Protein bank

From table 3.1, the protein bank can be regarded as a sylvopastoral practice, where the components are planted in strips or plots, coincident, with a fodder production function (Nair, 1985).

A protein bank is a form of sylvopastoral practice, including two plant species spatially separated (pasture and plots of woody perennial) along with the animal component (Somarriba, 1992). They consist of densely spaced, low trees or shrubs, of which the foliage is either cut and then carried to a place where livestock can consume it, or the livestock is lead into the protein banks at regular intervals.

The protein banks can be used as a complement to the feedstuff of the livestock, either in a qualitative sense (the protein of the foliage complements low nutritive fodder/pasture) or in a quantitative sense (the foliage is used to bridge times in which pasture production is insufficient for maintaining livestock).

Often, the trees/shrubs used are highly nutritive species, that resprout easily. Many legume species are apt for protein banks, e.g. *Gliricidia sepium*, *Erythrina spp.*, *Leucaena leucocephala.*

3.4.2 Living fences

From table 3.1, living fences can be regarded as boundary plantings, coincident, with a fodder production or a protective function (Nair, 1985).

Living fences are defined as: the plantations in lines of shrubs and trees in the boundaries of plots, with the principal target of hindering of passage of animals (to leave the pasture or enter a cultivated plot) or people, and also to indicate boundaries (Geilfus, 1989). Living fences are typical examples of the irregular spatial distribution of the forest component, where protection must be provided for animals under extreme conditions (Combe, 1982). 'Living' and 'live' fences are the same thing - the two terms are used interchangeably. As concluded in the definition, their primary purpose is to control the movement of animals or people. This purpose is what differentiates them from other agroforestry practices, based on trees planted in lines, such as boundary plantings, contour strips or hedgerow intercropping (Westley, 1992).

Other services, than limitation and protection of terrain, are:
- conservation of the soil,
- biological control of plagues,
- windbreaks.

Moreover, the plantations can provide products, like:
- fuelwood,
- forage,
- stakes for other living fences,
- green manure (mulch),
- posts and timber for other uses (with certain species),
- fruits
- edible flowers (Geilfus, 1989; Martinez, 1989).

The use of living fences has advantages and inconveniences, compared to dead fences, as explained in table 3.3.

Table 3.3: Advantages and inconveniences of live fences, compared to dead fences. From Geilfus (1989).

Advantages:

* they are longer lasting; the dead posts have to be replaced at regular bases or require scarce and costly timber;
* they are much more economic; the compact fences eliminate the buying of barbed wire and nails;
* they are much more efficient; the wired fences with 2 - 3 cords allow small animals to pass; a compact and preferably spined fence is impenetrable;
* they provide in additional products and services.

Inconveniences:

* often slow and difficult establishment;
* problems when there is not enough planting material available;
* often, they have to be protected against animals during establishment;
* several living fences serve as refuge for harmful animals like rats.

Two types of living fences can be discerned: Live fence posts and living fences/hedges. Live fence posts are permanent, widely spaced, single lines of woody plants that are regularly pruned. They are used to support wire or other inanimate material, such as sticks or dead branches. Living fences/hedges are permanent, densely spaced, single or multiple lines of woody plants. They are regularly pollarded and trimmed. Living fences/hedges may be thicker than live fenceposts and may comprise more than one species, including trees, shrubs and smaller plants. They usually do not include wire or other inanimate material (Westley, 1992).

Living fences are generally made with vigorously sprouting species. Legumes may be used (e.g. *Erythrina spp.* and *Gliricidia sepium*), as well as figs, cactus and euphorbia (Combe, 1982).

Living fences tend to be considerably less expensive than fences made from materials, like wood, metal or stone. However, it is important that they grow rapidly, at least during the first few years until they are tall and thick enough to withstand browsing livestock and to serve their barrier function. This requirement implies the selection of fast-growing species, propagation from large cuttings and careful maintenance, including weeding and watering if necessary. During this early period, living fences may need protection, particularly from hungry animals. As the trees and shrubs grow, they must be pruned, usually on an annual basis. Otherwise, they may take up too much space or cast too much shade on adjacent crops. Root competition may also be a problem (Westley, 1992).

Well-established living fences may be difficult and expensive to remove, so a careful selection of site and species should occur before planting. If planted on a boundary, a living fence will affect more than one land user, so it is important that all land owners and users should agree on its establishment (Westley, 1992).

3.4.3 Dispersed trees

From table 3.1, dispersed trees can be regarded as sparsely mixed, coincident sylvopastoral practices, with a timber, fodder, food and fuelwood production function and a protective function (Nair, 1985).

Although in the tropical zones, the pastures for breeding and growing of cattle have been established at the cost of natural forest, the cattle herding necessitates the presence of trees in them to provide shade and refuge to the cattle (Martinez, 1989). The trees that grow in the pastures are almost always multipurpose trees, in that they have more than one purpose for the farmers.

The principle uses of the association of trees in pastures, are the following (Russo, 1984; Geilfus, 1989):

* protection of the animals against sun, rain and wind,
* protection and improvement of the soil,
* production of timber, fuelwood, fodder, fruits, and other non-timber products,
* improvement of the pasture that grows beneath the tree.

The farmer can leave trees standing spread over the pasture after cutting the original forest, manage the secondary regrowth in the pasture, or plant the trees in the pasture.

Several categories of dispersed trees can be discerned according to their function (Combe, 1982):

1 - Commercial trees on rangelands/pastures;
2 - Fruit trees and fodder-producing trees in pastures;
3 - Shade trees in pastures;
4 - Pioneer trees (soil improvement, nitrogen fixation).

ad. 1: A sustained production of commercial timber is possible in pastures, as long as these perennial crops are managed at a sufficiently extensive level. Many forest species have been used in this association (Combe, 1982).

Ad. 2: Fruit trees can easily be combined with extensive grazing pastures and form relatively dense stands. Pure fruit tree plantations are possible; fruit producing forest species are also used successfully. The fodder-producing species belong to the same category. Their importance is particularly increasing in the arid regions, where they often represent the only food reserve for the cattle. This agroforestry practice still offers many possibilities, since only few fodder qualities of suitable tropical forest species are so far known (Combe, 1982).

Ad. 3: All trees, that are encountered in pastures give shade, at least part of the year (Zambon, 1989). The presence of trees in the pastures permits the animals to seek protection against the sun on the warmest hours of the day (Geilfus, 1989).

Ad. 4: Pioneer tree species must sometimes be associated with pastures, in order to protect and stabilize the soils. This protective and stabilizing effect applies particularly to all the tree species which are able to colonize marginal lands, which must be maintained under agricultural use. The capacity of fixing nitrogen through bacteria in the roots is often considered as an essential condition for a soil-improving species (Combe, 1982).

3.5 Agroforestry systems: from evolution to design

In the former section, the main sylvopastoral practices have been described. Like every agroforestry practice, sylvopastoral practices can be found all over the world, although the latter are more significant where agroforestry crop farming systems are not feasible, owing to (seasonal) low rain fall and lack of water.

Especially in these dryer areas, the agroforestry practices have probably evolved from a traditional form of agriculture; forestry being a naturally integrated part of agriculture. The term often used for agricultural systems with different production components is mixed farming. The techniques and ecologic principles used in both agroforestry and mixed farming are principally the same. Mixed farming systems have been developed step by step over the years by its users into agricultural production systems (Schinkel, 1992).

Nowadays, agroforestry is seen as a promising technique to achieve sustainability in land use and fulfilment of the needs of the local population (Duchhart et al., 1990). Relative outsiders (researchers, extension agents, community development fieldworkers) have only recently started designing agroforestry systems (Raintree, 1987b).

Both the mixed farming technology and the scientifically generated agroforestry technology use accumulated knowledge about the components of agroforestry practices, and the relations between these components, to design a desired agroforestry system. Scherr (1990) defines agroforestry design as follows:

> "Design corresponds to a 'package' or 'intervention' in extension terms. A complete design identifies multipurpose tree and shrub varieties and associated non-woody components, arranged and managed in specific ways to meet defined land-user objectives in defined types of sites."

Therefore, agroforestry design can be seen as a form of land use planning on local or even farm level.

Preceeding on design of alternative land use or agroforestry systems, the present systems and the problems, that land users have with the management of these systems, have to be diagnosed. Land use planning, and planning for agroforestry, that often occurs within land use planning, will be at order in the next chapter.

4. FROM LUT-DESCRIPTION TO LAND USE PLANNING

The previous chapter gave insight in agroforestry. Besides rainfed agriculture, forestry, and extensive grazing, agroforestry can be regarded as a way of using land (natural resources). This land use can be regarded at various levels of scale: the crop, the agroforesty system, the farm, the region, the country, etc. Especially at the higher level of scale, planning of land use becomes more important. In this chapter, two tools for land use planning are discussed upon their suitability for description of agroforestry land use types. The tools are Land Evaluation and Diagnosis and Design. But first, the place of the farm in the levels of scale is discussed.

4.1 The farm in its context

The application and development of agroforestry systems does not only occur at the biological level. The farmer and his environment are also involved. Higher ranking interactions, than the tree/pasture/crop/animal interactions, should also be identified. In effect, agroforestry systems belong to a hierarchy of systems, each being a component of the next higher level (see figure 4.1).

The farm is part of the regional system, which also includes physical-biological, social, political and macro-economic factors. These factors constitute the environment of farming systems. Within farming systems, family components are recognized and these are considered important in all aspects, since they determine labour use, motivations, preferences, problems, etc. Farming systems also include agroecosystems, such as agroforestry systems, in which interventions could be attempted. In turn, within these agroecosystems, physical-biological components can be recognized (Borel, 1987). The components of agroforestry systems have been dealt with in chapter 3.

The definition of agroforestry by ICRAF (see chapter 2) describes the land use, without considering the farmer as the land manager that puts the agroforestry practice into action. The definition only focuses on the levels of physical-biological components or on agroecosystems.

Like Borel (1985), Torres (1980) recognizes management as a part of agroforestry. Management encompasses the decision making necessary to meet the farmer's[1] objective(s).

[1] In this case, by 'the farmer' is meant the farming household, encompassing every member, living on the farm, that influences on the land use.

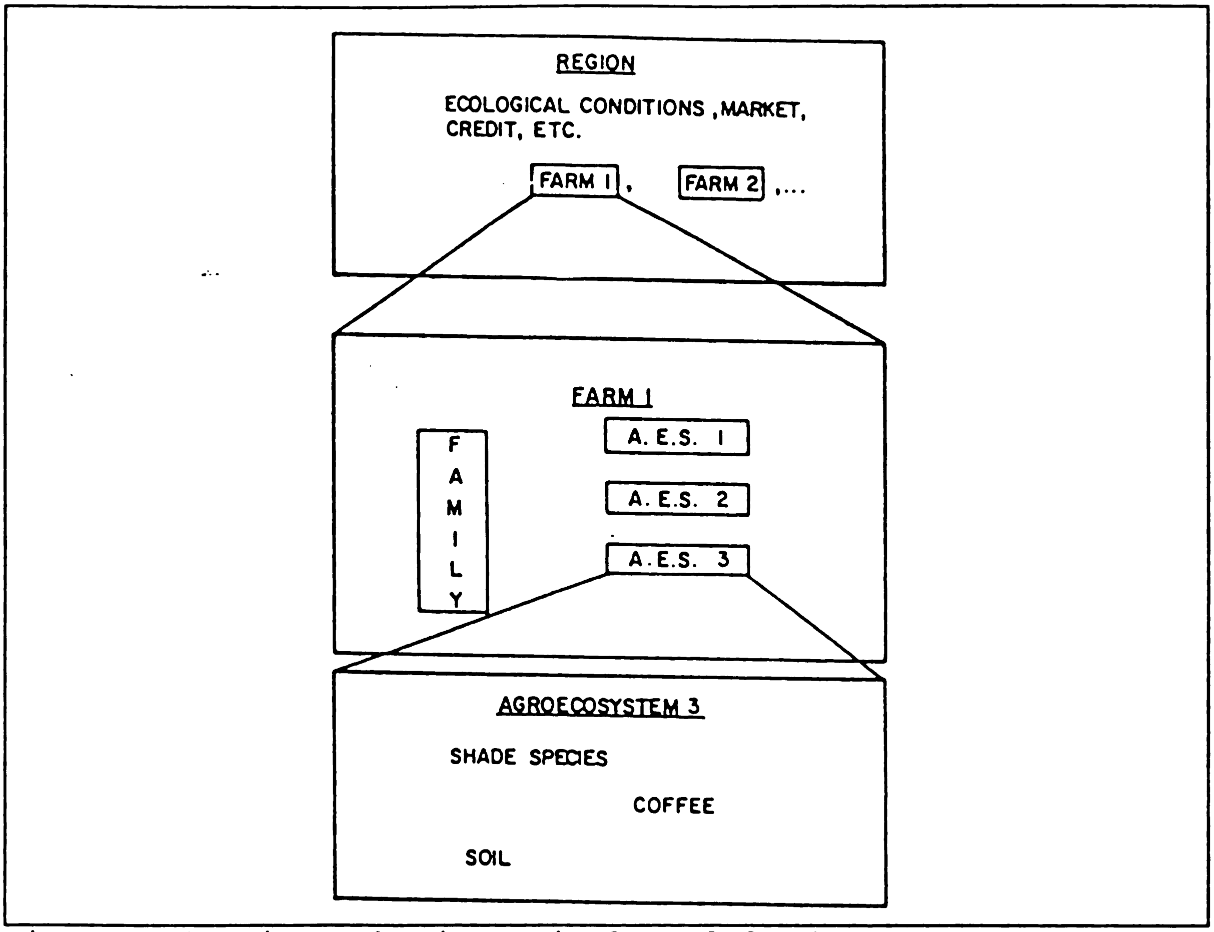

Figure 4.1: Hierarchy in agricultural land use. Source: Borel, 1987.

The farmer applies the biological and socio-economic premises, on which the concept of agroforestry is based, to his land management techniques, in order to achieve a higher (and sustainable) efficiency in the use of available resources.

Distinction is made here between the farm on the one hand, and the regional system on the other hand.

4.1.1 The farm as decision-making unit

Farming is a complicated interwoven mesh of soils, plants, animals, implements, workers, other inputs and environmental influences with the strands held and manipulated by a farmer, who, given his (or her) preferences and aspirations, attempts to produce outputs from the inputs and technology available. Within farming, farming households, farming systems and farm systems can be distinguished (Reijntjes et al., 1992).

Farm systems are considered as a local application of farming systems, with the farming household as the actor, that manages the farm system (similarity can be seen in the terminology of agroforestry system and practice (see § 3.1).

Ploeg (1986) gives an analysis of his idea of farming. In farming, there are two kinds of coordination: the practical coordination between production and reproduction, and the more socio-economic coordination between the domains of production and reproduction with other social domains like the household or that of the wider economic and institutional relations in which the farm is embedded (see fig. 4.2).

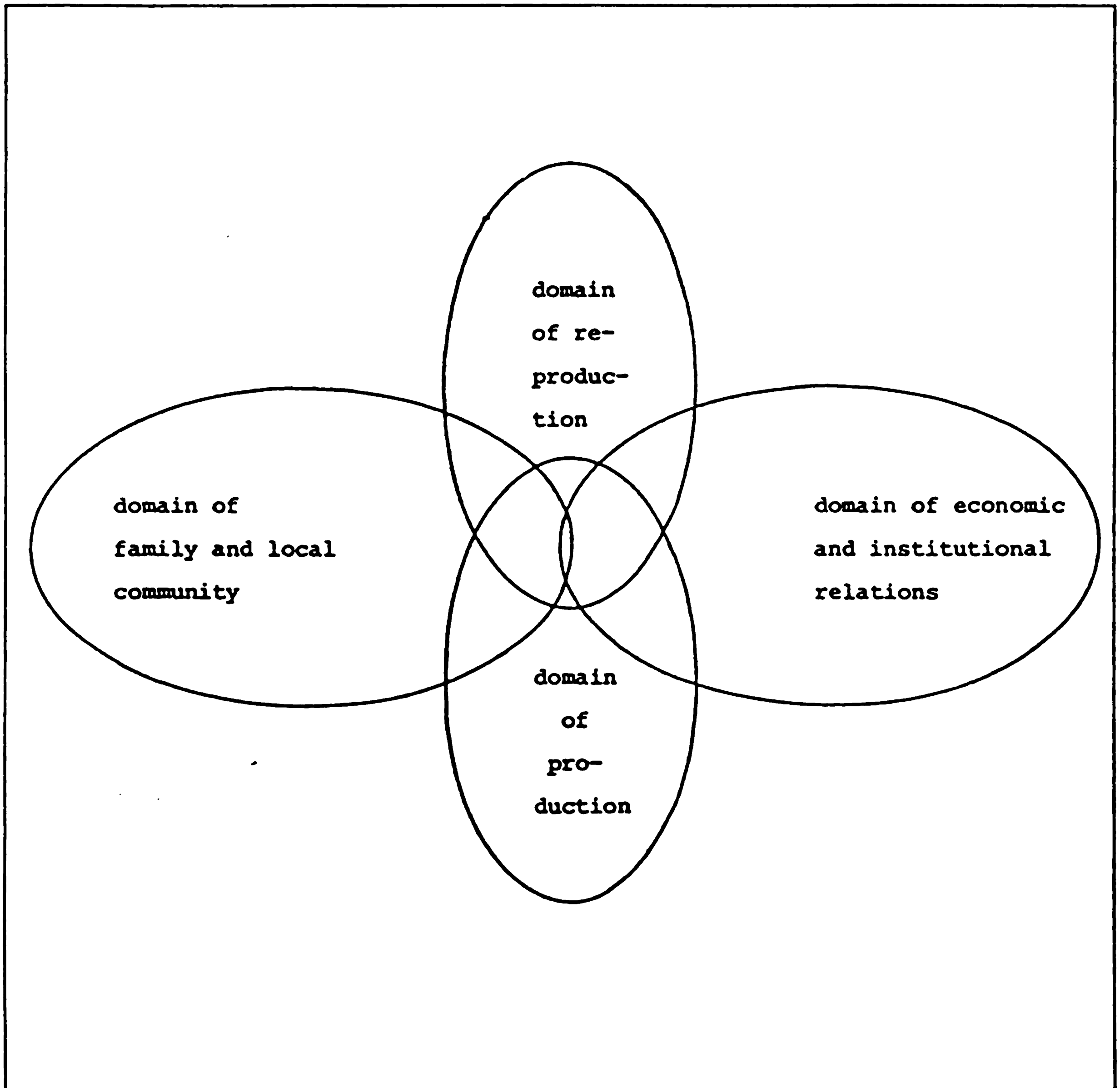

Figure 4.2: The domains of farming. Source: Ploeg, 1986.

Farming can be seen as a constant balancing of the farming domains to meet the needs of the farming households. Consequently, farming is a continuing decision making process: for the short, medium and long term. Complex factors are involved in decision making within the farming household, including biophysical characteristics of the farm, the availability and quality of external inputs and services, and the socio-economic and cultural processes within the community (Reijntjes et al., 1992). In this decision making process, innovations play the role of a possibility to respond to 'internal' or 'external' changes. For example, the coming of a new child within afarming household may call for the introduction of an innovation in the agricultural production, because income or production is no longer sufficient to feed another mouth. Or the introduction of a new pesticide may change the division of family labour, in that a shift of tasks is necessary to clear time for applying pesticides. It can be concluded that every innovation has its impact upon the farming strategy of a farming household.

Long (1986) argues that external forces are in effect always mediated by local structures (like a farming household): individuals must themselves come to terms with new elements in their life-worlds and naturally do this to a large extent on the basis of existing 'world views'. Outsiders can influence the economic and political setting in which farmers make their decisions and can provide farmers with information, guidance and encouragement, but the ultimate decision will still be made by farmers. Household members may interpret factors, that influence the farmer's decision making process in a different way than outsiders perceive them. To help farmers develop farming systems that suit the local biophysical and human setting, outsiders must achieve some understanding of how decisions are reached by households and the logic behind them. In addition, as the ecological, socio-economic and cultural environment changes, the farming system must be adjusted accordingly (Reijntjes et al., 1992).

Central to decision-making but also object of decision-making are the aims of a household with respect to the outcome of farming. Each household, and each individual household member, has specific needs and desires, but farm households appear to have in common various objectives, which can be classified as follows: productivity, security, continuity and identity.

<u>Productivity</u>: The output of the land per unit of land, labour, capital, time or other input. Productivity is the primary objective of farming, but farmers are not likely to value it solely in terms of market values, with a view to maximisation of output per unit of land. The household has a range of needs for consumption, health, housing, education, etc.

<u>Security</u>: Seeking security means minising the risk of production of income losses resulting from variations in ecological, economic or social processes. Farmers may assess the security of their farming systems according to food security, or to degree of self-security, or to degree of self-reliece in obtaining inputs or in marketing products, instead of only variability of production.

Continuity: Farmers who whish that they and their children may continue their way of life have vested interest in maintaining the potential of the farm system to yield products, i.e. in maintaining the resources that represent the productive 'capital' of the farm. Continuity also implies the ability to change. This capacity to adapt to changing conditions ultimately determines the sustainability of agriculture.
Identity: The extent to which the farm system and individual farming techniques harmonise with the local culture and the people's vision of their place within nature (Reijntjes et al., 1992).

These objectives are usually competing with immediate productivity, resulting in an optimal (from farmers' point of view) instead of a maximal productivity (Reijntjes et al., 1992).

Regarding land use, farmers themselves practice a kind of planning by choosing a certain kind of land use. They pose questions like which crops to use, which rotations, which level of inputs and so on. Often a lot of information is needed, which involves high costs and much human power.

Thus, the farm is the smallest decision making unit within land use. The farm produces in order to reach the objectives of the farmer. But the objectives of the farmer often do not coincide with the objectives that decision making units on regional, national or supra-national levels have with land use in the area in which the farm is situated.

4.1.2 Beyond the farm

As discussed in § 4.1.1, one can discern a physical biological component level, an agroecosystem level and a farm level within the farming system. Each higher level encompasses one or several of the lower ones. On its turn, the farming system is part of specific regional and national/supra-national contexts. These contexts are usually managed by the government.

Population growth and intensification of land use cause an ongoing destruction of natural resources (Duchhart et al., 1990). All kinds of interest groups claim their part of the country and many governments consider it as their task to promote that everyone gets a fair share. This task requires a great deal of planning, because in most parts of the world, no empty space remains, that people can claim without encroaching upon the rights of other people to the same piece of land. The organization of land use is done through land use planning.

4.2 Land use planning

Adapting and applying technology to convert an existing type of land use into a desired one, or entirely replacing the existing one with a land use that is more suitable, is a function of land use planning. Land use planning can be defined as a systematic process which has the function: "to guide decisions on land use in such a way that land is put to the most beneficial use for man, whilst at the same time conserving those resources for the future" (FAO, 1976).

When planning land use, it should always be born in mind, that the basic decision makers about land use (especially in rural areas) are the local people. Participation of these people is important in order to reach the objectives of the planning (participation as a means) and to give the right to people of self-determination (participation as a goal) (Overmars, 1990). Next to incentives and policy measures, extension can stimulate this participation and hereby improve the chance of succes of the land use planning.

Several tools for land use planning are available which provide guidance to the process of problem analysis and solution design (Overmars, 1990). Examples of such tools are: Land Evaluation (LE), Farming System Analysis (FSA), Farming System Research and Development (FSR&D), and Agro-Ecosystem Analysis (AEA). Derived methods are: Land Evaluation and Farming System Analysis (LEFSA); Agroforestry Diagnosis and Design (D&D), developed from FSR&D specifically for agroforestry; and Integrated D&D, an integration of Land Evaluation and D&D. In this report, only Land Evaluation and Diagnosis and Design will be dealt with.

4.3 Land Evaluation

The procedures of Land Evaluation evolved from the practical needs of land use planning. They were first standardized in the Framework for Land Evaluation (FAO, 1976). In this framework, the FAO presents land evaluation as a comprehensive method in which the suitability of land is assessed for alternative uses (Overmars, 1990). It sets out basic concepts and principles together with an outline of procedures, applicable in principle to any kind of rural land use (Young, 1986).

The Framework for Land Evaluation (FAO, 1976) recognizes major kinds of land use as a first subdivision in rural land use. On basis of the Framework, FAO Guidelines for Land Evaluation for major land uses have been written, covering Rainfed Agriculture (FAO, 1983), Forestry (FAO, 1984), Irrigated Agriculture (FAO, 1985) and Extensive Grazing (FAO, 1991). Agroforestry can also be considered as one of these major kinds of land use. However, FAO Guidelines for Agroforestry are still in preparation (Young, 1986).

4.3.1 The Land Evaluation procedure

Land Evaluation predicts the inputs, outputs, and other beneficial as well as adverse effects resulting from specified uses of the land that is evaluated (Beek, 1978). To come to an understanding both of the natural environment and of the kinds of land use envisaged, and to present planners with comparisons of the most promising kinds of land use, Land Evaluation should answer a set of questions (FAO, 1991);

- How is the land currently utilized?
- Are the existing land use practices sustainable, or is there evidence that they will result in degradation?
- Within the present means of using the land, what improvements in management practices are possible?
- Are there alternative uses of the land, which are physically possible and socially and economically preferable?
- Which of these alternative uses offer possibilities of sustained production or other benefits?
- What adverse effects, physical, economic or social, are associated with each alternative use?
- What recurrent inputs are required to minimize any adverse effect of the existing or adopted land use?
- What are the benefits of each form of land use?

Thus, with Land Evaluation, land uses envisaged by planners can be developed, based on how land is currently used and possibilities to improve these present use. Or these land uses can be exchanged for more profitable and/or sustainable alternative uses, relevant for the context in which they are to be implemented. Land evaluation takes into consideration the economics of the altered or alternative land uses, the social consequences for the people of the area and the country concerned, and the consequences, beneficial or adverse, for the environment (FAO, 1991). The objective of Land Evaluation is to assess the suitability of different tracts of land for selected and specified types of land use (Duchhart et al., 1990), resulting in specific Land Use Systems (LUS). Figure 4.3 shows a schematic example of a LUS and its components.

The LUS is the central system in Land Evaluation and comprises two elements: land and land use (which are respectively denoted in Land Evaluation as Land Mapping Unit (LMU) and Land Utilization Type (LUT)). The LUS is affected by physical inputs to the Land Mapping Unit (as land improvements), and inputs to the Land Use Type (as factor inputs, like labour, capital, etc.) (FAO, 1983).

A LUT can be defined as a technical organizational unit in a specific socio-economic and institutional setting (Bennema et al., 1981; Andel et al., 1981). Each LUT has certain land use requirements, and each LMU has certain land qualities. If inputs are provided through the LUT, the resulting LUS will yield certain outputs, as products, services and other benefits from the Land Mapping Unit (FAO, 1991).

The current report confines itself to a description of one of the elements of the LUS, the LUT. This element will be elaborated into more detail.

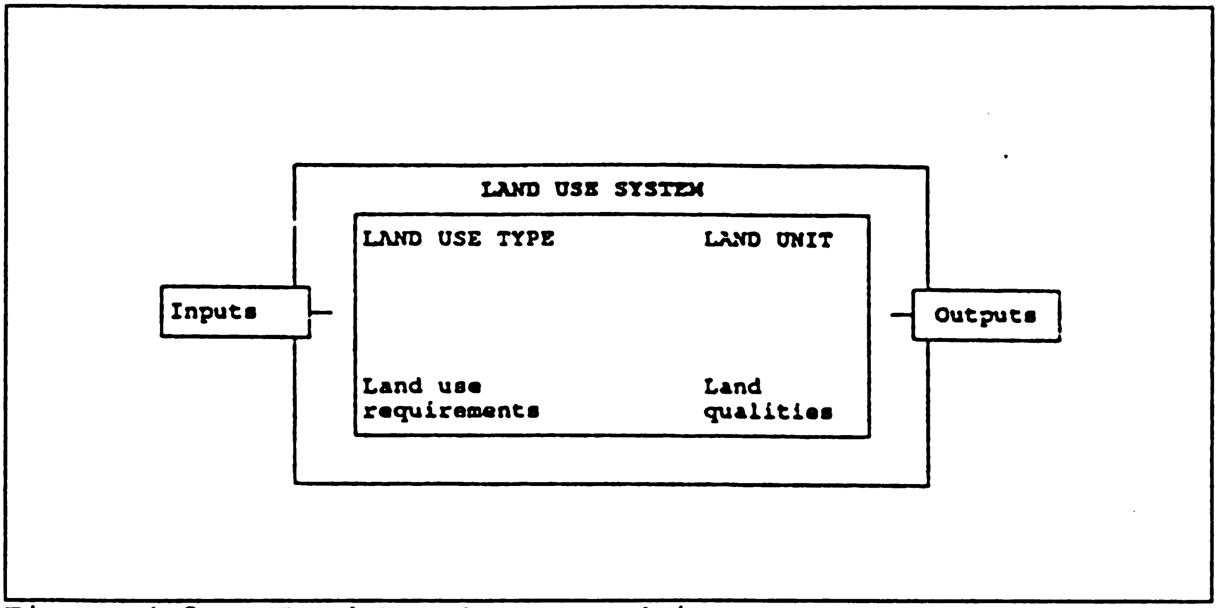

Figure 4.3: a Land Use System and its components. Source: FAO, 1984.

Land Utilization Type (LUT).

When a kind of land use needs to be described in greater detail, either qualitatively or quantitatively, it will be determined as LUT. LUTs are not a categorical level in a classification of land use, but refer to any defined use below the level of the major kind of land use (FAO, 1976). The description of a LUT should consist of a combination of carefully described key attributes (Beek, 1978). Key attributes are a set of technical and organizational specifications with as much detail and precision as the purpose requires (FAO, 1976).

Because of their close relationships, key attributes are identified simultaneously, in accordance with the purpose and detail of land evaluation. Key attributes are selected for their marked influence on the land requirements and therefore on the land suitability which depends on the land requirements and the land conditions (Beek, 1978). Differences in key attributes enable the LUTs to be distinguished from each other (Bennema et al., 1981).

The FAO Framework for Land Evaluation (1976) included a set of key attributes, which should enable researchers to give a detailed description of a LUT. Each of the Guidelines to Land Evaluation for major kinds of land use (as mentioned above) has restructured the original set of key attributes mentioned in the Framework, and added some or left some out. In this thesis, a set of key attributes will be used, extracted from various sources (A Framework for Land Evaluation (FAO, 1976); Beek, 1978; Guidelines: Land Evaluation for extensive grazing (FAO, 1991); Guidelines: Land Evaluation for rainfed agriculture (FAO, 1983); and Guidelines: Land Evaluation for forestry (FAO, 1983)). The key attributes are:

1) Produce
2) Labour
3) Capital
4) Land
5) Technical knowledge and attitudes
6) Technology
7) Management

Descriptions of key attributes should be sufficiently informative for easy identification of the land requirements (Beek, 1978). In Appendix V, a more detailed description of the key attributes has been outlined.

4.3.2 Advantages and disadvantages of Land Evaluation

Of course, Land Evaluation is not to be idealized. Overmars (1990) described some of the advantages and disadvantages of Land Evaluation (underlining added):

<u>advantages:</u>
Land Evaluation is based on the <u>physical capability of the land</u>. This means that sustainable use according to bio-ecological criteria is often its main objective. This guarantees a sound basis for using natural resources. As a method, it takes <u>present</u> but also <u>potential</u> and future uses into consideration, thus enlarging development possibilities. The method considers all possible land forms of land use relevant for the area. The result is a map which is often well understandable (Overmars, 1990).

<u>disadvantages:</u>
As a method which is developed from soil science, it is focusing on natural resources. Although a socio-economic analysis is included, hardly any attention is paid to human resource development. Generally no participation of local people is occurring. The choice of relevant LUTs remains often unclear, procedures are lacking and LUTs are not adapted according to the socio-economic conditions required. Although the allocation of resources to some land use types can have big implications for the farm as production and social system, <u>Land Evaluation often ignores any relations between land use types within the context of the farm</u>. Land Evaluation is not a cyclic process, the map is the final result and no procedures are included for further research. Feed-back mechanisms are difficult to

insert. The specific method is ill suited for planning at a detailed scale. However, the approach can be adapted to be applied at local level. To create the maps on a small scale, expensive equipment and a lot of manpower are needed (Overmars, 1990).

With Land Evaluation, one can arrive at the present, as well as an optimal land use (from the viewpoint of physical capability of the land). But the method ignores the farm context, when looking at the relations between the biophysical farm components, resulting in a sub-optimal land use from socio-economic point of view. Without the farmer accepting a new or improved kind of land use, time invested will have been wasted, because there is no place for feedback in the method.

No guidelines for Land Evaluation for agroforestry have been constructed yet (Young, 1986). It might have been supposed, that a system of Land Evaluation for agroforestry could have been constructed by a synthesis from the detailed FAO Guidelines on evaluation for rainfed agriculture, forestry and extensive grazing. According to Young (1987), experience has shown that the task of providing a Guideline for Land Evaluation for agroforestry is more complex than this. Two fundamental reasons can be mentioned, one is biophysically oriented and the second is socio-economically based:

First, in Land Evaluation e.g. for irrigated agriculture, the performance of the LUTs is relatively well known and thus land use requirements can be established (Young, 1987). However, in the case of agroforestry, the requirements depend on a scala of factors, e.g.: the large number of possible components and their arrangements, the poorly understood interactions between the components, the difficulty of quantifying some of the functions (e.g. environmental values and sustainability) (Beer et al., 1989). These land use requirements have rarely if ever been established (Young, 1987).

The second reason is that the suitability of given areas for establishment of certain agroforestry systems by no means depends on environmental conditions alone, but also on the problems, that farmers encounter while managing agroforestry systems (Young, 1987). Of course, this also holds true for other farming practices, but as agroforestry systems are very complex and difficult systems to manage, the problems that farmers encounter will probably be harder to overcome. Often there is a high diversity of expectations and objectives regarding the output of agroforestry systems (Beer et al, 1989).

As farmers problems play a large role in the complex agroforestry LUTs, an analysis of the land use (including the farming system) probably will enable alleviation of the problems encountered in Land Evaluation, even more if this method is already focused on agroforestry. An example of a method for agroforestry land use planning, that focuses on both agroforestry and the farming system, is ICRAF's Agroforestry Diagnosis and Design. This method will be described in the next paragraph.

4.4 Agroforestry Diagnosis and Design

Agroforestry Diagnosis and Design (D&D) was developed by the International Council for Research on Agroforestry (ICRAF) to assist agroforestry researchers and development projects (Raintree, 1987b).

4.4.1 The concept of D&D

D&D represents a family of procedures for the diagnosis of land-management problems, identification of agroforestry potentials, and design of appropriate agroforestry interventions (Raintree, 1990).

Initially, the methodology focused on household and farm level; a logical starting point for a methodology that sought to address farmer decision making. Most of the land-management decisions relevant to agroforestry are made on the household and farm level. This approach is also quite consistent with the Farming System Research of which the micro-D&D method might be regarded as an agroforestry specific variant. However, not all of the land use problems relevant to agroforestry originate from within a single farm, nor can they always be solved by action at the individual household level. Also, members of a household do not always form a homogeneous group. Larger scale, inter-household social organizations may facilitate opportunities for agroforestry related activities that would be missed by an exclusive focus on households (Raintree, 1990).

In the D&D process, the existing land use systems are diagnosed and the aim is to derive specifications for appropriate problem-solving treatments in terms of agroforestry interventions. The designs, that should result from the agroforestry interventions, are evaluated upon 3 criteria (which may show some overlap[2]); productivity, sustainability and adoptability, in order to select the most appropriate solution (Overmars, 1990).

D&D and the Land Use System

D&D focuses on the land use system. Since different systems are likely to have different problems and potentials, it follows that each distinctive land use system must have its own diagnosis and corresponding design. This does not mean that D&D results in agroforestry systems, that are 'site specific' since the same basic land use system may exist in many sites (as has been explained by Nair (1987); see § 2.2). The selection of sites, that represent important (often occurring) land use systems is an essential aspect of the target of D&D (Raintree, 1987b).

[2] There can be overlap between productivity, sustainability and adoptability; e.g. an agroforestry system is only adoptable for farmers, if it has a high productivity as well. But adoptability also depends on norms and values of the farmers and the context in which the agroforestry system will be situated. That is why the three criteria should be evaluated separately.

For the purposes of a D&D exercise, a land use system is defined as a distinctive combination of three interrelated factors: (1) the land resources exploited by (2) a particular technology to satisfy (3) the production objectives of a particular type of land user. All three elements are essential to the functioning of a land use system. If the human element is left out, it becomes too easy to overlook the objectives from which the existing land use system resulted. By consciously attempting to design with the grain of the existing land use system, rather than against it, the D&D methodology helps to avoid the kind of design error that results in technically and environmentally feasible but somehow "non-adoptable" agroforestry technologies (Raintree, 1987b).

D&D User's Manual (Raintree, 1987b) includes two lists, that can serve as guidelines for detailed description procedures of the agroforestry system to be investigated. These are lists of questions (Sample Diagnostic Survey Guidelines and AFRENA Worksheets for Land Use System Description (Scherr, 1987)) about how a D&D method can be applied in the field. As with all D&D applications, the suggested procedures should be used selectively and adapted to fit the requirements of particular programmes (Raintree, 1987b).

4.4.2 Advantages and disadvantages of D&D

Like Land Evaluation, D&D is not without shortcomings. Overmars (1990) has reviewed the advantages and disadvantages of this method (underlining added):

Advantages:

The methodology of D&D is a cyclic process which ensures feedback to preliminary stages of the procedure. Thus, adjustments can be made in the diagnosis or the design phase, so an optimal solution can be achieved. The research component assures appropriate technology development suited for each specific case (Overmars, 1990).

Disadvantages:

The method as such primarily deals with agroforestry. For a broader land use planning it narrows the nature of solutions. Although it is stated that care must be taken not to come forward only with agroforestry based solutions, the method as such does not provide a framework for the design of other types of land use. The framework for the design phase is not very clear, so far the design guidelines are limited. Farmer participation is not explicitly mentioned and certainly not put as central issue. The objectives of the farmer are taken as decision criteria, risking to disregard the interests of other groups. Benefits for the society as a whole, such as conserving natural resources, in this approach can be more easily omitted. The method's basis for analysis is the existing land use systems and tries to adjust these. Consequently, alternative land use systems which could provide farmers a way of reaching their objectives and that of the society more easily, but which do not occur in the area, are often overlooked. Real innovative farming methods are not explored (Overmars, 1990).

So the D&D method's starting point is the agroforestry system, used in farms, and the objectives of the farmers with their agroforestry system, and arrives at an agroforestry solution for the problems perceived (though these are perceived more by the researcher than by the farmer). But the narrow focus of the method does not include alternative (non-agroforestry) systems, nor the land use that is desired by others than the farmers.

4.5 Combination of Land Evaluation and D&D

Land Evaluation has become widely accepted as a suitable method for land use planning. It provides standard procedures for investigating all types of land use systems. Land Evaluation is conceived in terms of maps, and it compares different uses on the same area of land to discover which is best. D&D offers a possibility to focus more into detail on agroforestry systems. D&D is oriented towards people and their problems. Its conceptual view of a land use system in its representation as a farm with its dependent family, is a cultural rather than a spatial unit (Young, 1986). To provide an adequate description of Agroforestry LUTs, a combination of the merits of both procedures is in due place. Young (1986) has tried to develop a new method, integrated D&D, to provide such an integration between Agroforestry D&D and Land Evaluation.

It is not the purpose of the research to come to a new method for land use planning, based on Land Evaluation and D&D. The research presented here just extracts useful elements from the 'diagnostic phase'[3] of both procedures, to arrive at a more appropriate description of sylvopastoral land use in the research area of the Atlantic Zone of Costa Rica. The design phase is not included in this research.

D&D can be used to give a fairly accurate description of agroforestry systems. Based on the check-list provided with the D&D User's Manual (Scherr, 1987), D&D offers a possibility to describe the components (trees, pasture and cattle) of the sylvopastoral systems occurring in the research areas, and management of these systems by the farmers (including probable motivations behind this management).

From Land Evaluation, the possibility is borrowed to arrive at LUT descriptions, through application of key attributes on farming practices. Description of the farming practices in terms of key attributes derived from the Land Evaluation method has an advantage: the sylvopastoral LUTs can be compared with other LUTs, either in the research areas or elsewhere, on basis of the same standards (key attributes). Furthermore, it is possible to investigate into detail on the Land Mapping Units, that coincide with the LUTs, to come to an understanding of the physical/biological capacity of the land for the sylvopastoral LUT.

[3] With the 'diagnostic phase' of both methods is meant, the strategy that both methods have of coming to a description of current land use, and identifying constraints that hamper improvement. Identifying constraints is perceived as assessing the land use requirements of each LUT, and the land qualities of each Land Mapping Unit, in order to come to conclusions about to what extent the LUS can withstand the current land use.

Taking the two methods together, a list of descriptors can be made, that offer a possibility to describe the research area, the agroforestry system, the LUT and the sylvopastoral practice (see appendices V and VI). Figure 4.4 gives a schematic example of how all the elements of a sylvopastoral system can be seen in relation to each other. The figure has been derived from figure 4.3. In figure 4.4, the LUS (sylvopastoral system) is embedded in a certain environment (infrastructural, social, etc.), the regional level. It is formed out of a particular combination of available LUTs and the present LMU.

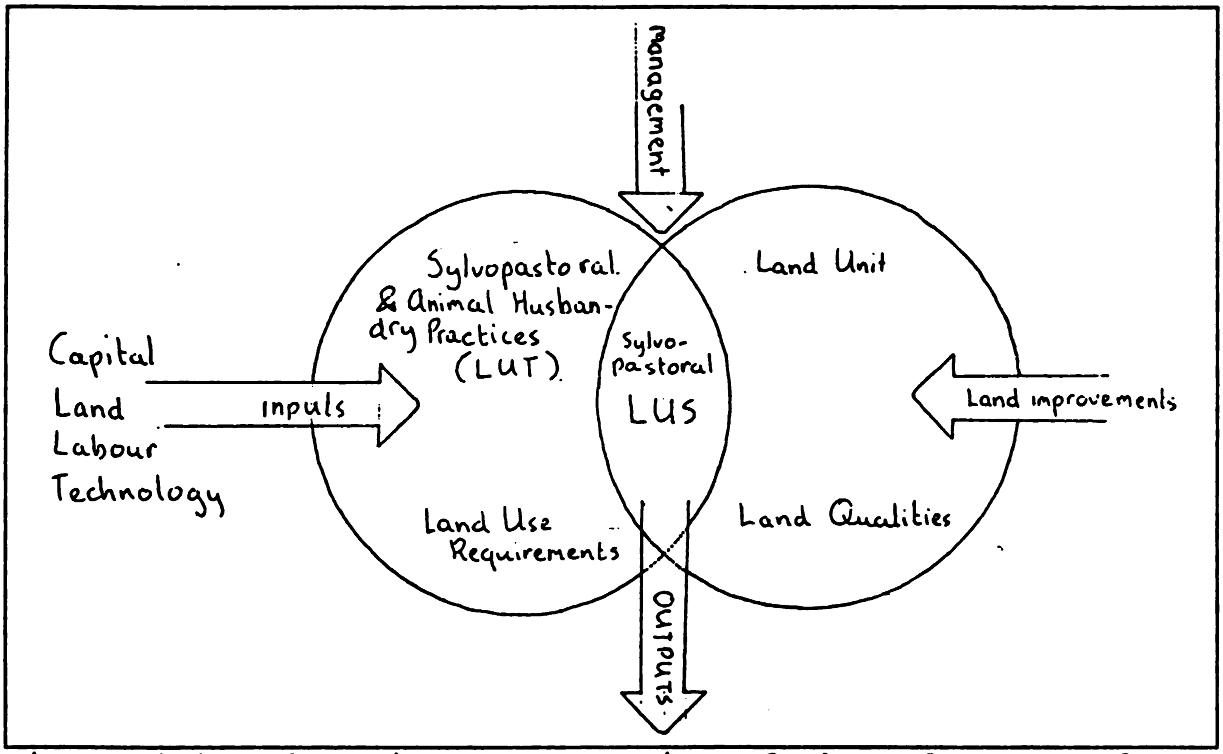

Figure 4.4: Schematic representation of the sylvopastoral LUS (adapted from FAO, 1976).

In this thesis, the focus is on the LUTs. The LUT is perceived as a combination of animal husbandry practices and sylvopastoral practices, in which the latter are of lesser importance. Therefore, the LUT is described as part of animal husbandry, of which the sylvopastoral practices (in fact more detailed LUTs) form a part. These sylvopastoral practices will be discussed separately.

Based on figure 4.4, the levels of descriptions can be dissemed. Table 4.1 is a schematic representation of how these descriptions should be seen in their context, including from what method they originate (Land Evaluation or D&D). The research areas are described on a regional level with help of the D&D checklist. The level below the regional level will be the sylvopastoral system level, as it will be described based on the D&D checklist as a general system occuring in the research areas. Below the sylvopastoral system level, the LUT level can be discerned, which will be described according to a list of key attributes. This LUT level can also be described as the farm level, as it combines inputs in and outputs from the farm[4]. The sylvopastoral practices are part of the LUT level and are described more into detail: they can be regarded as a component of the LUT. This level will be described with the D&D checklist.

Table 4.1: levels of descriptions in their context.

regional level	**D&D checklist**
sylvopastoral system level	**D&D checklist**
LUT level	**FAO key attributes**
Sylvopastoral practice level	**D&D checklist**

A detailed description of the sylvopastoral practices occurring in the research areas will be assessed and clarifying map of a fictive farm will be produced, including all agroforestry practices, that have been encountered on the farms of the interviewed farmers. In the next chapter, the way in which the sylvopastoral system, the LUTs and the practices are described will be elaborated.

[4] As the LMU is not investigated in this research, the LUT provides only part of the farm descripion. The physical environment of the farm is not taken into account.

5. FRAMEWORK FOR DESCRIPTION OF THE SYLVOPASTORAL SYSTEM, LUTS AND PRACTICES IN THE RESEARCH AREAS

In this chapter, a format of description will be developed based on the information in the former chapters. This format will be applied to the data, gathered from the field research and the literature research about the research areas. The end result will be a description of the overall management of the components of the sylvopastoral LUT and their interactions, an intermediate description of the sylvopastoral LUT, with focus on the sylvopastoral practices protein banks, live fences and dispersed trees.

5.1 Method for description of the sylvopastoral system

In Chapter 3 of this report, the elements of a sylvopastoral system were placed in a network of relationships (fig. 3.3). These relationships are managed by the farmer. Management is the direct translation of the possibilities and capabilities of the farmer on the natural resources.

From Chapter 4, it was concluded that farmer's objectives play a decisive role in the productivity of the farming system. These objectives find their translation to the farming system through the management applied by the farmer. Therefore management is the most influential factor determining a LUS. The position of all key attributes in a hierarchical system is displayed in figure 5.1.

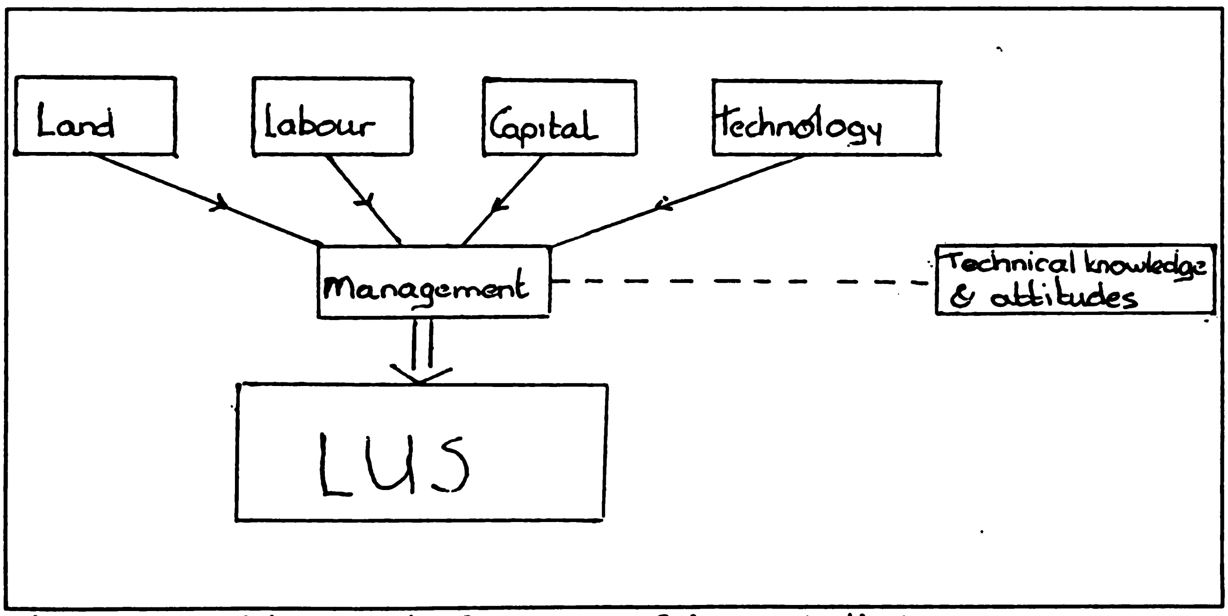

Figure 5.1: hierarchical system of key attributes.

However, as FAO (1983) noted, it is difficult to express management in exact terms. The other key attributes mentioned in § 4.3.1 can be described reasonably well, either qualitatively, like in 'high', 'moderate' or 'low', or quantitatively, like in man-months/ha/y. Management cannot be described like this.

Farm management can be seen as a (re)production factor of the farming system. A specific kind and level of produce requires, that a farmer has to allocate the (re)production factors at his disposal in such a way, that the requirements of the specific produce are met. In turn, this allows the farming system to remain compatible with the socio-economic context. Allocation of the (re)production factors occurs through management. If we look at farming as a continuous process, with t as a production interval, the specific set of (re)production factors obtained by management in interval t-1, is the basis of management in interval t (see figure 5.2).

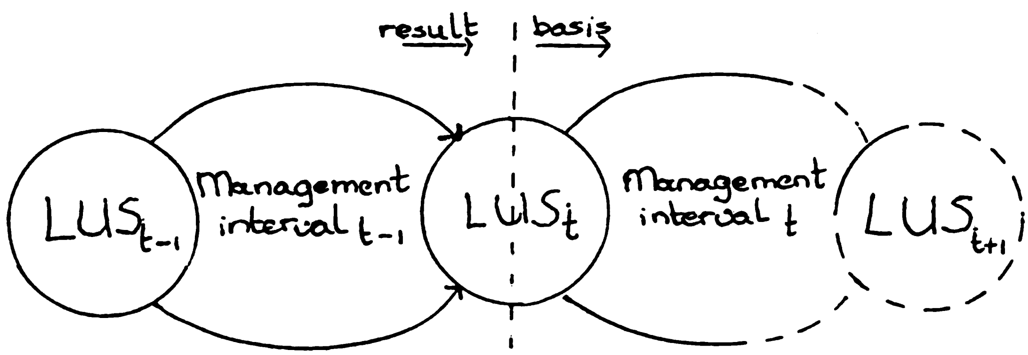

Figure 5.2: continuous management of production factors.

Although management in itself is difficult to describe, the description of the Land Use System can be regarded as the 'image' of management (in this case, the sylvopastoral system as occurring in the research areas). The LUS_t is the output of the management process, that occurred in interval t-1, allocating the system components and the (re)production factors to achieve the farmer's objective within the socio-economic and ecological setting. The LUS_t is also the initial set of components, (re)production factors and socio-economic and ecological setting for the interval t, which will (through management) eventually result in LUS_{t+1}.

The 'image' of management of the sylvopastoral system can be described, by describing the components, which are cattle, pasture, dispersed trees and fences, and the interactions

that exist between these components. The detailed description of the average sylvopastoral system should encompass the following elements (a list of common and systematic names of species is given in Appendix VII):
- cattle herd composition,
- pasture composition,
- dispersed tree composition,
- living fence composition,
- interactions between former components
- management of each of the components and the interactions between them.

Hulsebosch (1992) provided information on 105 farmers in the research areas. On basis of a hypothesis regarding dispersed trees (see Appendix VIII), the farmers interviewed by Hulsebosch (1992) were divided according to the ratio cattle/dispersed tree in their pastures. It was expected, that on farms with a different cattle/dispersed tree ration, the farmers would demonstrate different types of management of their sylvopastoral system. Five groups of farmers were discerned, each containing 2 farmers in each research area, who were selected upon the cattle/tree ratio in their pasture. These farmers were included in a general interview, in which they were asked about the above mentioned elements of their sylvopastoral system: cattle, pasture, dispersed trees and living fences, the interaction between the components, and the management of these components.

However, during the general interview, the cattle/tree ratio, based on information by Hulsebosch (1992) appeared to be inaccurate. The quantity of trees mentioned by the farmers did not correspond with the quantity of trees observed during a short walk through the pasture. During the research, questions in the interviews, that were meant to check the information by Hulsebosch (1992) also gave different results in the quantity of cattle mentioned by the farmer. Therefore, the initial division of the farmers in groups, according to the cattle/tree ratio in their pasture, was abandoned. The selection of farmers had already been made. On basis of the general interview with these farmers, a description of the sylvopastoral system, prevalent in the research area, has been made.

Probably noticeable differences occur between the different research areas, as socio-economic and ecological situation between the areas differ (see chapter 2). These differences will also be described, as they may be of influence on the LUT and the sylvopastoral practices, which are the next steps in the detailed description of the sylvopastoral LUT.

5.2 LUT-description

In the former section, the sylvopastoral LUS was presented as the 'image' or result of a production interval, resulting from a specific management. This management was explained as the allocation of (re)production factors, to reach the objectives of the farmer, bearing in mind the socio-economic and ecological setting. The separate reproduction factors and elements of socio-economic setting of the sylvopastoral LUS can be described, by describing the sylvopastoral LUT.

The LUT-descriptions are made on basis of Case Studies in the research areas. Each of these case studies deals with one sylvopastoral LUT that has been derived out of the management description. The LUT is expressed in the key attributes, as have been described in § 4.3.1.

There is a continuous range in the level of detail included in LUT description. Three levels of generalization may however be distinguished (FAO, 1983):

1) Summary description: up to about 5 lines and making many tacit assumptions as to what is known by the reader.
2) Intermediate length description: between one paragraph and one page in length, much of the description is qualitative, and agronomic details are given in generalized form or partly omitted.
3) Detailed description: usually over one page in length, giving much information quantitatively and including agronomic details.

An intermediate length LUT description of the existing sylvopastoral LUT will be used in the next chapter, in which the results of the research are discussed. This description will encompass a general and qualitative summary of the key attributes, as have been outlined in Appendix V. The following step in this LUT-description is noting the Land Use Requirements, which play an important part in designing an improved or alternative LUT, if necessary.

5.3 Sylvopastoral practices

The sylvopastoral system is the application of a sylvopastoral practice in a specific locality. In § 3.1, an agroforestry practice was defined as a distinctive arrangement of components in space and time, and the management of these components. Within the sylvopastoral LUT, tree establishment, maintenance and harvesting of tree products occur. The arrangement of the trees in relation to the pasture and livestock components in space and time are specific activities within the LUT.

The sylvopastoral practices have been explained in Chapter 3, and were divided into protein banks, living fences and dispersed trees. To provide a detailed description of these practices, the following activities should be included:

- establishment
- maintenance
- function (service/product)

In this report, a detailed description of the sylvopastoral practices will be derived out of the same case studies, that were used for the intermediate length LUT descriptions. The sylvopastoral practice they use, will be complemented with the specific local arrangements of their sylvopastoral practices (the sylvopastoral system): species composition of the specific practices, preferences of the farmers, perceived importance of the sylvopastoral practices, etc, as has been explained in Appendix VI.

By describing the sylvopastoral LUS, LUTs and practices, as they occur in the research areas Rio Jimenez, Neguev and Cocori in the Atlantic Zone of Costa Rica, the importance of the sylvopastoral practice within the LUT, and the influences that the practices have on the appearance of the LUS, can be outlined.

6. THE SYLVOPASTORAL SYSTEM IN THE ATLANTIC ZONE OF COSTA RICA: RESULTS

The components of the sylvopastoral system, their interactions, the management they require are outlined in § 6.1. They are discussed as part of one 'general or average' system, as the differences in management and components on the farms of the interviewed farmers were not perceived by the interviewer as strikingly different. Specific differences between the systems, as they occur in the different research areas are elaborated in § 6.2. Talking about sylvopastoral systems in the research areas, one should think about incorporating one or more sylvopastoral practices in a cattle herding system. Therefore, sylvopastoral LUTs will be determined by which type of cattle herding practice is used. The most occurring types of animal husbandry have been outlined in chapter 2. The LUTs have been described in § 6.3. The sylvopastoral practices are elaborated in § 6.4, including living fences and dispersed trees in the pasture. They are described separately from the LUTs, for reasons of clarity (avoiding repetition and overlap). The risk of describing the sylvopastoral practices apart from the LUTs is that the reader might perceive the practices as features that have no connection with the LUT. Although the management of these practices seems to stand on itself, it should not be forgotten that the practices indeed form a part of the LUT, requiring labour time, land and investments. Practices involving protein banks did not occur among the selected farmers, and are therefore not discussed here.

6.1 Sylvopastoral System in the research areas

The description of the 'average sylvopastoral system' (as an image of management; see § 5.1) is a generalization of the sylvopastoral systems occurring in the three research areas, which is not based on statistical reliability, but on interpretation by the interviewer of the information gathered in the interviews with 9 farmers in each area.

The general information about the 27. farmers that were reviewed in this research of sylvopastoral systems, has been outlined in table 6.1.

The average farmsize was 51.0 ha, ranging from 5.3 ha. to 280 ha. Of the average farmsize, 29.2 ha was pasture. The three most important land uses after pasture together covered an average area of 20.3 ha. 12 farmers reported to have dark (fertile) soils, 5 both had dark and red (less fertile) soils and 8 had only red soils (2 didn't tell). Of the 27 farmers, 8 originated from the Atlantic Zone. 21 farmers held a legal land title. 10 farmers had off farm work.

Table 6.1: overview of the average farm data of the 9 farmers in each research area. Source: Hulsebosch, 1992.

factor	Río Jiménez	Neguev	Cocorí	total
no. of farmers in research area (total)	424	311	142	
farmsize[1]	36.4	13.4	103.2	51.0
pasture[1]	32.1	8.7	46.7	29.2
other land use[1,2]	3.0	3.9	53.9	20.3
soils[3]				
-dark	6	3	3	12
-red	1	4	0	5
-both	2	2	4	8
origin of farmer[3]				
-Zone	4	4	0	8
-outside	5	5	9	19
land title[3]	9	8	4	21
off farm work[3]	3	4	3	10

[1] average in ha.; [2] under this heading: summation of annuals, perennials, forest, plantations and fallow; [3] number of farmers that provided information.

Interesting details are, that very few farmers originate from the Atlantic Zone. This could have consequences for their farming system, because they have to become familiar with their new environment, which can take a lot of muddling through. The fact that most of the farmers have a legal land title can be stimulating for the application of agroforestry practices, as there is a fair chance that the farmers can enjoy the long term benefits of planting trees on their farm area. Furthermore, it can be concluded that most of the farmers do not solely depend on animal husbandry for income generation: most farmers also cultivate annuals and/or perennials.

6.1.1 The components of the sylvopastoral system in the research areas

The basic components of the sylvopastoral system are cattle, pasture and trees. These components will be described 'sec' (without management actions) and will contain species composition, quantity and quality of species.

Cattle

The composition of the average herd in the three research areas has been outlined in table 6.2. Only 22 of the 27 farms of the interview held cattle at the time of the interview (7 in Cocorí, 9 in Río Jiménez and 6 in Neguev). The first column (frequency of occurrence on farms) shows us if a certain type of age/sex class is indeed often occurring on the farms of an area. The second column displays the number of animals involved in each age/sex class and, together with the first average (third column), indicates the importance of each age/sex class within the farms on which they occur.

Table 6.2: age/sex composition of an average cattle herd in Río Jiménez, Neguev and Cocorí

area	type	freq. of occ. on farm	total no. on farms	average no. on farm[1]	average no. on farm[2]	age (*[3])
Rio Jimenez	Bulls	8	14	1.8	1.6	3.5 (1*)
	Young bulls /cows	7	76	10.9	8.4	0.5 (1*)
	Cows	8	197	24.6	21.9	6.0 (1*)
	Calves	4	140	35.0	15.6	?
	Oxen	0	0	0	0	0
Total for area		9 +	427 +		47.4 +	
Neguev	Bulls	4	5	1.3	0.6	2.3 (2*)
	Young bulls /cows	5	41	8.2	4.6	0.9 (3*)
	Cows	5	41	8.2	4.6	5.1 (3*)
	Calves	4	26	6.5	2.9	2.0 (1*)
	Oxen	0	0	0	0	0
Total for area		6 +	113 +		12.6 +	
Cocori	Bulls	5	7	1.4	0.8	3.6 (5*)
	Young bulls /cows	6	59	9.8	6.6	0.4 (6*)
	Cows	7	152	21.7	16.9	3.1 (7*)
	Calves	1	115	115.0	12.7	1.5 (1*)
	Oxen	2	4	2.0	0.4	3.0 (2*)
Total for area		7 +	337 +		37.4 +	
Total	Bulls	17	26	1.5	1.0	3.3 (8*)
	Young bulls /cows	18	176	9.8	6.5	0.6 (10*)
	Cows	20	390	19.5	14.4	3.9 (11*)
	Calves	9	281	31.2	10.4	1.8 (2*)
	Oxen	2	4	2.0	0.1	3.0 (2*)
Total for areas		22 +	877 +		32.5 +	

[1] This average is obtained when the total amount of cattle of one age/sex class is divided by the frequency of occurrence on farms in the specific area. Thus: WHEN a class occurs on a certain farm in an area, the average number of heads can be found in this column. [2] This average is obtained when the total amount of cattle of one age/sex class is divided by the number of interviewed farmers in an area (which is 9 in each area). [3] * = number of farmers that mentioned the age of the cattle.

For instance in Cocorí, one can see that calves occur only on one farm. If only the real (second) average would be given, the importance of this age/sex class for this farm would be seriously underestimated. The second average is the real average and shows the numberof animals of each age/sex class occurring on the average farm. From the table, it can be deduced that the total number of cattle on the average farm is 32.5 heads. This corresponds to 22.5 Livestock Units (LU)[1]. Accordingly, the average cattle density on the pasture is 0.8 LU/ha. This animal density is lower than the national average animal density, which is about 1 LU/ha (Fajardo, in Koffeman (1989)).

Most occurring cattle species is Brahman or crossbreeds of this species with others (like Indio brasil, Guier, etc.). In total, 13 species and crossbreeds were present, and of the 22 farms that held cattle, 11 had only one species and only 3 farms had more than 2 species.

Pasture

The farmers mentioned 8 grass species, of which Ratana (*Ischaenum ciliare*) is most occurring, followed by Pasto natural (a mixture of several originally occurring species, with for instance *Axonopus compressus*). Usually, the composition of the different types of pasture vegetation was homogeneous; the species occurred in patches. Especially the two species Para (*Brachiaria mutica*) and Aleman (*Echinochloa polystachya*) were occurring on specific sites: swampy areas. More information on these pasture vegetation types is given by Nobbe (1988).

Production was mentioned to be high, but nutritional value of the most occurring species (Ratana and Pasto natural) was perceived as low. Hermsen (1989) has discussed the composition and management of pastures in the research areas in more detail.

Trees

Dispersed trees: The amount of trees in the pasture (and the density) was impossible to assess: farmers usually mentioned less trees in the interview, than could be observed in the field. 52 tree species were mentioned in the research areas. The average farm unit contained about 6 dispersed tree species (see table 6.3). Most of the trees originated from spontaneous secondary regrowth in the pastures. The fruit trees in the pasture were often planted by the farmers. Most occurring dispersed tree species were Laurel (*Cordia alliodora*), Cedro amargo (*Cedrela odorata*), and Gavilan (*Pentaclethra macroloba*), which were mentioned by the farmers 21, 19 and 15 times respectively. They are timber producing species.

[1] Livestock Units were calculated according to the conversion factors of 1 for bulls, cows and oxen, 0.6 for young bulls/cows and 0.3 for calves, as has been mentioned by Hermsen (1989).

Table 6.3: average dispersed tree species per farm mentioned in the research areas.

Río Jiménez	: 49 sp/	9 farms	=	5.4 sp/farm
Neguev	: 39 sp/	9 farms	=	4.0 sp/farm
Cocorí	: 83 sp/	9 farms	=	9.2 sp/farm
Total	:171 sp/	27 farms	=	6.3 sp/farm

Living fences: of the 13 species that occurred in the living fence, Poro (*Erythrina spp.*) and Madero negro (*Gliricidia sepium*) were most occurring. The living fences either occur in a mixed or pure stand, and have an average length of about 1350 m (see table 6.4). Average age is of the fence is 4.5 - 5 years, average height of the live fence poles is 2.10 m (without sprouts).

Table 6.4: average length on farm and composition of living fences in the research areas.

Area	freq. of occurrence	length (m)	mixed	pure
Río Jiménez	9	2260	4	6
Neguev	9	1000	7	2
Cocorí	5	790	2	2
Total	23	1350	13	10

One can observe that the sylvopastoral system is very diverse: of each component that the sylvopastoral system includes, the diversity is rather high. The system contains a selection of at least 86 species. This makes the sylvopastoral system very versatile in its production: the production varies from meat and milk to timber and fruits.

6.1.2 Perceived interaction between system components

The interviews included questions about the interactions, that the farmers perceived between the components[2]. A schematic map of a fictive farm shows the division of the farm unit and the possible occurrence of components.

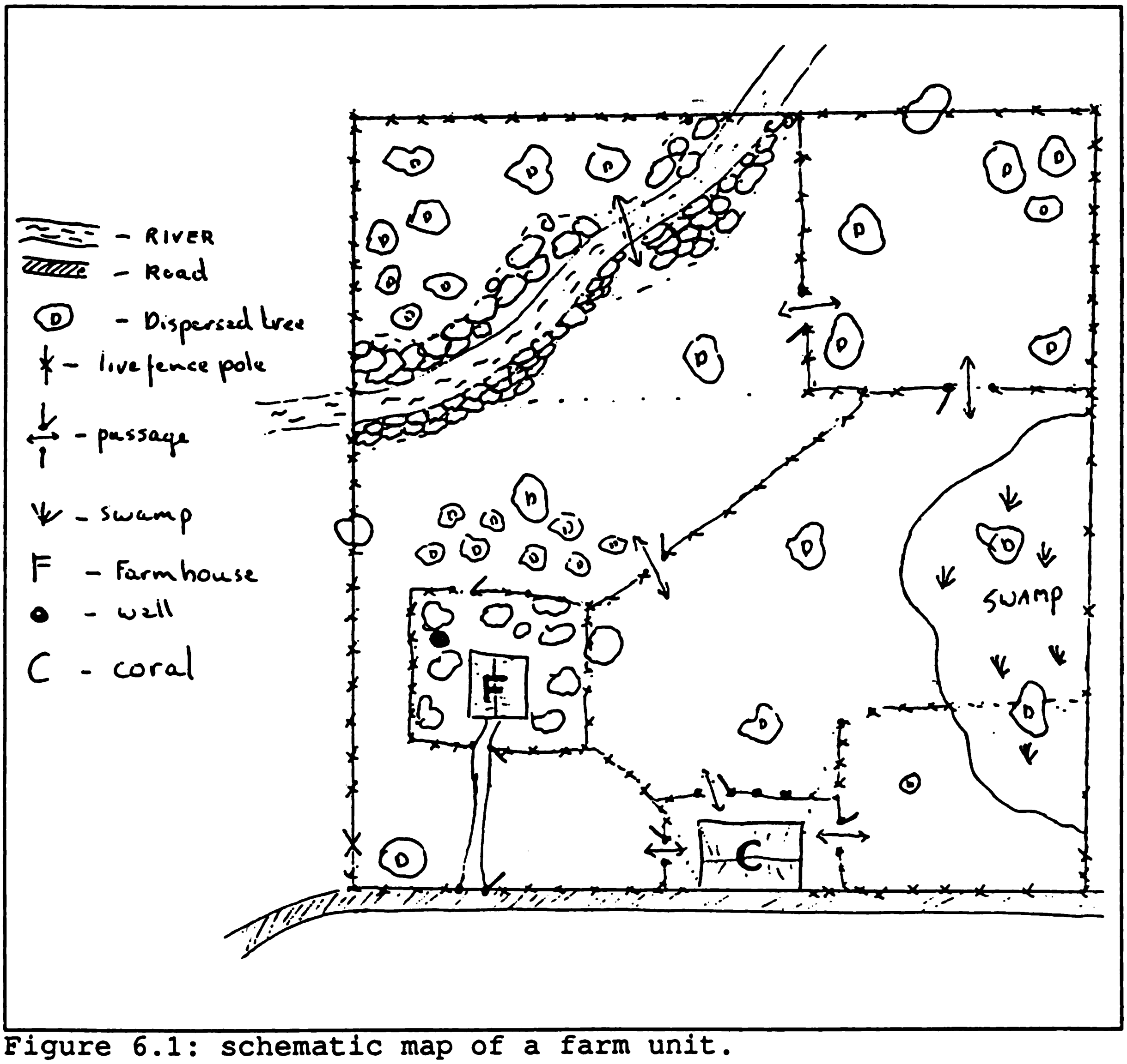

Figure 6.1: schematic map of a farm unit.

[2] The terms complementarity, competitive and indifferent are used here to give an explanation of the interactions. Complementary means that the components benefit from each others presence. Competitive means that the components compete for food, water and space. Indifferent means that no interaction is perceived.

About the interaction of the dispersed trees with the pasture (see table 6.5); the farmers reported either a worse, equal or better growth of the pasture, that was under influence of trees (compared to open pasture without trees). The trees influenced the growth, colour and freshness of the grass, depending on the amount of shade they provided: evenly dispersed trees with a fair distance between them were reported as having no or beneficial influence on the pasture. About the influence of living fences on the pasture, the farmers' opinions were divided, but most of the farmers mentioned the pasture to show an indifferent reaction to the influence of living fences.

The farmers mentioned that their cattle preferred shade of trees to open pasture, but many said that this preference depended on the weather: a lot of sun will cause the cattle to seek refuge in the shade of trees. But there was another determining factor at play: the cattle species. The most occurring cattle species, Brahman, is indifferent to heat and therefore it can often be found roaming about, when other species or crossbreeds prefer to be in the shade. This indifference applied to both dispersed trees and living fences. The farmers mentioned that the cattle liked to eat the fruits of the fruit trees in the pasture, especially those of guayava (*Psidium guyava*) and the citrus trees (*Citrus spp*). Several of the farmers mentioned that a danger existed, that the cows would choke on the unripe citrus fruits.

The influence of cows on trees was also discussed. Death of trees was sometimes blamed on treading of the immediate surroundings of a tree by cattle. Most farmers said that only small trees were molested by scraping and treading, but that the trees are only scarcely eaten. Big trees and live posts are only damaged when there is a lack of vitamins or minerals in the pasture (cattle debarks the live fence poles). Buds and leaves of living fences are eaten, especially of the two most occurring species, Poro and Madero negro.

The influence of the cattle on the pasture seems obvious: the grass is eaten by the cattle. However, several farmers mentioned that cattle always prefer food of a better quality, which can be seen in the fact, that cattle will always graze on the 'better' grass species (higher nutritive value, fresher, etc.). The droppings of the cattle on a patch of pasture results in a temporary setback in growth of that pasture, but after some time, production is higher. However, often these patches of grass are not grazed by cattle, due to possible toxic effects, as has been reported by several farmers.

Table 6.5: Interactions (+/-), perceived by farmers between the different components of the system in the research areas.

Type of interaction[*1]	Rio Jiménez				Neguev				Cocorí			
	+	0	-	N[*2]	+	0	-	N	+	0	-	N
COWARD	6	0	3	0	7	2	0	0	5	3	1	0
PASARD	1	5	3	0	5	2	2	0	1	4	4	0
COWLIF	4	0	6	0	6	1	2	0	2	2	1	4
PASLIF	0	3	4	2	3	5	1	0	1	2	2	4
COWFRU	3	0	2	4	4	0	1	4	6	1	0	2
LIFPRU	7	1	1	0	7	1	1	0	5	0	0	4
PRUCOW	9	0	0	0	7	1	1	0	4	1	0	4
COWDAM	3	0	6	0	8	0	1	0	4	0	4	1

[*1] COWARD = interaction between cows and dispersed trees; PASARD = interaction between cows and dispersed trees; COWLIF = interaction between cows and living fence; PASLIF = interaction between pasture and living fence; COWFRU = interaction between cows and fruit trees; LIFPRU = deposit of pruning residues of living fences; PRUCOW = consumption of pruned material by cows; COWDAM = damaging of trees (living fences and dispersed trees) by cows.
[*2] + = complementary, - = competitive, 0 = Indifferent, N = Not sure or no answer.

Farmers do indeed recognize both positive (beneficial) and negative (harmful) interactions between the components of their sylvopastoral system. Still, most attention of farmers goes out to their cattle.

6.1.3 Management

Management can be seen as the farmer's activities in guiding the system's basic components and interactions to an output, that is satisfactory to the farmer. It involves all actions, that the farmer takes, to arrive at an output of the combination of cattle, pasture and trees, that is optimal from the viewpoint of the farmer's objectives.

Cattle: The main occurring purpose of the herd is said to be double purpose, meaning that both milk and meat are produced. Most of the farmers mention that they hold cattle to survive: it is their source of food and income. The cattle is mainly fed on pasture, but a lot of farmers provide supplements in alimentation, like salt, molasses and a mixture of minerals with (known as Pecutrin) or without vitamins (known as Sal Aleman). The average time that is spent daily on milking is about 1.5 hours, and the average total time daily spent in direct cattle holding (including milking, provision of alimentation, change of pasture, etc.) is about 3.5 hours.

Three types of cattle holding occurred: small scale meat production, large scale meat production and breeding, and large scale meat production and commercial milk production.

The latter was easily recognizable, because the milk is sold to processing companies, which require a special milk collection/storage facilities. The former two types were more difficult to distinguish. Small scale meat production was purely focused on survival and sale of cattle occurred when there was a need; sales do not occur on such regular rates as with large scale meat production. Furthermore, small scale meat production required purchase of young animals to a large extent from other farms in the area, whereas large scale meat production and breeding was more self sufficient in provision of young cattle. These three farm types could more or less be discerned.

Pasture: The pasture is managed by cleaning it (which is called 'chapiar') with a machete, often twice a year. In most cases, this is done by the farmer himself (often aided by labourers). This cleaning takes about 25 hours/ha, depending on the state of the pasture. Sometimes, herbicides were applied.

Dispersed trees: The species of dispersed trees that are preferred by the farmer (most of them are double purpose), are Cedro amargo and Laurel, two fast growing timber species. The most common practice, used by the farmer to promote the establishment of dispersed trees in the pastures is leave them in the pastures, when cutting the grass. Often, the farmers clean the area around the small trees to improve their establishment. About the future, most farmers say that they will leave or plant more timber species in the pastures. Timber and shade is mentioned by the farmers to be very important reasons for planting or leaving dispersed trees, with shade as most important. However, they scarcely mention typical shade trees, but always double purpose trees: shade is indeed perceived as very important, but trees are not planted or left for providing shade.

Living fences: The wooden fences, that serve to support the living fences are mostly kept for stability and often consist of poles of Manu (*Minquartia guianensis/ Vitex cooperi*) or Gavilan (*Pentaclethra macroloba*). They are only used as fence and normally have no other purpose. Preferred species are Poro and Madero negro and an often mentioned reason is that they are 'mas pegador' (they establish themselves easily). The distances between the dead posts and the amount of live posts planted between them varies a lot (2-10 m between dead posts; 1-5 live posts between them).

Interaction: Several practices were mentioned by the farmers to avoid or stimulate interactions between the different components.
- Only few mentioned some activities directed at improving the relation grass/tree, like pruning of trees that gave too much shade.
- Several prevented the cattle from eating the fruits of fruit trees (especially citrus trees), that were standing in the pastures, by scaring the cattle off when they were in the neighbourhood of citrus trees. Another practice was pruning the low branches of the citrus trees to a height out of reach of the cattle.
- The pruned material from the living fences was mostly thrown inside the pasture, for which most of the farmers mentioned as reason that the cows ate the leaves of the pruned material (at least, the pruned material from fences with Poro and Madero negro). Some

farmers mentioned that a rule existed that made them throw the pruned material inside their pasture.

It seems that the management of the system is predominantly directed towards minimizing the influence of the tree component on the other components (pasture and cattle). As long as no negative (harmful) influence from the tree component on the other components is perceived, the tree component is tolerated in the field. If such an influence is observed, the tree component will be cut or pruned. Stimulation of the growth of the tree component, like fertilization, is hardly ever applied.

6.1.4 The specific differences between the research areas

Differences between the research areas regarding the sylvopastoral systems that occur, seems to be related to the history of settlement and the farm area.

Each area has a different history of settlement: Río Jiménez is the 'oldest' area; probably the sylvopastoral system in this area should be somewhat more established than in the other areas. Río Jiménez has been colonized a long time ago (more than 80 years). The settlement Neguev was formed in 1979, and formally is the youngest area. However, although Cocorí was colonized about 30 years ago, rapid migration into the area started only in recent years. Therefore, the division in length of period of settlement will be: Río Jiménez (oldest), Neguev (intermediate), Cocorí (youngest). Indications that support this notion can be summarized as follows:

- In Cocorí, the farms have a higher average farm area under forest and fallow, compared to the other areas. It is not unlikely, that forest and fallow will dissappear when more people invade the area and land use becomes more intensive.
- None of the farmers of Cocorí seems to originate from the Atlantic Zone, whereas in both other areas almost half of the interviewed farmers originated out of the Atlantic zone. In Cocorí, only four farmers have a legal land title, which is a small amount compared to the other areas.
- If the numbers of cattle on the farms are compared to the average farmsize, a difference between Cocorí and the other areas occurs: whereas both other areas have a density of Livestock Units/ha of pasture of more than one (Neguev 1.01 and Río Jiménez 1.03), Cocorí has a density of 0.55. This means that the farms in Neguev and Río Jiménez correspond to the national average cattle density, and the farms in Cocorí have the most extensive form of animal husbandry.
- Regarding the pastures: there is a low occurrence of pasto natural and the high occurrence of the grass species Tanner in Cocorí. This indicates that in Cocorí, pastures were sown recently with 'improved' grass species, and that Pasto natural (the species that occurs naturally) had no time to establish itself.

The pasture area can be another factor that influences the sylvopastoral system present in the different areas: the farmers in Neguev have farm areas ranging from 10 to 17 ha., with an average pasture area of 8.7 ha, which is small compared to the other areas. This should imply differences in farming practices. Indications that support this notion are the

following:
- There were no farmers in Neguev that mentioned a cattle-system other than for 'double purpose' (meaning that they used milk and sold meat from the cattle), whereas in the other areas meat production and breeding were also mentioned. Moreover, the motivation of the farmers for cattle holding seems to differ somewhat in Neguev. All farmers in this area mentioned 'survival' as motivation for their animal husbandry practices. In both other areas, several farmers also mentioned to have cattle for investment and commercial purposes, meaning that several farmers in Río Jiménez and Cocorí were no longer holding cattle for subsistence but for profit gaining.
- Neguev-farms show the highest amount of time needed for milking, maybe displaying a closer contact to and more efficient use of domestic animals.

In Neguev, extensive grazing is not paying on the pasture area of small farms; these farms are more likely to have more intensive husbandry practices (double purpose or milk production). In Cocorí, farms are still extensive, because a lot of land is still available; farmers are expanding their farm area by putting cattle on land, that was formerly covered with forest. These factors may also have an influence on the use of trees in the sylvopastoral system.

Several differences exist between the research areas in the use of trees on the farm, which may correspond with the differences in history of settlement and the pasture area of the farms.

In table 6.3, it was shown, that Cocorí farms have a greater species diversity in dispersed trees, followed by Río Jiménez and Neguev. Also the farmers in Cocorí show a greater willingness to plant fruit trees, as well as they mention a high frequency of planting fruit trees as origin of their dispersed trees. The farmers in the other areas scarcely mention the purpose of their dispersed trees to be production of fruits (see table 6.6).

Table 6.6 : Purpose of the dispersed trees for farm mentioned by the farmers in the research areas (9 in each area).

Area	timber	shade	fruits
Río Jiménez	7	9	0
Neguev	8	8	1
Cocorí	6	8	4

Farmers in Cocorí and Neguev mention as origin of the dispersed trees an equal occurrence of the remnants of the original forest (4 times mentioned), whereas in Río Jiménez only one farmer mentioned the origin of some of his dispersed trees to be natural forest, which is probably a result of the long history of farming in Río Jiménez. About the preference for certain dispersed trees species, the following can be said: preference for dispersed tree species limits itself to timber species. Cocorí farmers show a relatively strong preference for Caobilla, more or less replacing the preference for Laurel in the other areas (see table 6.7). Cocorí farmers also show a stronger preference for diversity in dispersed tree species. Preference is probably tied to occurrence of tree species.

Table 6.7 : Preference for dispersed tree-species of all kinds in the research areas, as mentioned by the farmers (9 in each area).

Species	Río Jiménez	Neguev	Cocorí
Caobilla*1	0	1	4
Laurel	7	8	2
Cedro amargo	8	5	5
Gavilan	1	2	3
Others	4	4	9

*1 Caobilla = *Guarea spp.*

Río Jiménez farmers undertake the least activities in dispersed trees of the three areas. The answers about intended activities with dispersed trees in the future, indicated that Cocorí farmers show the most inspiration to plant trees of all kinds. This may be caused by the minor occurrence of useful species for other causes than timber, and even these timber species are not fast growing species that the farmers prefer. Río Jiménez farmers express a lack of intention to plant fruit trees, likely to be caused by an already frequent occurrence of these trees. In Neguev, the low species diversity in dispersed trees is probably tied to an intensive use of the pasture, where trees are seen as occupants of land that can better be used for pasture (land is scarce). If trees are used, these are high productive timber species, like laurel.

Concerning living fences, Neguev farms have the largest average species diversity, followed by Río Jiménez and Cocorí farms (see table 6.8), and from table 6.4 it can be deduced that Neguev farmers prefer to plant more than one species in their fences. It is interesting to see the relative frequent occurrence of timber and fruit species in living fences on Neguev farms, compared to the other areas. Possibly, the small farm area has got something to do with this: the farmers do not want to loose much of their valuable pasture by the influence of dispersed trees, so they plant them in the fences, where the influence is already present.

Table 6.8 : occurrence of living fence species in the research areas, as mentioned by the farmers.

Species	Rio Jiménez	Neguev	Cocori
Number of farmers	9	9	5
Poro	8	7	5
Madero negro	3	7	2
Javillo*	1	2	0
Others	1	1	0
Timber species	1	2	0
Fruit species	0	2	1

* Javillo - *Hura crepitans*

Río Jiménez farms have the largest average length of living fences of the three areas (see table 6.4), followed by Neguev farms and Cocorí. One may conclude that the living fences are not (yet) too important in Cocorí, because 4 of the 9 farms of Cocorí have no living fences. The use of dead posts in Cocorí is mentioned more often by farmers in Cocorí. Timber is not yet expensive in this area, as there is still a much forest left from which timber can be extracted. The living fences in Río Jiménez are the oldest (6-6.5 years on average), followed by those in Neguev (4.5 - 5 years) and Cocorí (1.5-2 years). In the preference for living fence species, the maturity of the area is also shown: Neguev and Río Jiménez farmers have a wider interest in species than the farmers of Cocorí, who currently start thinking of establishing living fences.

About the interactions between the different elements, as observed by the farmers of the three different areas (see table 6.5), the following can be said:
- The interactions between cattle and dispersed trees shows only one difference between the areas: more farmers in Río Jiménez observe that the cattle prefer to be away from the dispersed trees, but two farmers in Cocorí explicitly mention that Brahman likes to be in open pasture.
- More farmers in the Neguev observe a complementary interaction between the pasture and the dispersed trees, meaning that the grass grows better under the trees.
- In Río Jiménez, farmers observe a competitive interaction between the cattle and the living fence (their cattle shun the vicinity of the living fences), whereas the Cocorí farmers mention an indifferent reaction of the cattle to their whereabouts.
- Between the pasture and the living fence, farmers in Neguev mostly perceive a complementary or indifferent interaction in Neguev. In Río Jiménez, farmers observe a competitive interaction between the two components.
- In Cocorí, the farmers frequently see the cattle eat the fruits of fruit trees (one might see a link between these answers and the intention to plant more fruit trees). Also in Cocorí, relatively a lot of measures are taken to protect the cattle from eating citrus fruits.
- About the pruning of the fences can be said, that all farmers that have living fences in Cocorí, threw the pruned material in their pasture. In both other areas, two cases occurred in which the residues are thrown outside of the field (this might be due to the fact that in Cocorí hardly any other species occur than Poro and Madero negro of which the foliage is

edible). Only in Neguev, cattle are reported by the farmers to dislike the foliage of the living fences, but both times, these are species other than the both N-fixing species.
- The opinion of the farmers about the damage of cattle done to the trees, is somewhat different for all three areas. In Cocorí, opinions of the farmers about this subject are divided. In Río Jiménez, more farmers say that the cows do not harm the trees and in Neguev, a lot of farmers say that they do. This may have got something to do with the nutritional value of the grasses and therefore with the soil (which is generally poorer in Neguev), in addition to the relatively high stocking rates in Neguev, when the poor soils are taken into consideration.

6.2 Important LUTs in the research areas

In this paragraph, a LUT description is provided of the three animal husbandry types, that are most prominent in the research areas. As has been explained in Chapter 5, an intermediate length LUT description serves this purpose best.

Each of the animal husbandry practices, briefly described in § 2.4, will be represented by a case study in the research areas:
- an example of dual purpose cattle farming with sale of milk and dairy products on a large farm in Río Jiménez; and
- an example of the dual purpose cattle farming with on farm consumption of milk on a small farm in the research area Neguev;
- an example of beef production on a large farm in Cocorí.

6.2.1 Dual purpose cattle farming with sale of milk and dairy products on a large farm in Río Jiménez

The farm of Victor is situated in the Río Jiménez district. The farming practice that Victor applies can be termed dairy and meat cattle holding on a large farm. He has to take care of 4 persons.

The land covered by the farm, consists of two parts. One part is situated close to the farmhouse and occupies 50 ha (in 13 parts) of pasture; the other part of 70 ha (in 11 parts) is situated further away from the farm house (about 45 minutes by boat). Furthermore, there are 2 ha of forest and a half hectare of crops, like banana and yucca. The land is held under legal ownership, except for 34 ha of pasture (not part of the farm area), that is hired from a neighbour. The cattle density on the pasture is 0.9 LU/ha.

The produce of the farm is based on milk and meat, sold on commercial basis. The average milk production per head is 5.5 kg/day. Milk is sold to Borden in Guapiles for about 39 C/kg. The milk is not used for cheese production. Young cows and bulls are heldfor production of meat. These are sold after one year of fattening, at an age of 3 years and a weight of 400 - 450 kg, at a price of 60.000 C/ head. Sale occurs at a frequency of 10 - 15 heads every month. The meat cattle is sold in Montesillos Impacador for export (the good ones), the rest is sold on the regional market.

Labour is provided by the farmer and his son, at times supplemented with hired labour. Daily routine is mostly based on milking of the cows in the morning and a variety of activities in the afternoon, like maintenance of fences, tracking of stray animals, business trips and tending the animals from the second, meat production farm. If the labour intensity of this LUT should be expressed in man-month/ha/y, this farm would have an intensity of at least[3] 0.16 man-month/ha/y, and can be termed a medium labour intensity LUT.

Also capital has to be invested. Within the context of animal husbandry, the farming practice as applied by the farmer, can be discerned as a high capital intensity LUT: normal in commercial ranching, where fences, machinery, motor transport, roads, etc., are provided.

The current farming practice is partly a result of the technical knowledge and attitudes of the farmer. Victor has not completed his primary school; his father taught him agricultural practices. Forestry practices were learned from farmers in the neighbourhood.

About the technology involved, the following things can be said about the LUT (bearing in mind, that the LUT is part of cattle holding);

- medium to high mechanical power requiring LUT: animal power in conjunction with human labour, but fuel-driven milking equipment and motor transport are also important for production.
- infrastructural requirements are: veterinary services and stores for delivery of additional feedstuff, antibiotics, etc.; storage facility of milk before transport; processing industry (Borden in Guapiles); frequent visits by middle men; and a reasonably well developed road net with filling stations, that are within reach of the farms.
- medium amount of material inputs by more affluent and commercially oriented pastoralists, often on the advice of extension and veterinary services, but who have a fair amount of technical knowledge and capital resources. Including drugs, mineral supplements, disinfectants, some fertilizers, possibly some use of chemical weed or pest control, etc.

The role of trees on the farm is reported by the farmer to be a timber resource for future home consumption or a capital resource when cash is needed. Furthermore, fruit is consumed on the farm. The living fences are planted, because they are economically beneficial, compared to dead fences. Also, a timber species is planted in the fence as a future source of construction material or capital.

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[3] This intensity is a minimum: it is produced out of the data available. It can however be assumed, that not all labour consuming practices have been mentioned by the farmers. Practices like the deliverance of calves, the search for young cows/bulls that are to be acquired, tracking of stray cattle, etc. are not included in this intensity. Therefore, the intensity should be regarded as indicative. This also holds true for the other LUTs.

6.2.2 Dual purpose cattle farming with on farm consumption on a small farm in Neguev

The farm of Nelson is situated in the IDA settlement Neguev. It can be described as a small cattle farm, on which 2 people (Nelson and his partner in life) partly depend for a living.

The amount of land, that the farm area covers, stretches over 12 ha (divided by a river into two plots of 5 and 7 ha). The farm is situated on "tierra negra" (black and fertile soil) and "tierra integral" (red/black soil with less fertility). The land is held under legal ownership ('escritura'). Before that he had a type of user's right to the land. The cattle density on the pasture is 1.7 LU/ha.

The produce of the farm is meat and milk. The meat is produced for the market. Young bulls and cows are fattened for 1.5 years and are then sold to middle men at a weight of about 350 - 400 kg at a price of 100 Colon/kg. Milk and cheese are produced for home consumption; three cows produce 10 - 20 bottles/day. Fruits of trees are also used for home consumption.

To come to the forementioned produce, labour has to be applied. Both Nelson and his partner in life work outside the farm a large part of the week to earn money. In terms of a qualitative description of the labour intensity, the intensity of Nelson's farming system can be termed low: at least 0.09 man-month/ha/y.

Also capital has to be invested in the system. Within the context of animal husbandry, the level of capital intensity can be determined as medium: a considerable investment must be made to obtain the cattle and external inputs remain necessary in the form of insecticides, herbicides and supplementary feedstuff. But inputs coinciding with high capital intensity levels, like machinery, roads, etc. are not present in this cattle holding practice.

The current farming practice is partly a result of the technical knowledge and attitudes of the farmer. Nelson has had no formal education. His father taught him agricultural practices and also tree-management. The reason for the fact that Nelson holds cattle is that he grew up in a cattle farm and consequently cattle holding is what he knows best.

About the technology involved, the following things can be said;

- largely or entirely human labour, with little or no animal power, and no use of power-driven machinery.
- infrastructural requirements are: the frequently passing by of middle men, that buy the fattened cattle from the farmer; and accessability to veterinary services and agricultural supply stores.
- material inputs by more affluent and commercially oriented pastoralists, who have limited technical knowledge and capital resources. Often, material inputs are applied on the advice of extension and veterinary services.

Nelson mentiones that he perceives the role of trees on the farm to be a timber resource for future home consumption. Furthermore, fruit is consumed on the farm. According to Nelson, the trees increase the value of the land. The living fences are planted, because they are economically beneficial, compared to dead fences, but also because Nelson likes to plant them. Leguminose trees are planted in the pasture for improvement of the soil and because Nelson observes a better production of the cattle that eat the foliage of the trees.

6.2.3 Beef production on a large farm in Cocorí

The farm of Leonel and his brother Carlos is situated in the Cocorí area. The farming practice applied by them can be described as meat cattle holding on a large farm. The farm has to feed 8 mouths.

The land occupied by the farm is 247 ha, consisting of about 180 ha pasture, 40 ha forest and 1.5 ha of rice. Another 25 ha is lent to other persons (they receive no rent). Carlos has a legal property document for 150 ha, the rest of the farm is owned through right of occupation. Livestock density on the farm in Livestock Units per hectare of pasture is 0.7 LU/ha.

The produce of livestock on Leonel's farm is meat and calves for fattening. After the fattening, they are sold at an age of 2 - 2.5 y and a weight of 350 - 400 kg, for a price of 65.000 to 70.000 C/head. Leonel sells the meat per kilogram "en canal"[4] to Montesillos Empacadora for a price of 250C/kg. Frequency of sale is 3 times per year and 24 - 25 pieces are sold each time. Milking of three cows takes one hour every morning, about 3 - 3.5 litre per head is produced. The milk is used on the farm (consumption and cheese-production for home consumption).

Most of the labour is provided by Leonel and his brother Carlos. Leonel's daughters work on the farm. Leonel and Carlos have no off-farm work. The labour intensity is at least 0,09 man-month/ha/y, and the LUT can therefore be termed a low labour intensity LUT (however, seen from the fact that this labour intensity is a minimum, the division between medium and low is small on this farm).

Within the context of animal husbandry, this farming system can be determined as a high capital intensity LUT: normal in commercial ranching, where fences, motor transport, roads, etc., are provided. Cattle represents a large part of the capital. In this case, land was not bought and a part of the capital was derived by selling standing timber on the land.

The success of the farming practice depends for a considerable part on technical knowledge and attitudes of the farmer. Leonel and Carlos have not completed their primary education. Agricultural practices have been learned from their father. However, Leonel and Carlos appeared to have an extensive amount of knowledge of animal husbandry practices.

Bearing in mind, that the LUT is part of animal husbandry, the following things can be said about the LUT, regarding the technology involved;

- medium mechanical power requiring LUT: animal power in conjunction with human labour. However, motor transport is present for buying medicines, pesticides, and groceries.
- Infrastructural requirements are: veterinary services and stores for delivery of additional feedstuff, antibiotics, etc.; frequent visits by cattle trucks that transport cattle for a price/head; and a reasonably well developed road net with reachable filling stations.
- medium amount of material inputs by more affluent and commercially oriented pastoralists, often on the advice of extension and veterinary services, but who have a fair

[4] Selling meat "en canal" means that the percentage of meat, without non-edible components, is calculated with a formula and for this percentage of meat, a price is paid.

amount of technical knowledge and capital resources. Including drugs, mineral supplements, disinfectants, some fertilizers, possibly some use of chemical weed or pest control, etc.

For Leonel the role of trees on the farm is perceived to be a timber resource for future home consumption and a resource of capital. Fruit of fruit trees is consumed on the farm. The living fences are planted, because they are economically beneficial, compared to dead fences. Like Victor, Leonel wants to plant a timber species in the living fence, as a future source of construction material or capital.

6.3 Sylvopastoral practices

The following description of the sylvopastoral practice involving dispersed trees has been derived from the three case studies. These practices form part of the LUT and are specified on the use of trees within the farm. References are marked with a number: 1 = Nelson, 2 = Victor, 3 = Leonel (see intermediate length LUT-description).

Dispersed trees

The dispersed trees can be divided into 4 groups, according to their function: timber, fruit, shade and pioneer trees. The most occurring species per class are: laurel, cedro amargo, pilon for timber; citrus and aguacate for fruits; gavilan for shade (and timber); and Poro as pioneer. The four groups are described in terms of establishment, maintenance and investment and return (tangible and intangible). Timber and fruit trees add value to the land. For instance, one hectare of land with fruit trees may cost 0.5 million C, whereas the same piece of land without trees costs 250.000 C (1).

Timber species

Timber species originate from secondary regrowth. None of the farmers plant them at present. This results in a dispersion of the trees without a strict pattern, but they often occur in clusters (2). The pasture is divided into plots of about 5 - 7 ha (1,2), and different plots show a different amount and species of trees in a different dispersion.

Management of the trees consists of cleaning around the stem, especially when the trees are in their juvenile phase. This is done simultaneously with the cutting/cleaning of the pasture (1,2,3). The valuable trees may be pruned: laurel is pruned in the juvenile phase to a height that the farmer can reach (1); this also occurs during pasture cleaning.

The harvesting of trees occurs when there is need for timber. All farmers mentioned to cut trees only for use on their own farm; however, when in need of cash or when a good opportunity occurred, they would sell it (2,3). Cutting the trees occurs with a chainsaw and is done either by the farmer himself (2) and/or by a hired labourer (1,3). For a detailed description of the cutting practice (with investment and return).

Gavilan and Manu are used for posts, other timber species are used for construction purposes. No real time investment on the timber trees occurs, as they are not planted and management does not require extra time (because the pasture has to be cleaned anyway).

Fruit species

Fruit species are planted in the pasture. Usually, they are planted near the farm-house. Whenever the farmer wants to plant fruit trees, a small nursery is made (1,3). This can be done on a small cleared plot (3) or on the farm yard (1). On the farm yard, seeds of desired species are planted in plastic bags, filled with a mixture of soil and sand. The amount of seeds differs with the volume and form of the seeds. When the seedlings have reached a height of about 30 cm, they are transplanted into the pastures in patches or lines at 10 m distance, with a planting depth of 10 cm (1). On a small cleared plot, the seeds are directly planted and when they reach a height of about 1.5 m, they are pulled out and transplanted into the pasture (3).

Management of the fruit trees is the same as that of timber trees. Sometimes, also fruit trees are pruned; this is reported to enhance the development and production of fruit and it prevents the eating of fruits from the trees by cattle.

Harvesting takes place when fruits are ripe; the fruit is predominantly used for home consumption. Because of a high occurrence of diseases (especially Mata palo and drying out)(2,3), the difficulty of selling the fruit (3) and the labour time necessary for planting (3), no trees are planted for commercial purposes (an exception to this is the planting of coconuts, which might indeed give financial return (1)). Investment is low, as management is done simultaneously with the pasture cleaning and planting is sporadically done. Furthermore, seeds are not bought.

Shade species

Hardly any specific shade tree species are mentioned by the farmers to be present on the farms. All trees are considered useful as providers of shade. To avoid too much influence of the trees on the pasture, the farmers prefer a certain tree density (20 - 25 trees/ha); this density depends on the tree species.

The farmers do not mention any management on the shade trees: no pruning occurs to influence the amount of shading. Gavilan is a preferred shade tree; this species is also left in the pasture for production of fence posts.

Time nor money is invested in shade trees.

Pioneer species

Only one farmer had pioneer trees in his pasture (1). Stakes of Poro are planted at a distance of 10*10 m, in the same way as living fences of this species are established. This sylvopastoral practice resulted from a research project of CATIE on the effect of Poro on the production of pasture and cattle.

Management of the trees encompasses pruning them once a year. Every pruning sequence, 2 branches (so-called 'guias') are left on the mother tree, to enhance resprouting.

The branches of the trees are transplanted into the living fence or in the pasture. The pruned material is left in the pasture (green manure) and has a production improving effect on the cattle (see interactions). Time invested in the establishment and maintenance of the pioneer trees is: 9 minutes/stake for planting and about 8 minutes for pruning a mother tree, producing 4 new stakes. No money was invested in the practice (1).

Living fences

The living fences that occur on the farms are all part of what was denoted in § 3.4.2 as live fence posts. They can be divided roughly into two groups, according to the function they have for the farmer: living fences with only live fence posts and wooden posts and living fences including timber species. Schematic examples of both types of living fence are given in figure 6.2.

Living fences with live fence posts and wooden posts

This type of living fence may consist of Poro, Madero negro, Javillo or other species, placed at a certain distance, in either mixed or pure composition. Some of these fences need a somewhat different management, but their function is only to demarcate the borders of the farm and to avoid straying of cattle and trespassing of property (1,2,3).

Establishment of a new fence starts with the construction of a wooden fence. The purpose of this wooden fence is enhancing the stability of the living fence, as the newly planted stakes will not be able to withstand the force of attached barbed wire on their own, nor will they avoid cattle to break out.

Construction of the wooden fence starts with placing wooden posts at strategic places, e.g. corners of the field (1,3). Barbed wire is attached to these wooden posts and serves as guide for placing the other posts (3). Wooden posts from Manu and Gavilan are preferred, that are either cut with a chainsaw (1,2) or cloven (3), at a length of 2 m and a width of 5 pulgadas (3). Holes of about 30 (1) - 75 (3) cm in depth are dug with shovel and 'macana' (a kind of spade). The distance between the wooden posts differs among the farmers: 1 m (1), 2 - 2.5 m (2) and 5 m (3). Barbed wire is nailed to the posts; 3 - 5 strings are reported optimal (considering cost and benefit) for avoiding animals to stray.

Next, the live fence posts are established. The stakes that are to be transplanted are cut from the mother trees, at a length of about 2.5 meters. They are defoliated and transported to the planting site, which is often close. There are two ways of establishment, depending on the soil (2):

- when the soil is hard, holes are dug of about 10 cm with macana; the live fence poles are cut at the bottom end, resulting in a dull point with two edges; the top end is cut at a length of 2.10 meter with a sharp angle (1,2); holes are dug of 8 - 10 cm with macana (1,2); the live fence poles are put into the holes in an upright position; the soil is treadled firmly (1,2,3).
- when the soil is soft, the live fence poles are cut at the bottom end, resulting in a sharp point with 4 edges; the top end is cut with a sharp angle at 2.10 m (1,2); the stakes are immediately pierced into the soil. The soil is treadled firmly (2).

Like the wooden posts, the live fence poles are planted at different distances; distances are mentioned of every 20 - 30 cm (1), every 80 - 100 cm (2), or every 130 - 170 cm (3).
The live fence poles are attached to the barbed wire with strings, because they can not yet withstand nails. After one year, the barbed wire is nailed to the live fence poles.

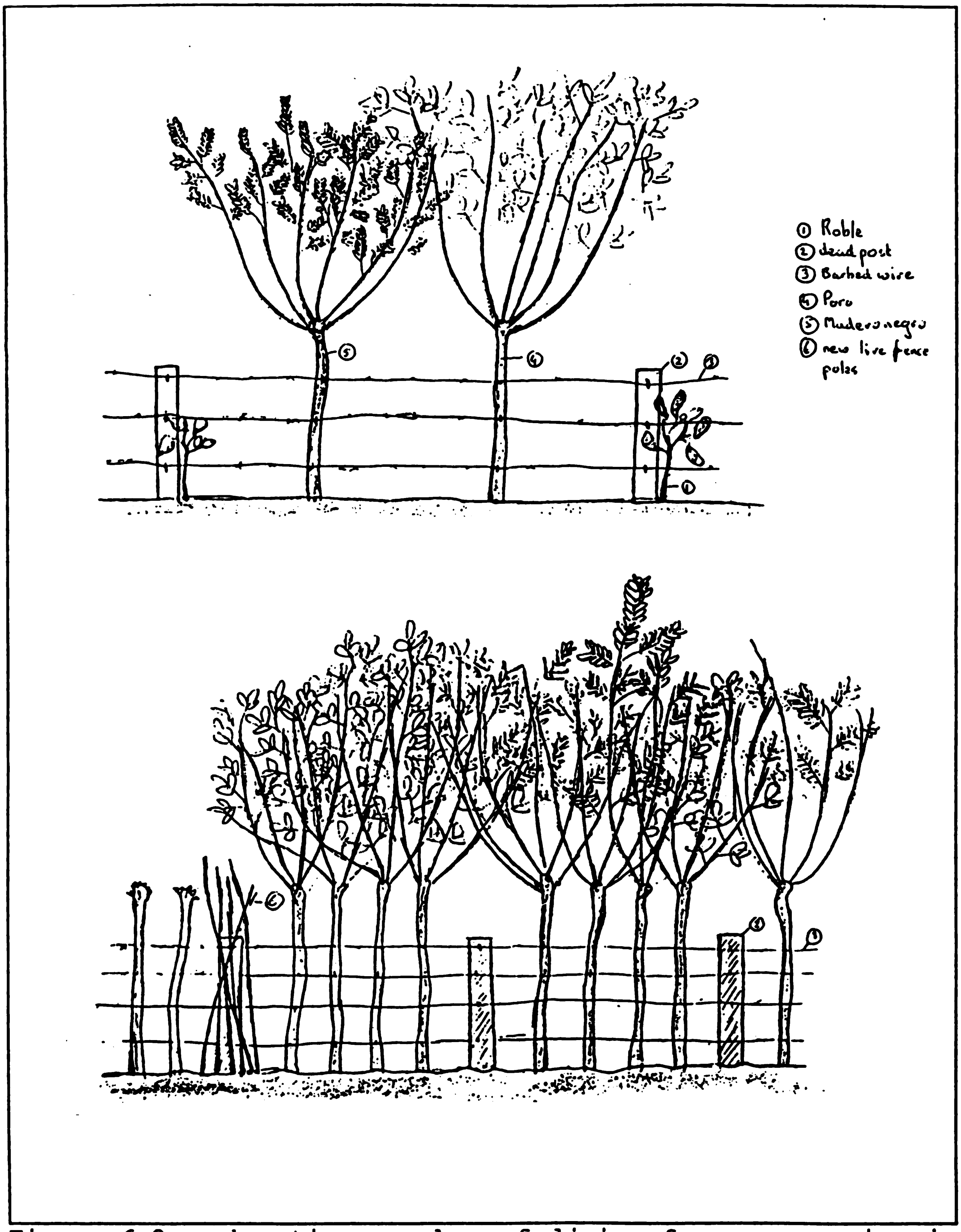

Figure 6.2: schematic examples of living fences occurring in the research areas.

Because the use of pruned branches of Javillo as new live fence poles is not possible (1,2), living fences with this species are established in a somewhat different way. Seedlings from secondary regeneration in the pastures are uprooted and replanted in the fence when they are about 30 cm in height (2), or young trees from secondary regrowth are cut at the stem basis and then replanted in the fence (1). This species is not much used among the case study farmers.

Maintenance of the fences consists of pruning and transplanting of pruned branches in existing fences. When the fences include spiny species, like certain Poro species and Javillo, gloves should be worn. Pruning of fences depends on the need for stakes for establishment of new fences: if stakes are needed, pruning occurs every six months (2). Otherwise, the fences are pruned once every year (1,2,3). Preferred time is January and February (1) at waning moon[5] (1,3). The first pruning in a pruning sequence of a living fence, the live fence poles have to cut at 'casca mula', the height that a mule can reach (which is about 2 m). The hanging branches are removed, leaving 4 - 5 branches, which can serve as new stakes in the second year (1). After the second year, every pruning yields new stakes for transplanting. One or two branches ('guias') are left on the mother tree to enhance resprouting (1,3), and as a reserve for mending (1).

Depending on the species, the established fences yield an amount of stakes, that are transplanted into the old fences, or used for establishment of new fences. Furthermore, living fences can yield fuelwood and food (flowers of Itabo and Poro can be eaten). Furthermore, fruit trees are sometimes planted in or close to the fences, because influence of shading is already present and will not greatly increase with introduction of fruit trees, whereas additional production of fruit is obtained for home consumption (1). Also, the live fence poles provide shade for the cattle and, in the case of nitrogen fixing tree species, may improve the soil fertility. The service function depends on the management of the live fence poles: pruning influences the amount of shade provided. Investment in the fences encompasses labour time and costs of establishment.

Establishing the fence represents investments: the wooden posts and live fence poles have to be bought, if they are not yet present on the farm, and barbed wire is expensive. Also labour time has to be invested. Costs depend on the materials used, the composition of the fence and the willingness to invest labour. Investments on different fences has been shown in table 6.13.

[5] If the living fences are pruned at waxing moon, the stakes will not be suitable for replanting, because they loose their fluids and establishment will be poorer(1). For more information, see Baron et al. (1987).

Table 6.9 : investment in living fence

farmer	1	2	3
composition of fence			
- stakes	400	135-200	60-80
- posts	100	50-67	20
- lines of barbed wire	4-5	4	3
labour (100 m fence; in hours)			
- establishment of wooden fence	25-30	13-17	5
- wiring and nailing of barbed wire	15-20	12-15	8-12
- placing stakes	9	3-4.5	1.5-2
- attaching stakes to wire	0.5	0.5	0.5
subtotal establishment	50-60	29-37	16-20
- pruning	10	8-8.5	8
capital (*1000C)			
- wooden posts	10	5.0-6.7	2.0
- barbed wire	2.7-3.4	2.7	2.0
- stakes (fictive value)	4.0	1.4-2.0	0.6-0.8
subtotal costs material	16.7-17.4	9.1-11.4	4.6-4.8

According to table 6.9 , the fence with densely spaced living fence poles (25 - 30 cm apart and distance between wooden poles of 1 m) represents 50 to 60 hours in labour for establishment with material costs of about 17.000 C (if stakes are bought for 10 C/stake (1,3)). The fence with the intermediately densely spaced living fence poles (80 - 100 cm apart and distance between wooden poles of 2 to 2.5 meter) represents about 29 to 37 hours in labour for establishment and about 10.000 C in material costs. The most widely spaced fence (130 - 170 cm apart with a distance between wooden poles of 5 meter) is obviously the cheapest and the least time consuming: labour time 16 to 20 hours and a material cost of about 5000 C. Time investment in pruning is occurring every year: 8 - 10 hours.

Living fences (as above), including timber species

This practice is not very different from the above mentioned, with the exception that timber species are included. Thus the function of the fence changes from only avoiding cattle to stray to both this and providing timber (as a reserve). A species used in this fence was Roble de sabana (*Tabebuia rosea*) (2,3).

The establishment does not differ much: distances between wooden posts and stakes remain the same. But in this fence, a seedling of Roble is planted every two meter. They are planted close to the wooden posts to protect the seedling.

The seedlings are planted in small nurseries in the pasture. They are cultivated to a height of about 30 cm (for the inundated areas, bigger seedlings are bred). When needed, they are pulled out, the leaves are removed (except the ones of the final bud) and the top of the main root is cut to avoid breaking at planting. The leaves are removed, because otherwise the seedling would dry out; the main root is cut, because otherwise this would break and rot would have easy access. They are planted with a pointed stick. The hole is about 5 - 7 cm deep and is imposed in a place that has been cleaned first with machete and hook. The seedlings are put in the holes in such a way that they are erect and that it is easy to fill the hole with soil. The filled hole is treadled securely. It takes about 45 minutes to plant 30 plants.

The practice of planting timber species in the fence is still in an experimental phase (2,3), but might prove to be very beneficial in the future, as the farmers expect an alternative timber stock, that can be used if there is need for construction material or can be sold.

Alternative practices by farmers:

Two of the case study farmers featured a special agroforestry practice. This practice had only indirect meaning for the sylvopastoral system, occurring on the farm, but represents possible benefits for the future.

Live fence pole nursery: farmer 3 has a nursery of living fence species. This nursery mainly holds the triangularly leafed Poro, but the other class can also be found in this nursery, as well as Jinocuave (*Bursea simaruba*), Javillo, and Jocote (*Spondias purpurea*). He observed that the mother trees in the nursery resprout more easily and produce stakes for replanting more rapidly, compared to mother trees in the fence. Nowadays, he does not use the nursery any more. The purpose of this practice is provide in a continuous resource (and reserve) of straight stakes for planting in the living fence.

Coconut palm-living fence system: farmer 1 applies an agroforestry practice, combining living fences and coconut palms (*Cocos nucifera*). In this practice (see figure 6.3), a kind of living fence bank is constructed, that is about 3 m in width and contains the initial living fence, a row of coconut palms and a newly planted, temporary living fence. The fence of about 50 m has been planted in two days, including the planting of the coconut. An experienced team will need only about a day and a half. Purpose of the practice: after the risk of damage to the coconut palms has vanished, the coconuts can be used for on farm consumption and/or sale. Furthermore, the palms provide shade for the cattle, whereas the influence of the coconut palms is relatively small as part of the palms overlap with the area of influence of the initial living fence.

6.4 The role of trees and requirements and constraints to their use in the sylvopastoral systems

In the former part of this chapter, the sylvopastoral system, present in the research areas, was discussed upon species composition and management. In this section, the role of trees in these sylvopastoral system, as perceived by the farmers, will be outlined and mentioned requirements and constraints will be discussed. This will give an idea of the importance of trees in the sylvopastoral systems in the research areas.

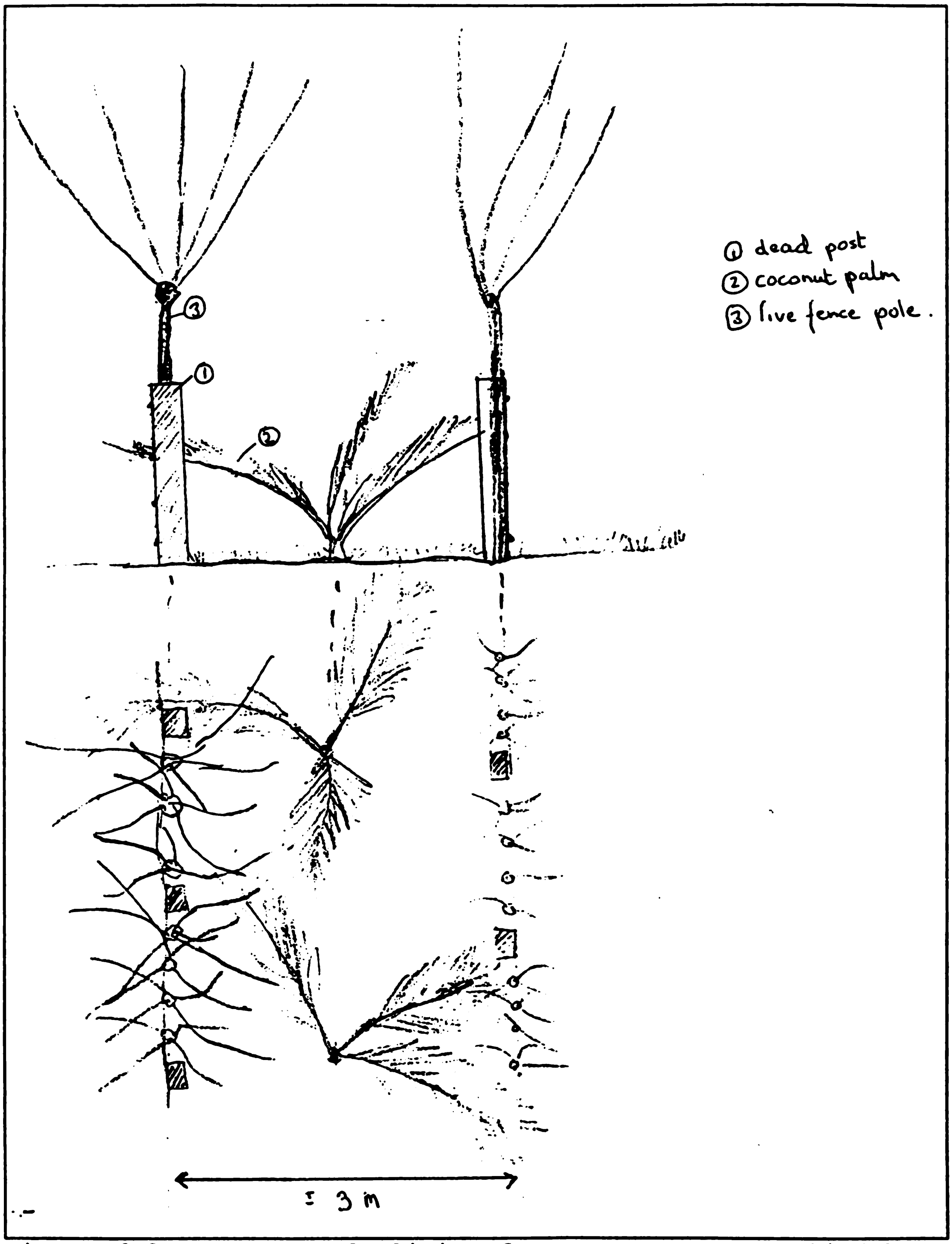

Figure 6.3: coconut palm-living fence system, as applied by a farmer in Neguev.

6.4.1 The role of trees

The sylvopastoral systems in the research areas apply to the definition of agroforestry. The woody perennials are deliberately combined on the same management unit (pasture plot), in a specific spatial arrangement. Living fences are planted on plot boundaries and dispersed trees are planted or left in the pastures. Interactions between the different components (woody perennials, pasture and livestock) are observed by the farmers, both on ecological and economic terms.

Generally, it can be stated, that the farmers like trees and living fences, as long as their influence is not too pronounced. The systems focus mainly on animal husbandry. The components of the system, i.e. cattle, pasture, dispersed trees and living fences, are mostly managed by the farmers as separate entities with their own purpose (except the pasture, which is managed for an optimal cattle production). Interaction between the trees on the one hand, and pasture and cows on the other hand, is suspected, but often differences in opinion occur if these interactions are positive or negative for the total production of the system. The dispersed trees are mainly kept for production of timber or fruits, for home consumption or sale. Shade is convenient, but selection of trees or management is scarcely directed towards this purpose. Practices towards protection or conservation of the land are almost absent. The living fences are managed as just another form of dead fences: they serve the purpose of field boundary demarcation.

The management actions by farmers focus on their cattle and little time is left for trees and fences.

Differences between the research areas regarding trees on farm land are mainly caused by differences in settlement history, with Cocorí as the area with the youngest settlement history, Neguev with an intermediate, and Río Jiménez with the oldest history of settlement. For instance, Cocorí often shows other features regarding trees, compared to the other two areas. The dispersed trees on the farm are often not the species that the farmers need: they want fast growing timber species and fruit trees. As the farmers have only recently occupied the area, they are still adapting their farm land to their needs and searching for an optimal cattle density and for tree species, that satisfy their needs. They are not yet too concerned with the interactions between cattle, pasture and trees.

Also, farm characteristics, like pasture area seem to play a part in the differences between the areas, regarding the use of trees. As a general trend can be mentioned, that Neguev farmers have a somewhat more positive opinion about trees and the interaction of these trees with the other components on their farm: their farm area is smaller and thus, they depend to a larger extent on an optimal production on their farm. Río Jiménez farmers seem somewhat less involved with their trees: most farms are big, but rather highly stocked with animals. More time is invested in cattle.

Dispersed trees in the research area predominantly represent a function of timber reserve. Virtually no management is practised upon all categories of dispersed trees. Usually, management consists of leaving the trees in the pasture and harvesting them when in need of money or construction material. Sporadically, farmers prune timber species to improve the future quality of the timber. Fruit trees are planted only when the farmer has time and as labour time seems to be a commonly shared problem, this does not happen very often. There are no specific shade trees: in fact, all trees in the pasture are regarded as shade trees, but they were planted or left in the pasture for other purposes, or because cutting was simply not worthwhile. But farmers recognize, that shade is important for their cattle. Several farmers mentioned, what they called an optimal coverage of trees (20 - 25 trees/ha, depending on the species). This coverage would provide enough shade, and in the mean time would not have negative influence on the pasture. But the management of the trees does not demonstrate this notion.

An intensive management seems to occur only on pioneer trees. These trees need to be pruned. However, so far, there is minimal knowledge among the farmers of the benefits of this practice, compared to the extra labour they have to invest, which is a serious constraint to a further implementation of this practice.

In the research areas, a lot of living fences consist for a large part of other species, than Poró and Madero negro and farmers do not manage their living fences as a source of fodder. Most of the farmers have observed that the foliage of certain species is liked by the cattle as food, and some even said, that this foliage can have a positive effect on the production and quality of both meat and milk. But they also point out that this requires high investments in time and the fact that the pastures provide enough food. As the farmers mentioned labour time to be the main bottleneck in the farming practices, the extra investment in time is probably considered as too high, compared to the extra income by improvement of production by cattle.

The establishment of timber species in the living fence, as is being practised on a small scale by several farmers in the research area, is being reported by the farmers as commercially beneficial. The establishment of these fences should not require more time, than the usual fence; in maintenance it may even require less time. However, ecological and socio-economic (e.g. land tenure) implications of this practice in the research area are still unknown.

6.4.2 Requirements and constraints for the use of trees

The farmers have mentioned several requirements for the use of trees in the sylvopastoral system, e.g. time, labour, planting stock, information and the possibility to enjoy produce. These requirements are linked to the constraints for using trees: a lack of arequirement is a constraint for the use of trees in the farming system.

Time is a requirement for the use of trees, which was mentioned by many farmers. The farmers complained that it was hard to invest time in labour intensive practices, like maintenance of living fences or establishment of a nursery for fruit trees. The factor time is immediately linked with the factor labour, because when one cannot invest sufficient time oneself, a labourer has to be contracted. However, labour is scarce and expensive, due to the influence of banana companies. These provide much and unskilled employment and pay reasonably well (e.g. labourers in banana companies are payed 150 Colon, whereas labourers on farms usually get 100 Colon), with the result that many labourers decide to work for the banana companies, instead of working as a labourer on other farms.

Consequently, labour is getting scarce and expensive and farmers have to rely more and more on own resources of labour, restricting the time available for other practices than animal husbandry.

Several farmers mentioned that they would have planted more trees, if they were provided with the right planting stock. What they want are fast growing timber species, that look nice in the field, like pines (*Pinus spp.*). Especially in Cocorí, farmers mentioned that it was hard to get live fence poles to plant in their living fences. Sometimes, they were not given permission to use the stakes, that their neighbours pruned to plant in their own fences.

Several farmers mentioned that a possibility to sell the produce obtained from the trees was a requirement for planting trees. This especially held true for fruit trees, but was also important for timber trees. Mentioned by the farmer was the need for appropriate laws and a good infrastructure. Farmers mentioned that it is very difficult to obtain cutting permits for the trees on their farm. They do agree with the laws that exist upon the cutting of trees, but they oppose to the administrative process that has to be gone through, before obtaining such permits. Many farmers mentioned this as a reason for cutting illegally on a small scale: they mentioned that they use the timber from trees in the pasture for home consumption. Furthermore, farmers complained that they have to depend on middle men, that frequent the area occasionally, for selling their cattle and timber. Also, the road net is still inadequate to allow easy transport of cattle and timber. Input of veterinary products, supplementary alimentation (salt and molasses) and herbicides is reported to represent a heavy financial burden on the farmers, and are hard to get.

An important requirement for the use of trees in the farming system is knowledge about how these trees can be managed and what benefits can be enjoyed from them. A lot of farmers do indeed have extensive knowledge about the trees that they have in and around their pastures, regarding the produce they can obtain from these trees. However, about the interactions between the components of the system and the reaction of the system on the environment, still knowledge is concise. The sylvopastoral practices are applied, but the technology behind them is not yet fully understood. Some farmers understood this, when they mentioned that they lacked reference: e.g. they guessed that a beneficial effect of the foliage of certain living fence species on their cattle existed, but they had no point of reference to check that an improvement in production of milk and meat could indeed be ascribed to the fact that cattle ate this foliage.

As the last mentioned requirement of agroforestry technology and the constraint linked to it are perceived by the author to be a very important one, this subject is further outlined in the next chapter.

7. KNOWLEDGE SYSTEMS IN THE ATLANTIC ZONE OF COSTA RICA

7.1 Introduction

In the last part of section 6.4.2, it was concluded that in the research areas the technology behind the agroforestry practices was often not fully understood. Section 3.1 stated that without proper agroforestry technology behind management of agroforestry practices can often only have limited succes. In this chapter, the reality of knowledge systems that occur in the Atlantic Zone of Costa Rica will be discussed, and it will be illustrated that the technology provided by research institutes and extension organization does not connect to the farmers' knowledge systems. A simple model of a knowledge and information system (KIS) consists of roughly three components: Research, Extension and Client (Wapenaar et al., 1989). A model of such a KIS, adapted to the farmers' situation, has been given in figure 7.1.

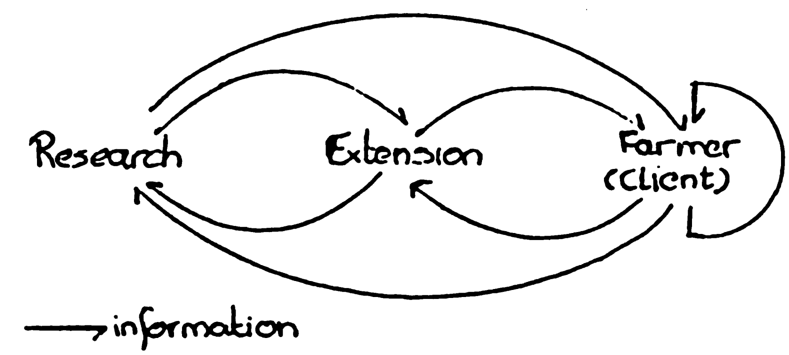

Figure 7.1: a simple model of the knowledge and information system. Adapted from Wapenaar et al., 1989.

The components of the KIS maintain relationships with each other, in order to exchange information. Some of the relationships between the components will be dealt with in the following paragraphs. In section 7.2, an important factor determining farmers' knowledge systems will be discussed; i.e. their 'world views'. Section 7.3 deals with the generation of knowledge by farmers. In section 7.4, it is outlined that extension given by research and extension organizations is not effective in the Research areas. Based on the formar sections, the knowledge systems that are present in the research areas, are confronted with the model presented in figure 7.1.

7.2 Different 'world views' in the Atlantic Zone

The farm is the smallest decision making unit within land use. A complex network of factors are involved in decision making within the farming household. In this decision making process, innovations play the role of a possibility to respond to 'internal' or 'external' changes. When these changes occur, the individual farmers must themselves come to terms with new elements in their environment and naturally do this to large extent on the basis of existing 'world views'.

Farmers in the Atlantic zone are extemely varied with regard to their backgrounds (Waaijenberg, 1986). The farmers originate from all parts of Costa Rica (like Guanacaste and the Central Valley) and even from other countries (Honduras, Nicaragua, etc.). Their places of origin differ in many aspects from their current place of residence, both in ecological, political and economic (infrastructural) sense. The backgrounds of these people are therefore differing; they have other experiences and gathered different knowledge (and thus have different 'world views'). Where agriculture is in its initial phase in the area, the knowledge gathered elsewhere is more or less applied to the new situation (Hermsen, 1989).

That agricultural backgrounds differ between farmers can be shown in the following example: one farmer mentioned a 'sickness of the soil' to exist; this is a change of soil temperature, that avoid that e.g. the living fences form roots and it is called 'canicula'. In Guanacaste, where he came from, this sickness lasted from 15 July to 15 August. However, the farmer found out that in Neguev, where he currently lives, the sickness occurs in the months April and May (pers. comm. Nelson). Another farmer mentioned that he planted his living fences in March, April and May, because his most important fence species were Poro and Madero negro, and these shed their leaves in these months (pers. comm. Leonel). This farmer originated from San Carlos in Alejuela, which is also in Guanacaste, but somewhat more near the central valley.

According to their background, farmers start to apply in their present situation, the knowledge about farming practices, that had been accumulated in their former situation. Therefore, the background of the farmers forms an important reference for the farmers, when they generate knowledge about their new situation.

7.3 Generation of knowledge

Often, the application of known techniques fails, which results in experimenting by farmers (Hermsen, 1989). One farmer presently is involved in planting Poro as a dispersed tree in the pasture to increase the output of his cattle (pers. comm. Nelson). Another farmer tries to increase the output of his living fences, by planting timber species in them (pers. comm. Victor). A third farmer has a nursery for living fence species, because he wanted to establish more living fences. He observed that the mother trees from the nursery grew stakes more rapidly than mother trees in the fence (pers. comm. Leonel). One can remark that experimenting is not uncommon among the farmers. More and more knowledge is generated by the farmers about the possibilities of the natural environment and the use of trees to reach their objectives, within ecological and socio-economic limits. Farmers start to observe, that there is an optimal dispersal of trees in the pasture: a too dense stand damages the pasture and increases the chance of insect diseases of cattle, a too sparce stand does not provide sufficient shade and increases the risk of future timber and fruit shortage. More and more living fences are planted, because finacial benefit is observed, but also because a positive interaction of these fences with soil, pasture and cattle is observed.

The knowledge is not only gathered from own experiments, but is also obtained through personal contacts (neighbours, family, etc.) (Hermsen, 1989). For instance, several farmers mentioned that they had learned to manage trees by watching their neighbours work (Pers. comm. Victor). One farmer mentioned that he learned to work with fruit trees from an uncle, that took pride in teaching everybody who wanted to know about fruit trees (pers. comm. Leonel). Another farmer was even hired by his neighbours to demonstrate the establishment of living fences (pers. comm. Nelson).

In this informal way, the knowledge from experiments by one farmer can slowly be dispersed over the whole community, each farmer picking out the elements that are useful to him and starting his own experiments.

7.4 Information supply from outside the community

Obviously, innovations also have external sources. Several farmers in the research areas asked for advice about living fences and dispersed trees during the interviews. They will not hesitate to incorporate a certain practice into their farming system, when this practice seems both beneficial for and compatible with their farming system. For instance, Nelson incorporated the use of Poro as dispersed tree in his farming system, because he recognized the advantages of the practice. The practice was introduced to him by an on-farm experiment of CATIE[1].

Information is also provided by veterinaries, cooperations (like Montesillos), salesmen (for cattle, herbicides, etc.), milk processing plants (Borden) and banks (when applying for credit). The exchange of information happens in informal meetings. An example of such a meeting is the Expo-Pococi (a big fair for cattle owners) in Guapiles (Hermsen, 1989), which a considerable number of farmers from the research areas visited. In these meetings, the farmers select information that they perceive to be usefull.

Several farmers mentioned that they would like some information about the use of living fences and dispersed trees from research and extension organisations. But most farmers agreed that the research and extension organisations did not frequent the area, nor did these organisations give extension about the use of dispersed trees and living fences.

[1] CATIE = Centro Agronomico Tropical de Investigacion y Ensenanza (Tropical Agricultural Research and Training Centre).

Extension by the extension service of MAG[2] is a scarce event. Carillo & Groot (1990) mentioned that it is estimated that only 10 % of the farmers of the Zone are reached. In Rio Jimenez, regularly extension agents pass by, but they focus on cash crops and livestock (Pers. comm. Victor). Cocori is hardly ever visited by extension agents, because it is remote and difficult to reach (Pers. comm. Leonel). In Neguev, extension is practiced by IDA[3], but again the focus is on cash crops and livestock (Pers. comm. Nelson). Mudde (1990) concluded that the extensionists of IDA believe that it is best for tenants to follow their recommendations; they do not think in terms of an exchange of agricultural knowledge, but rather about one way traffic to the farmers. Furthermore, contact between extension agencies is minimal (Carillo & Groot, 1990).

Research in Costa Rica is mainly done by MAG and CATIE. Research conducted by these organisations does not include extension for the farmers (Hermsen, 1989). Even when there is locally tested technology available, the transfer of this knowledge often is insufficient (Waaijenberg, 1986).

So the linkage between research and extension has been weak, leading to research results which could not always be applied by the farmers in the region, either because they were not economically worthwile, or because the necessary inputs were not available (Carillo & Groot, 1990).

7.5 The reality of the knowledge systems in the Atlantic Zone

In comparison to the ideal knowledge system described in the introduction (see figure 7.1), the following model seems to do more justice to reality (see figure 7.2). As can be deduced from figure 7.2, the links between the farmers (the clients) and the research and extension organisations are disturbed. The main cause of this disturbance is a lack of knowledge. Not on the side of the farmers, but on the side of the research and extension organisations. These organisations should realize that household members may interpret the factors, that influence the farmer's decision making process in a different way than outsiders perceive them. To help farmers developing farming systems that suit the local biophysical and human setting, outsiders must achieve some understanding of how decisions are reached by the households and the logic behind them. There seems to be a lack of this understanding among the agencies that frequent the area, resulting in a sceptic opinion of the farmers about the research and extension organisations.

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[2] MAG = Ministerio de Agricultura y Ganaderia (Ministry of Agriculture and Animal Husbandry).

[3] IDA = Instituto de Desarollo Agrario (Institute for agricultural development).

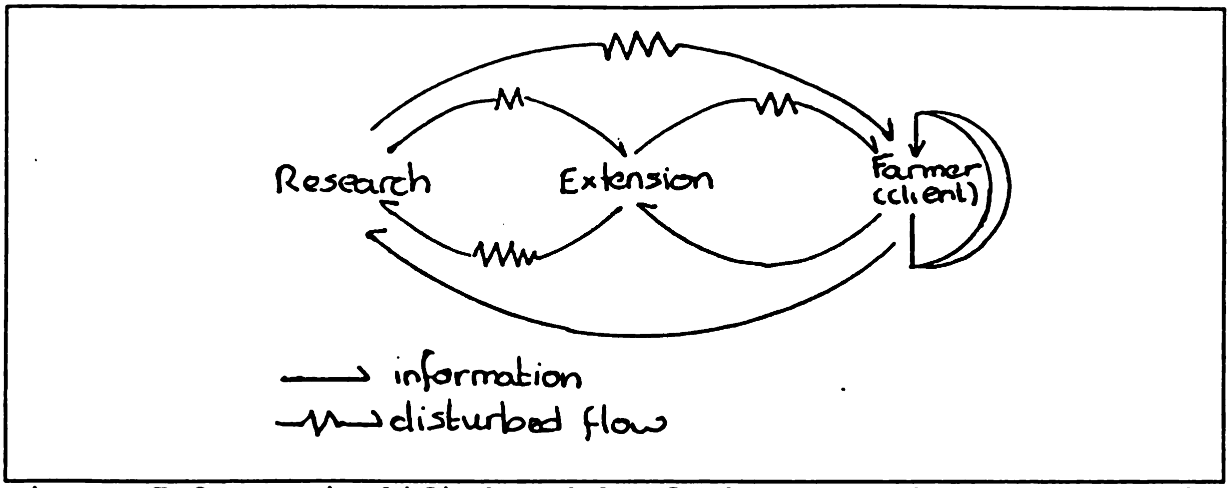

Figure 7.2: a simplified model of the KIS, that seems to be present in the research areas.

A larger part of the budget of these organisations should be dedicated to investigation of the KIS existing in the research areas, in order to improve the adaptation of the technology that the organisations offer to the farmers' knowledge systems. This can avoid that "extensionists offer a uniform technological package, not adapted to the wishes of individual (or groups of) tenants" (Mudde, 1990), which in fact are their clients.

8. CONCLUSIONS & RECOMMENDATIONS

8.1 Introduction

The conclusions of this research are discussed on basis of the objective and the research questions (stated in section 1.2). Section 8.2 discusses to what extent the methodology provided a structured manner to describe the sylvopastoral land use types. Section 8.3 discusses the role of the tree-element in the sylvopastoral system of a farm. Section 8.4 deals with the requirements for on farm tree production. Finally, section 8.5 gives recommendations the way in which possible improvements regarding sylvopastoral practices can be attained.

8.2 Application of the methodology

It is attempted in this report to give a description of the sylvopastoral land use that is present in the research areas. To describe this land use, literature about tools for land use planning was consulted. A combination of Land Evaluation and Agroforestry Diagnosis and Design (D&D) was chosen for a description of the sylvopastoral system, the land utilization types (LUTs) and the sylvopastoral practices. In theory, a combination of Land Evaluation and D&D already existed (see Young, 1986), but practical application of this theory could not be found in literature (Young (1987) even said that applying the Land Evaluation method to agroforestry was impossible to do).

In this report, it has been shown that the diagnostic phases of both methods can be combined to provide a basis for description of the sylvopastoral system, the LUTs and the sylvopastoral practices present in the research areas. These 3 elements for description of land use were perceived by the author as good possibilities for assessing the importance of trees for cattle farmers and comparison of sylvopastoral land use with other (agroforestry or non-agroforestry) land uses.

A problem occurs when the LUTs are described: literature about Land Evaluation does not provide a solid basis for description of the key attributes. The lack of consistency within the guidelines for Land Evaluation for the major kinds of land use (which are rainfed agriculture, irrigated agriculture, forestry and extensive grazing) about how to describe the key attributes for LUT description is a serious constraint for using the method. For instance, the manner in which labour and capital intensity should be assessed is not described in the Guidelines for Land Evaluation. In this report a list of key attributes was produced out of Land Evaluation for other major kinds of land use (mostly extensive grazing, but also rainfed agriculture and forestry), to overcome this problem, but it hinders comparison with other LUT descriptions from literature. Unless the same list of key attributes is used for other LUT descriptions of land uses that occur in the Atlantic Zone of Costa Rica, not even comparison of different LUTs in the Zone is possible.

When using tools like D&D and Land Evaluation for land use planning, it should be born in mind, that decisions made will affect a lot of people. These people should be made aware of what the intentions are of the organizations, that are involved in the land use planning. Therefore, extension should be an important part of land use planning, as it can be applied to allow the local people to participate in the planning process.

8.3 The role of the tree-element in the sylvopastoral system

Farmers in the research areas do not consider the ecological interactions between components of the sylvopastoral system as very important. In their eyes, the pastures are always green and the livestock has access to abundant food, due to the climatic conditions (high precipitation and temperatures) in the research areas; there is no visual degradation of the pastures and the cattle produces, with or without influence of trees. So from the farmers point of view, continuity of the farming system is certain. Dispersed trees in the pasture give shade to the animals, but the farmers consider this as convenient; trees are generally not left in the pasture for that reason.

When trees are not hindering the main production purpose of the system, breeding of cattle, trees are perceived by the farmers to have the following benefits:

- Timber trees, that stand dispersed in the pasture provide valuable construction material, that can be used on the farm or can be sold, and therefore represents commercial value.
- Fruit trees are kept on the farm for home consumption, hereby representing a diversification in the menu of the farmers.
- Living fences are established, because they are perceived by the farmers to represent a substantial financial gain compared to fences of wooden posts, although they need more management than wooden posts on a year basis. But contrary to wooden posts, live fence poles do not have to be replaced after some years.

In summary, even though sylvopastoral practices are popular among the farmers for reasons of security and productivity, the fact remains that the farmers' identity is that of cattle holders. Animal husbandry is the main purpose of their farm: breeding cattle, fattening cattle, production of milk. Production by woody perennials is just a by-product of the farming practices, although they can represent substantial value.

8.4 Requirements for on-farm tree production

Requirements for on-farm tree production, that were mentioned by the farmers were time, labour, planting stock, information and the possibility to enjoy produce. One can discern four important factors in this statement: labour, capital, technology and law. Labour is needed especially for establishment and maintenance of living fences. For the factor capital, the same can be said: living fences represent the only real capital consuming agroforestry practice. Technology is required to manage the trees, not only for produce, but also for managing the interactions of the trees with other components of the system. The factor law is an important pressure on the farming system from external sources: farmers need to follow the rules on exploitation of trees, set by the government.

These requirements have to a great extent not been met in the research areas. Labour are scarce. Capital is invested in the animal husbandry system (it is a big step for the farmers to accept loans at the high interest rate in the country). Technology has been imported mostly from other areas in the country and is still adapted by the farmers to their current farming conditions.

Furthermore, research and extension organizations do not provide extension on the use of trees in the farming system. Their focus is on promotion of capital and labour intensive farming practices based on cash crops and diary production.

The farmers are not too positive about the influence of research and extension organisations in the research areas. Most of the farmers in the research areas originate from areas outside the Atlantic Zone. Most farmers have had no education or a the most a few years of primary education. Agricultural and husbandry practices have been learned from relatives and picked up from farmers in the neighbourhood. Therefore, their knowledge on and experience with trees in the conditions as present in their current farming context is still limited. The use of trees in their farming system is often still in an experimental stage.

Research by services, that frequent the research areas, usually focuses on Poró and, to a lesser extent, Madero negro, because it is believed that these species can benefit the farmers through fodder provision. Furthermore, these species are researched upon in the arrangement of living fences, as a source of food for the cattle. Already, a lot of literature exists about the use of foliage from Poró and Madero negro in living fences as fodder for cattle (e.g. Benavides, 1985; Smits, 1988; Beer, 1987a).

Not much information is available in literature about dispersed trees in the pastures of the research areas. The base line study (Zambon, 1989) provides a description of the dispersed trees, occurring on farm lands in the areas. Hulsebosch (1992) made another inventory. Most publications about dispersed trees in Costa Rica deal with Poró and Laurel, in Coffee-Poró-Laurel cultures (e.g. Fassbender, 1987; Beer, 1987b), some research is done on the influence of Guayava on cattle (e.g. Somarriba, 1987), but none of these with relation to the research areas. Most of these studies do not involve research and field experiments. Implications of the importance of shade for the production of cattle is another subject, that has scarcely been investigated in the research areas.

8.5 Recommendations

Before coming to specific recommendations about the use of trees in the sylvopastoral system, it is useful to point out again, that the farmers in the research areas are mainly involved with animal husbandry. This should be born in mind, when it is assessed if improvements in the sylvopastoral system are possible and desirable.

Improvement of the sylvopastoral system depends on a better knowledge of the farming systems' possibilities (interactions between the components, objectives and possibilities of the farmer). It furthermore depends on a better infrastructure in which sylvopastoral practices could provide a welcome addition to the income by animal husbandry practices. Possibilities have to be created for sale of fruit and timber; the administrative path behind cutting permissions has to be relaxed; and incentives for reforestation should be better extended. These subjects need further research.

Research on sylvopastoral systems by the research institutes and organizations that are present in the research areas, has to be made more fit to practical circumstances and conditions in the research areas. Extension could provide a good means for involving the farmers in the research, and thereby assuring that if improvements in the sylvopastoral systems can be made, the implementation of these improvements can be adopted by the farmers. Therefore, research and extension organisation should pursue more participation by the farmers, especially in the initial stages of research and extension to increase the interest of the farmers and the adoptability of proposed changes. The organizations should provide appropriate technology, that connects with the knowledge and possibilities of the farmers. Extension research focused on the knowledge and information systems that are present in the research areas is recommendable.

In the following recommendations, the focus is on the sylvopastoral practices, as occurring in the research areas.

Living fences:

For the farmers, living fences represent a cheaper way for providing a boundary to their pasture plots, compared to fences of solely wooden posts. Next to focusing on Poró and Madero negro as fodder producing species in the fences, which might become important in the future, research and extension should be directed more to living fence species that do not require much labour in maintenance and/or provide in commercial products (like Jocote (*Spondias purpurea*), of which fruits can be sold).

Several farmers are starting to plant tree species in their fences, that do not have boundary demarcation as purpose, but other things, like timber production. About this practice, information is lacking. A financial analysis could be conducted to determine if these fences may provide income to the farmers (without too much extra labour input), compared to living fences without these species. Also, ecological impact of these fences on the other components of the system (crops, pasture, animals) should be assessed.

Dispersed trees:

If the administrative process, coinciding with the application for a cutting permit, can be speeded up, and the laws concerning cutting of trees can be differentiated for natural forest, plantations and dispersed trees, commercial production of dispersed timber trees can be further stimulated. This would make commercial tree growing on farm land more attractive, and therefore could help to alleviate the pressure on natural forest (through cutting by e.g. banana companies), without too much influence on the farming practices, that are most occurring in the research areas. The constraints regarding commercial exploitation of dispersed timber species, should be investigated, as selling tree produce could provide farmers with a welcome addition to their farm income. An economic study should be carried out, that gives insight in the viability of commercial production and exploitation of dispersed trees in pastures.

Fruit trees, especially coconuts, are becoming more important as a source of income: several farmers have mentioned that they intend to plant fruit trees. However, hitherto, the fruits are not gathered from fruit trees in the pasture, but only from plantations, or from fruit trees standing in the farmyard. Maybe a different agroforestry practice, like animal husbandry in plantations can be applied here. This subject needs further research.

Protein banks:

Further investigation should be carried out regarding protein banks. When this practice is applied in a labour extensive way, which probably can be done by allowing the cattle to browse in the protein bank for a certain amount of time with a certain interval, the production of cattle can be increased.

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APPENDIX I: Interview

The interview was conducted among 27 farmers; 9 in each research area. The interview consisted of a structured list of questions, which were more or less open ended: the farmer was given opportunity to answer. The information given by the farmer was written down on the questionnaire; if the answers did not provide enough information, the farmers were encouraged to go on by giving examples (like: "What about ...."; or "Several farmers have mentioned .... Do these occur on your farm?).

Introduction (originally in Spanish):

It is possible that questions will be asked, that have already been asked by other researchers. These questions are part of my interview, because I want get a general impression about the farming systems involving dispersed trees and living fences. I have some information, which other persons have collected before my research started. <state the information>. Is this information correct, or has anything changed?

Cattle herd.

What is the composition of your cattle herd?
- cattle species; Brahman, Criollo, Indio brasil, etc.
- age and quantity of bulls, young bulls/cows, cows, calves and oxen, if present.
- principal use and other uses or services rendered by cattle (milk, meat, double purpose).
- importance of the herd for the farm (is it the most important resource for survival for the family).

Which types of feedstuff do you give your cattle?
- only grass
- crop residues
- leaves of trees
-

Which products and how many kilos of them do the cattle provide, and which price can be received for them?
- meat
- milk
- breeding
-

How many time is needed in hours per day to manage the cattle?
- Activity and time (hours/day): feeding, milking, change of site, ...

****

Pasture

What type of pasture is present on your farm?
- Pasto natural
- Ratana
- Pasto mejorado;
- a mixture of grass and leguminoses
- other

How are they managed?
- sowing
- burning
- fertilizing
- other

How much time (hours/hectare) is necessary for these practices and which tools are used?

****

Dispersed trees

Which types of dispersed trees are present in the pastures and in what quantity?
- types
- quantity/type
- age/type

Why do you have dispersed trees in your pasture?
- Principal use; timber, shade, fruits, other..
- Origin: planted, original forest, secondary regrowth...
- Preference for species

Do you manage your small and big trees in some way? With what intention?

What doe you want to do in the future with your dispersed trees?
- cut all trees
- nothing
- plant more timber trees
- plant more fruit trees
- plant more shade trees
- other

****

Living fences

Which types of living fence species do you have in your living fences and in what quantity?
- types; quantity/type; age/type
- occurrence of wooden posts
- occurrence of mixed fence; different species and/or wooden posts

How are the living fences managed?
- primary use; only fence, forage, shade
- different management of different types
- preference for species

****

<u>Interactions</u>

Do the cattle prefer being close to the dispersed trees or do they prefer being outside the area of influence of trees?

How is the growth of the pasture close to the dispersed trees compared to pasture outside the influence of the trees?
- better
- the same
- worse

Do the cattle prefer being close to the living fences to graze or do they prefer pasture outside the influence of the fences?

How is the growth of the pasture close to the living fences compared to the pasture outside the influence of the fences?
- better
- the same
- worse

Do the cattle eat the fruits of the fruit trees?
- many
- little
- none

Do you apply a certain practice to avoid or stimulate this?

What do you do with the leaves and branches of the living fences? Do you throw them outside the pasture or inside; or does it depend on the situation?

Do the cattle like to eat the leaves and branches of the living fences?
- much
- little
- none

Do you apply a certain practice to avoid or stimulate this?

Do the cattle damage the dispersed trees or the living fences in the pasture? Do you apply a certain practice to avoid or stimulate this?

Appendix II: information about Río Jiménez.

General for region:

* Geographical situation
  - location in country (latitude): between 9°30'-10°30' NB and 83°00'-84°00 OL.
  - height above sea level (altitude): between 10 and 40 m a.s.l.
  - surface area: 11300 ha (Waayenberg, 1990a).
* Climate and vegetation zone
  - source of information (location meteorological institute): Meteorological station of the Compañia Bananera del Atlantico (COBAL), localized in the western part of the district (10°15'NB, 83°40' OL) and at 55 a.s.l.
  - annual mean temperature and daily variations (degree Celsius): little variation in temperature between months: mean average temperature is 24.4 °C, but mean daily variations can reach up to 10.7 °C.
  - rainfall: quantity (in mm.) and distribution over the year: Mean annual precipitation is 3934 mm, with 266 rainy days per year. February and March are "dry" months, November and December are "wet" months.
  - occurrence of winds: velocity (m/s) and distribution over the year: generally very low, monthly average vary between 2.7 and 3.6 km/h
  - Agro-ecological zone, according to Holdridge: almost all of Río Jiménez is part of 'premontane very humid forest, transition to basal', with small areas in the 'tropical humid forest, transition to perhumid' (southwest), and 'very humid tropical forest' (extreme northeast)(Waayenberg, 1990).
* Soils: For a detailed soil survey of the Río Jiménez area, see Dam (1987).
* Topography
  - relief (descriptive): plane, with presence of small mounds of 1 - 6 meters high.
  - angles of slopes (percentages): very small (Wielemaker, 1990a).
* Population density
  - density (persons per square kilometer): 800 farms with 4102 occupants (5.1 per farm), over an area of 11300 ha = 0.36 persons/ha.
  - distribution over the region (in hectares): mostly living in small population centres, but also scattered over the area (Waayenberg, 1990).
* Agricultural structure
  - average farm size in region (in hectares): 11300 ha/800 farms = 14.1 ha/farm. Koster (in draft) mentions 27.7 ha/ farm.
  - subdivision of classes of farmers (criteria and subdivision): Waayenberg (1990) subdivides on farm area: classes <4 ha, 4 - 20 ha, 20-50 ha, 50-200 ha.
  - land use in region (in percentages): e.g. pasture lands, arable lands, forests, plantations and permanent crops: based on a study by Waayenberg (1990) on 46 farms of Río Jiménez in 1987: annuals 21%, perennials 9%, pasture 53%, shrubland 4%, forest 9%, others 3%.
  - Marketing (purchase of inputs and destination and price of outputs): research by Marketing group of the Atlantic Zone Program, lead by John Belt.

* Río Jiménez: the research area.

- general information: The western half of Río Jiménez district, 20 km ENE of Guapiles, is 55 km^2 in area and harbours about 200 farm households. The sub-area has a relatively long settlement history (Anonimous, 1987). The agricultural history of the area is estimated on ca. 60 years. The eastern part of the Río Jiménez area (Santa Rosa and surroundings) is younger, ca. 25 years. The town Río Jiménez is located next to the railroad, from which the reclamation has started (Hermsen, 1989): railway remnants witness that large parts were once used for plantation agriculture (banana, abaca) (Anonimous, 1987). Especially in the past, large (banana)plantations were present in the area, and even in recent years, they still represent a major form of land use and source of labour. From old, this area is a centrum of the cultivation of maize in the Atlantic zone. The area is known for its strong orientation on the market (Hermsen, 1989). Nowadays, the land is used by small and medium scale farmers for milk and beef production and maize, rice, cassava, cocoa and fruittree growing. Increasing scarcity of land and changes in marketing possibilities force farmers towards intensification and specialization (Anonimous, 1987). The infrastructure of the area is adequate. The eastern part of Río Jiménez is bordered by a progressing agricultural frontier, showing strong resemblance with the Cocorí area (Hermsen, 1989).

The area of Río Jiménez partly overlaps Neguev (Koster, in draft). This research area is a district with administrative borders. It is more diverse than the other areas. The eastern part is less developed and has poor access. Small dusty roads and large distances between the houses and villages are normal. In the western part, a good road connection between Río Jiménez and Guacimo is available. This part is better developed. This difference in development has resulted out of the colonization period. The colonization process accelerated with the railway construction that reached Río Jiménez village in 1913. In that time the railway was the most important way of transport for people and freight. Some mud roads were made from Río Jiménez to Santa Maria, Ligia and Cartagena. At that time the banana (*Musa spp.*) was the most important crop and all activities were focused on that. During World War II the banana plantations disappeared because of a root disease (Panama disease), nut in 1967 a resistant species was introduced. In the same year that the banana plantations were established for the second time, an asphalt road was constructed between Río Jiménez and Guacimo. Along that road, large (multinational) companies established their banana and ornamental plantations which attracted a lot of people to settle and work. At the moment, new banana plantations are being established in the eastern part of Río Jiménez. It can be expected, that more people will move into the area to find work but also the already settled people can find better labour opportunities (Hulsebosch, 1992). Today, the railway does not work any more and the only access is by road. There is a daily bus service to all parts of Río Jiménez.
- forestry information: The most occurring component in this research area is the living fence. Here, mostly Poro (*Erythrina spp.*) is used. The size of the farm is larger coinciding with a higher amount of fences (Zambon, 1989). The total area of natural forest in Río Jiménez is very small. It was estimated in 1987 by Sluys et al. (1987) at 8 % of the total area. The remaining patches occur mainly on large farms and along the rivers. Zambon (1987) mentioned that the average size of forest in Río Jiménez is 2 ha. in comparison with Cocorí, 54.3 ha. The forest in Río Jiménez is strongly exploited and the basal area of timber species is smallest of the research areas. The dispersed trees were mostly fruit trees in this area. The timber species were mainly young trees while in Cocorí the old trees dominated (Zambon, 1987). The dispersed trees were occuring on all farms but in this area in small numbers. There are only a few plantations in this area. They are of a small scale and most of Laurel (Cordia alliodora). The fruittrees have the same important role as in the Neguev. Home consumption of the wide variety of fruits is common. Sometimes the fruits are sold (Hulsebosch, 1992).

Appendix III: information about Neguev.

<u>General for region:</u>

* Geographical situation
  - location in country (latitude): The settlement Neguev is localized between the coordinates 5.80 - 5.90 NB and 2.40 - 2.50 OL, at the same cartographical hight as Bomilla and Guacimo, in the districts of Germania and Cairo of the canton of Siquirres and of Pocora and Río Jiménez of the 'kanton' Guacimo, in the province of Limon (Oñoro, 1990).
  - height above sea level (altitude): approximately 50 m (Oñoro, 1990).
* Climate and vegetation zone
  - source of information (location meteorological institute): Estaccion Meteorologica El Carmen (from the years 1977 - 1985) at 593.6 E, 242.9 N and at an elevation of 14 m.a.s.l (Beks & van Olst, 1986).
  - annual mean temperature and daily variations (degree Celcius): the temperature does not vary much during the year and has an anual average of 24.7 degrees (Beks & van Olst, 1986), with a minimum monthly temperature of 23.5 degree and a maximum of 25.9 degree.
  - rainfall: quantity (in mm.) and distribution over the year: 3,666 mm, divided rather equally over the year. Normally the precipitation is higher than the evapotranspiration (2,500 mm annually), but in the dry months (March and April), the evapotranspiration can be 120 mm higher (Oñoro, 1990).
  - humidity: the average annual humidity is 88.0 % (Beks & van Olst, 1986)
  - occurence of winds: velocity (m/s) and distribution over the year: ???
  - Agro-ecological zone, according to Holdridge: ???
* Soils: the area is formed by old, strongly weathered lahars, originating from the vulcan Turrialba. For detailed information see Beks & van Olst (1986), Lansu (1988) and Koster, (draft).
* Topography
  - relief (descriptive) and angles of slopes (percentages): On top of depositions of the Quarternary, a strongly disected landscape was formed, with slopes of app. 30% and elevations of about 10 m. hight. The valleys associated with the elevations are swampy, because they are under influence of the principal rivers (Oñoro, 1990).
* Population density
  - density (persons per square kilometer): the information reveals that there are an average of 5.3 persons living on a finca. Furthermore, there are 311 fincas in the Nequev: meaning 311 * 5.3 = ca. 1650 persons. The area of Neguev covers 5,340 ha, which means that the population density should be about 5,340/1650 = ca. 3.2 pers/ha (Oñoro, 1990).
  - distribution over the region (in hectares): probably the population is rather evenly distributed over the region, but there are 5 population centres present, that hold a higher amount of people (Oñoro, 1990).
  - structure of the area (descriptive): Nequev is devided into five sectors: La Lucha, Milano, Bella Vista, El Silencio and El Peje, and covers an area of 5.340 ha with 311 plots (Oñoro, 1990).
* Agricultural structure
  - average farm size in region (in hectares): the average farm size in the region is 10 - 17 ha., of which the sizes 10, 15 and 17 ha. are dominant.
  - subdivision of classes of farmers (criteria and subdivision): no subdivision in farm area.
  - land use in region (in percentages): e.g. pasture lands (app. 70%), arable lands, plantations and permanent crops: forests cover about 5% of the area (Lansu, 1988).
  - Marketing (purchase of inputs and destination and price of outputs): more detailed information by Hulzebosch (1992) and marketing research by John Belt (draft).
  - Available services: Each sector holds a communal centre, which includes a school, a multipurpose hall, a sporting facility, one or two pulperias and a small population centre. In the centre of Milano, the headoffice of IDA is situated, which is the official body responsible for the mastering of the settlement. Next to the office, there are a shop, a dining facility, a sleeping facility, nurseries of cacao and pejibaye and a medicinal garden. Only Milano has electricity and only the IDA has running water (Brooymans ;in Oñoro, 1990).

* Political context: see Brooymans (in Oñoro, (1990)).

* Neguev: the research area.

- general information: The IDA settlement scheme Neguev, 25 km ESE of Guapiles, is also about 55 km^2 in area. Neguev was once a large extensive cattle estate (Anonimous, 1987). Some years ago, this area has been invaded by 'precaristas' and the IDA has taken the part of intermediate between the occupying farmers and the owner (Hermsen, 1989) and the area was subdivided into 310 farms for settlers of various origins (Anonimous, 1987). Still, IDA is issuing out pieces of land (10, 15 or 17 ha) to farmers, that can work the land. These are all small farmers, that in this way are given opportunity to start their own farm. A lot of people display other activities next to their farm work and not seldom, they live off-farm (Hermsen, 1989). Intensification processes in Neguev, amongst others from pasture to annual crops are guided by IDA (Anonimous, 1987). A large part of the area is still under forest cover, or has been clearcut in recent years. A smaller part of the area was already covered with pasture, when it was invaded (the pastures of the cattle estate); these are often the better and more central areas (Hermsen, 1989). The history of the Neguev is special because this settlement started with an (illegal) land occupation of small farmers organized in the UPAGRA in september 1979. The area belonged to the Agricola Ganadera Industril Neguev S.A., a daughter company of Inmobilliaria Agromercantil Caribe S.A. In this occupation conflict, the government institution IDA intermediated between the two parties. The landscape of Neguev is different from the other research areas. Small hills with an altitude of about 30 m are very frequent. In the valleys, small swamps are sometimes present and rivers occur. Most trees are situated along rivers and only few are on hills. The production systems are almost uniform, due to the fact that all farmers are more or less in the same situation. The farmers have the same size of parcel, the same types of soil and are equally far away from off-farm work opportunities and markets for selling and buying products. Exceptional is the northern part of the research area. There the soil has a better quality and the access to the market is easier due to a paved road near the settlement and daily bus service. Only a few people have lived in the Neguev since the land occupation in 1979. The first who came had to clear the secondary forest to grow crops. Most farmers had only basic hand tootls to do it, for instance axes. The people who bought a parcel had often more equipment, like a chain saw (Hulzebosch, 1992). The predominant type of land use is pasture. Only in the northern part, pastures are seldom. There, the soil quality is better and agricultural crops are cultivated in a wide variety (Oñoro, 1990).

- forestry information: The natural forest has almost disappeared in the Neguev. In 1987, the percentage was estimated by Sluys et al. (1987) on 15 %. A few patches of forest can be found north of Bella Vista and El Peje. In Neguev, big plantations occur in comparison with the other research areas. The average plantation area was 4.4 ha (Sluys et al., 1987). One of the most important tree components is the living fence. 70 % of the farms had living fences. In this component, the tree species Madero negro (Gliricidia sepium) and Poro (Erythrina spp.) are most used (Zambon, 1989).

Appendix IV: information about Cocorí.

General for region:

* Geographical situation
  - location in country (latitude): between 10°00' - 11°00' NB and 83°00' - 84°00' WL
  - height above sea level (altitude): between 250 m a.s.l. maximally and 16 m a.s.l. minimally.
  - surface area: 12.000 ha (Wielemaker, 1990)
* Climate and vegetation zone
  - source of information (location meteorological institute): Meteorological station of Guapiles (40 km to the south) and Meteorological station of Tortuguero (20 km to the west).
  - annual mean temperature and daily variations (degree Celsius): 26 °C, depending on cloudiness.
  - rainfall: quantity (in mm.) and distribution over the year: annual mean precipitation is 5000 mm.
  - occurrence of winds: velocity (m/s) and distribution over the year: between October and February, the winds of the north and northwest are intercepted, resulting in precipitations of between 300 and 700 mm monthly. After a transition period, in May the eastern and southeastern winds start to blow, but the turbulence of the Caribbean also brings along rain towards the Atlantic zone (Wielemaker, 1990).
  - Agro-ecological zone, according to Holdridge: unknown, probably the same as for the Atlantic Zone.
* Soils: see Koster (in draft).
* Topography
  - relief (descriptive): ranging from lowland to volcanic hills of 250 m in height.
  - angles of slopes (percentages): strongest slopes of 90% (Wielemaker, 1990).
* Population density
  - density (persons per square kilometre): no exact data available, but estimated about 300 families (Brooijmans & Sluys, 1990). Investigations by Waayenberg (1990b) on 50 farms in Cocorí show a density of 5.1 persons per farm, meaning 300 * 5.1 = about 1500 people on a surface of 12000 ha, is app. 0,13 person/ha.
  - distribution over the region (in hectares): formerly dispersed, nowadays living along the roads (Brooijmans & Sluys, 1990).
* Agricultural structure
  - average farm size in region (in hectares): 12.000/300 = 40 ha. But according to Koster (in draft), it is 124.5 ha.
  - subdivision of classes of farmers (criteria and subdivision): Farmsize has been considered by Waayenberg (1990b), with as components farms of <20, 20-50 ha, 50-200 ha and ≥200 ha.
  - land use in region (in percentages): e.g. pasture lands, arable lands, forests, plantations and permanent crops: From the study of Waayenberg (1990b) about 50 farms in Cocorí, could be concluded: annuals 3%, perennials 1%, pasture 36%, shrubland 8%, forest 52% and others <1%.
  - Marketing (purchase of inputs and destination and price of outputs): study done by the marketing group of the Atlantic Zone Program, lead by John Belt.

* Cocorí.

- general information: The Lomas of Cocorí and surroundings, 50 km north of Guapiles, covers about 120 km^2 and harbours 150 households (Anonimous, 1987). This is the youngest area of the three. About 14 years ago, the first pioneers entered this area and ever since many have followed. At the same time, and caused by it, a rapid deforestation is occurring (Hermsen, 1989). The land is deforested by precaristas, bought by urban landlords and subsequently used as grazing land for beef cattle (Anonimous, 1987). Pasture is an important form of land use. Next to that, several crops are cultivated, mainly for own consumption. The infrastructure is inadequate, but is being improved (Hermsen, 1989). Cocorí consists of different landscapes. The relief varies between a mountainous part in the centre of the area, with an altitude of 250 m, and large lowland areas with or without swamps and lakes with an altitude of 15 m above sea level. The main land use is forest. Pastures are an important, but mostly extensive land use. The cultivation of annual crops is mainly for subsistence and it is practised by almost every farmer on a small scale. The most important activity of the farmers is cattle herding. The land use in Cocorí is generally extensive. The colonization in this area has begun some 30 years ago and was very spontaneous. The migration out of the area

is very strong in the last years. Some people leave without selling the farm, maybe in the hope to return some time, others leave permanently. Reason for the migration is the lack of facilities in Cocorí, like electricity and running water (Brooijmans; in Hulsebosch, 1992). The construction of a new road a few years ago, allowed better access to Cocorí, but this road is still in bad condition. A daily bus service reaches Caño Zapote (a village in the north of Cocorí) from Cariari, if the weather allows the busses to drive. About 70 % of the area is a "refugio de animales silvestres", meaning that it has a special status by law and deforestation is restricted. But because a lack of governmental control, the difference between protected and un-protected areas can only be observed on paper (Hulsebosch, 1992). The land tenure is in most cases only based on presence and use of the soil by the occupier. About half of the people have got a land title (Wielemaker, 1990).
- forestry information: The natural forest is present in almost all parts. The total percentage is estimated in 1987 by Sluys et al. (1987) on 49 % of the total research area. On 98 % of all farms, natural forest existed. 12 % of the farms in the sample of Sluys et al. (1987) had plantations, while 0.1 % of the total area was plantation. The number of dispersed trees in the pastures varies strongly. Some pastures were observed to be totally cleared. Next to the trees, a lot of felled stems can be found in the pastures (Hulsebosch, 1992). The component of living fences is almost absent on farms in Cocorí. Dead poles play a dominant role in avoiding trespass of cattle. In this area, only 14 % of the farm had living fences (Sluys et al., 1987). Zambon (1989) mentioned that in this area still the resources (useful trees) are available for dead poles. The role of the fruit trees is the same like in the other research areas. All farmhouses are surrounded by trees, mostly fruit trees (Hulsebosch, 1992).

APPENDIX V: Relevant key attributes explained

From § 4.3.1, the key attributes have been mentioned, that give opportunity to give a detailed land use type description. These key attributes are:
- produce;
- labour;
- capital;
- land (natural resources);
- technology;
- technical knowledge and attitudes;
- management.

These features can be connected into a delicate network, forming a Sylvopastoral System. These key attributes will be discussed into detail here, and where necessary, the other 'minor' key attributes will be discussed within these topics.

<u>Produce</u>

Produce is the most diversified and important key attribute. It determines to a great extent the essence of the other key attributes and of the ecological land requirements. In Chapter X, the possible produce of Sylvopastoral Systems has been outlined. The description of produce should be as precise as possible (Beek, 1978).

<u>Labour</u>

Land may differ in response to labour inputs. Besides labour intensity, other aspects such as labour productivity, labour absorption and labour substitution are important variables in land use planning (Beek, 1978). However, of the mentioned labour-related issues, labour intensity is the key attribute that is most discussed in the FAO-Guidelines.

Labour intensity is the total amount of human labour inputs provided to the LUT, per unit of land, including family and hired labour. It can be described qualitatively as low, intermediate or high labour intensity, but for management specifications these intensities should be based on estimates of man-months of labour provided per unit area (FAO, 1991).

For the specific sylvopastoral LUT, the simplest system is one with hardly any tree in and around the pasture, resembling ranching activity. The most intensive sylvopastoral practice will consume a lot of labour, and may resemble a non-mechanized cropping practice. Therefore, the low border will be set at the border given in the FAO Guidelines for Extensive Grazing (1991), and the high border will be set at the border given by the FAO Guidelines for Rainfed Agriculture (1984). It should be noted that these are just examples:

1) Low: labour input as is normally found in ranching in developing countries. Less than 0.1 man-months/ha/y (FAO, 1991);
2) medium: labour input between low and high;
3) high: labour input such as normally found in non-mechanized farms in less developed countries. More than 2.5 man-months/ha/y (FAO, 1983).

For a quantitative description, labour inputs should be specified in man-days for each produce (FAO, 1983).

Labour inputs into what may be classed as a 'low input level' of extensive grazing include herding, construction and maintenance of corals, fences, feeding, particular care for young and pregnant animals, milking, etc. (FAO, 1991). The presence of trees in and around the field is a additional burden, that should not only be considered as labour consuming, but also as hard work. On the other hand, labour inputs qualified as 'high input level' may occur built in in other practices and therefore in effect not consuming extra time. Thus the high, medium and low boundaries of labour intensity, even when expressed in specific numbers, remain indicative. Labour intesity can be calculated by taking the daily input in hours of farm labour; converting this to a yearly input in hours; adding the yearly input in hours of hired labour; converting to an inputin man-month/y/farm (dividing by 720 (hours in a month)); and finally dividing by the pasture area.

<u>Capital</u>

Technically, it may be possible to condition virtually any site to satisfy a particular requirement of a LUT. However, the extent to which land conditions and reproduction material can be altered depends on economic considerations: the cost of modifying them in relation to the value of the desired produce, and the availability of private and public capital (FAO, 1984).

Capital intensity refers to the levels of capital investment and recurrent costs on the farm (FAO, 1991). It determines the range of possibilities for applying technology for management improvement and conservation of the domain of reproduction. A distinction is usually made between non-recurrent capital and recurrent capital, the former one-time-only investments, the latter required for the year to year manipulation of the reproduction factors (FAO, 1984). For qualitative description, levels of capital intensity can be classified as high, medium or low. The following are broad examples of classes of capital intensity LUTs:

1) high: are normal in commercial ranching, where fences, machinery, motor transport, roads, water storage tanks and stores are provided (FAO, 1991).
2) medium: between low and high capital intensity LUTs.
3) low: are normal on traditional subsistence orientated small farms in the tropics (FAO, 1983); hardly any external inputs representing financial burden.

There are significant regional variations in the meanings of 'high' and 'low' when applied to capital investments and so, wherever possible, quantitative terms should be used for the description of this attribute (FAO, 1991). For quantitative description the following information should be given, figures should be given as ranges:

- value of capital investment, per hectare, per plot and for the production unit;
- recurrent costs per hectare for each crop/livestock component of the LUT (adapted from FAO, 1983).

Apart from their livestock, which represent a very substantial asset, ranching LUTs require considerably large investments, including fencing the outer boundaries and the paddock subdivision within them. When forage crops are introduced into a grazing system, the related investments are comparable with those made into cropping LUTs (FAO, 1991).

Land

For the purpose of Land Evaluation, land consists of all the features of the natural environment that have an influence on its potential for land use in the area under study (FAO, 1991). These features are expressed in the construction of the Land Mapping Unit. However, land (or the way in which it is used) also represents certain restrictions upon the LUT. Important land related factors that influence the LUT are: 1) Size and shape of holdings, and 2) Land tenure.

1) The basic information required is the range of size of farms within the land utilization type. The meaning attacked to terms such as 'large farms' varies so much with the physical environment and economic context, that no classes are suggested (FAO, 1983). The likely range of sizes is usually the best that can be given (FAO, 1991). Details of farm lay-out or fragmentation should be given where relevant (FAO, 1983).
2) Land tenure is the legal or customary manner in which ownership or rights to use of land is held. There is a wide range of circumstances, ranging from owner-occupied freehold at one extreme to community or state ownership with temporary rights to cultivate at the other (FAO, 1983, 1991).

As trees are normally a part of the farm, that is longer lasting, also tree tenure has to be included in this key attribute. Tree tenure can be seen as the legal or customary manner in which ownership or rights to use of trees is held. Trees are not automatically part of the land on which they stand; different legal or customary manners may be applicable to trees and the land they are on.

Technical knowledge and attitudes

The FAO-Guidelines for Rainfed Agriculture and Extensive Grazing describe this key attribute as: "Levels of general education, including literacy, levels of agricultural education, and likely receptiveness to innovation and change, these usually being introduced through extension services" (FAO, 1983; 1991). However, this does not state anything about the knowledge of the farmer about the sylvopastoral system he is using, nor about his attitudes towards the importance of the specific combination of components for his produce.

Technology

According to FAO (1984), technology refers to the complex of technical practices employed in the management of a land utilization type. This does not correspond with the definition given in § 3.1, in which technology was defined as the whole of knowledge and the on basis of this knowledge developed processes, instruments and machines, that are produced by science and supply an ability to control (Koningsveld, 1987). The latter definition will be used in this report.

Technology is a key attribute complementing the production factors capital and labour. For the purpose of land evaluation it is preferable to point out feasible land management and improvement practices, or at least a range of key techniques and corresponding inputs, because of their great influence on the land suitability classification (Beek, 1978). Technology, as a major key attribute, includes several minor key attributes: 1) Power, 2) Mechanization, 3) Infrastructural requirements, 4) Material inputs, 5) Cultivation practices. The last minor attribute will be only assessed for the agroforestry practices.

1) **Power:** The basic distinctions are between human labour, animal power, and tractors or other fuel-driven-machinery. For qualitative description, the following classes may be used:

a) largely or entirely human labour, with little or no animal power;
b) animal power in conjunction with human labour, but little or no fuel-driven machinery
c) mostly power from fuel driven machinery.

For quantitative description the amount of power used can be stated (e.g. in joules/ha) (FAO, 1983).

2) **Mechanization:** This aspect is closely linked to power sources. The fundamental distinction is the extent of mechanization of mechanization on the farm; implements and tools may also be described. Qualitative description is sufficient; the following classes of farming may be recognized:

a) mechanized; farming operations carried out largely using power driven machines
b) partly mechanized: limited use of machinery, possibly including intermediate technology and motor transport.
c) non-mechanized farming: no use of power-driven machinery.l

These descriptions should be amplified by listing main items used (FAO, 1983).

3) **Infrastructural requirements:** This heading is peripheral to the description of the LUT as such, but should be included since it plays an important part in development planning. Aspects covered include the needs of the LUT for ready access to processing factories, distribution centre, of improved seed or clonal material and specialist advisory services (FAO, 1983).

4) **Material inputs:** The level of materials in a grazing operation is usually in direct relationships to the levels of capital investment and recurrent costs, as more capital will allow the purchase of more materials (FAO, 1991). Material inputs refer to seeds, drugs, lickstones, fertilizers, pesticides, etc. They may be described in generalized terms; as levels of input, or specified into detail. For generalized purposes, three levels of inputs are recognized:

a) Low: no significant use of purchased inputs such as artificial fertilizers, etc. Traditional farming in developing countries (FAO, 1983).

b) intermediate: material inputs by more affluent and commercially oriented pastoralists, often on the advice of extension and veterinary services, but who have limited technical knowledge and capital resources. Including drugs, mineral supplements, desinfectants, some fertilizers, possibly some use of chemical weed or pest control, etc. (FAO, 1983; 1991).

c) High: methods based on advanced technology and high capital resources, and applicable to ranching; includes forage and grass seed, fertilizer, browse trees, concentrates, silage and hay (FAO, 1991).

The following should be specified whenever possible: varieties, feedstuff, fertilizers, protection inputs.

APPENDIX VI: Check-list for sylvopastoral system description

From the D&D User's Manual (Raintree, 1987b) and the AFRENA worksheets for land use system description (Scherr, 1987), the following list of descriptors is included, that, together with the key attributes, mentioned in Appendix IV, provide in a detailed description of the agroforestry system, in this case the sylvopastoral system. The list is composed of different levels of detail: 1) general information about the region; 2) general information about the sylvopastoral systems occurring in the Atlantic Zone; 3) general information about the farm; 4) information about the sylvopastoral system on the farm.

<u>General for region</u>:

* Geographical situation
  - location in country (latitude)
  - height above sea level (altitude)
* Climate and vegetation zone
  - source of information (location meteorological institute)
  - annual mean temperature and daily variations (degree Celsius)
  - rainfall: quantity (in mm.) and distribution over the year
  - occurrence of winds: velocity (m/s) and distribution over the year
  - Agro-ecological zone, according to Holdridge.
* Soils
  - soiltype
  - drainage
  - mother material
* Topography
  - relief (descriptive)
  - angles of slopes (percentages)
* Population density
  - density (persons per square kilometre)
  - distribution over the region (in hectares)
* Agricultural structure
  - average farm size in region (in hectares)
  - subdivision of classes of farmers (criteria and subdivision)
  - land use in region (in percentages): e.g. pasture lands, arable lands, forests, plantations and permanent crops.
  - Marketing (purchase of inputs and destination and price of outputs)

<u>General for farm</u>

* Farm area
  - farm size (hectares)
  - shape of area (drawing: triangular, quadrangular, etc.)
  - subdivision
* Number of people directly dependent on farm
  - number of people in and structure of family
  - other people depending on farm
* Forms of cultivation
  - occurring land use systems (short descriptions)
  - use of available resources: water, forest etc.
* Treatments of the crops/livestock
  - what crops/livestock in different LUS-es (scientific name and local name)
  - short description of the uses of each element
  - treatments of the crops/livestock and attached costs (labour, time and financial burden)
  - benefits of specific treatments (increased production, control of erosion, ornamental value: descriptive or, if possible, in kg and Colones
* Results
  - yield of cash crops (kg. and Colones)
  - production of livestock (kg and Colones)
  - yield of commercial tree products (kg. and Colones)

- on-farm use of crop- and livestock (kg and Colones (shadow prices))

Sylvopastoral system in the research areas:

* Type of sylvopastoral system on specific farm
  - which of the above mentioned occurring systems is present on the specific farm
  - what are the differences of the sylvopastoral system on this farm, compared to the general occurring system.
  - what may be the reasons for these differences
* Tree/shrub species and use (extrapolated from above gathered information)
* inputs and outputs of trees/shrubs
  - inputs:
    type of practices (e.g. reproduction, pruning, pollarding, etc., but also soil improvements and planting, etc.)
    labour involved (time and costs: in hours and Colones)
    fertilizer inputs (types and costs: descriptive and colones)
    tools and machinery (types, use, costs; descriptive and in Colones)
    combat of diseases: type of disease, time involved and costs (descriptive, in hours, in Colones)
  - outputs:
    products (kg. and Colones)
    services (descriptive, if possible shadow prices in Colones)
* livestock species and use
* inputs and outputs of livestock species
  _ inputs:
    type of management (e.g. reproduction, feeding practices, etc.)
    labour involved (time and costs: in hours and Colones)
    type and costs of fodder (kg. and Colones (shadow prices if possible))
    combat of diseases: type of disease, time involved and costs (in hours and Colones)
  - outputs:
    products (kg. or litres and Colones)
    services (descriptive, if possible shadow prices in Colones)
* pastures/fodder species and use
* inputs and outputs of pasture/fodder species
  - inputs:
    type of practices (e.g. reproduction, burning, etc., but also soil improvements, planting, etc.)
    labour involved (time and costs; in hours and Colones)
    fertilizer types and costs (kg. and Colones)
    use and costs of tools and machinery (types and Colones)
    combat of diseases: type of diseases, time involved and costs (in hours and Colones)
  - outputs:
    products (kg. and Colones)
    services (descriptive, if possible with shadow prices in Colones)
* relations between tree/shrub, livestock and fodder
  - descriptive model of interactions (drawing of sylvopastoral system, with elements and interactions)
  - description of complementary, supplementary and competition effects
    complementary: to what extent do the plants fill different niches of the area
    supplementary: what are the beneficial relationships between trees/shrubs, livestock and fodder species in the system
    competitive: what are the constraints of the relations between the elements in the system

- advantages
  - increase in production (kg. and Colones) of each element on account of relationships
  - beneficial on-farm use of each of the elements (descriptive, if possible in Colones (shadow prices) on account of the relations

* perceived constraints of production system
  - labour; time and costs (hours and Colones): special for the production system sylvopastoral
  - unequal distribution of possibly increased burden of the system on different members of the farming system (descriptive)
  - dependence on external (not produced on the farm) inputs (descriptive and in percentages of all inputs)

Appendix VII: list of species names.

In this list the most important tree species for the farmers are presented. The common name, the systematic name and the main use are mentioned. The source is Zambon (1989).

Aceituno	Simarouba amara	Timber
Aguacate	Persea americana	Fruit
Almendro	Dipteryx panamensis	Timber
Anonillo	Guaterea	Timber
	Rolinea microcephala	Timber
Balsa	Ochroma lagopus	Timber
Botarama	Vochysia ferriginea	Timber
Caimito	Chrysophyllum caimito	Fruit
Canfin	Tetragastris panamensis	Timber
Campano	Socoglottis trichogyna	Timber
Caobilla	Guarrrrea spp.	Timber
Carambola	Averrhoa carambola	Fruit
Carao	Cassia grandis	Fruit
Castanea	Artocarpus heterophyllus	Fruit
Cedro amargo	Cedrela odorata	Timber
	Cedrela mexicana	Timber
Cedro macho	Carapa guianensis	Timber
Cedro maría	Calophyllum brasilensis	Timber
Cedro real	Cedrela fissilis	Timber
Ceibo	Ceiba pentandra	Timber
Chilimate	Ficus spp.	Timber
Cocotero	Cocos nucifera	Fruit
Cola de pavo	Hymenolobium pulcherrimum	Timber
Cristobal	Platymiscium ninnatum	Timber
Eucalipto	Eucalyptus deglupta	Timber
Fruta de pan	Artocarpus altilis	Fruit
Fruta dorada	Virola koschnyi	Fruit, Timber
Gallinazo	Jacaranda copaia	Timber
Garroche	?	Timber
Gavilan	Pentaclethra macroloba	Timber
Guácimo blanco	Geothalsia mianthra	Timber
Guácimo colorado	Lonchocarpus sericeus	Timber
Guaitil	Gonipa americana	Timber
Guanábana	Anona muricata	Fruit
Guanacaste	Enterolobium cyclocarpum	Timber
Guaromo	Cecropia obtusifolia	Timber
Guavo	Inga spp.	Firewood
Guayaba	Psidium guayava	Fruit
Guayabón	Terminalia chirricensis	Timber
Higuerón	Polyscias guifoylei	Timber
Hombre grande	Quassia amara	Medicins, timber
Hule	Castilloa elastica	Timber
Indio desnudo	Bursea simaruba	Fence, medicins, firewood
Javillo	Hura crepitans	Fence, firewood
Jícaro	Lecythis ampla	Fence, firewood
Jobó	Spondias mombin	Fence, firewood
Jocote	Spondias purpurea	Fence, firewood
Laurel	Cordia alliodora	Timber
Limón acido	Citrus aurantifolia	Fruit, medicins
Limón dulce	Citrus limetta	Fruit, medicins

Llama del bosque	Spathodea campanulata	Firewood
Madero negro	Gliricidia sepium	Fence
Mamey	Mammea americana	Fruit
Mamon	?	Fruit
Mamon chino	?	Fruit
Mandarina	Citrus reticulata	Fruit
Mango	Mangifera indica	Fruit
Manú negro	Minquartia guianensis	Timber
Manú platano	Vitex cooperi	Timber
Manzana de agua	Eugenia malaccensis	Fruit
Manzana rosa	Eugenia jambos	Fruit
Marañon	Anacardium occidentale	Fruit
Nance	Byrsonima crassifolia	Fruit
Naranja agria	Citrus aurantium	Fruit
Naranja dulce	Citrus sinensis	Fruit
Níspero	Manilkara achras	Fruit, timber
Ocora	Billia colombiana	Timber
Ojoche	Brosium spp.	Timber
Palma de aceite	Elaeis guineensis	Fruit, timber
Pejibaye	Bactris gasipides	Fruits
Pilon	Hieronyma longipetula	Timber
Pocora	Guarea spp.	Timber
Pochote	Bombacopsis quinatum	Fence, timber
Poró	Erythrina berteroana	Fence
Quizarrá	Nectandra spp.	Timber
Roble coral	Terminalia amaznia	Timber
Roble sabana	Tabeuia rosea	Timber
Ron ron	Astronium graveolens	Timber
Sangrillo	Pterocarpus oficinales	Firewood
	Pterocarpus hayensis	Firewood
Saragundi	Cassia reticulata	Medicines, firewood
Sotacaballo	Pithecolobium longifolium	Firewood
Surá	Terminalia chirricensis	Timber
Teca	Tectona grandis	Timber
Toronja	Citrus spp.	Fruit
Yuplón	Spondias dulcis	Fruit
Zapotillo	Pouteria spp.	Fruit

APPENDIX VIII: Selection of farmers

In the methodology for the research (§ 1.4), it was mentioned that the farmers have been selected on basis of a hypothesis about the use of dispersed trees in the pasture. It was also mentioned, that it appeared to be impossible to check the hypothesis as the information gathered by Hulzebosch (1992), on which the selection was based, appeared to be inacurate. In the following text, the process of farmer selection is explained.

Hypothesis

Dispersed trees in the pastures can be there either for economical gain, or because they do not represent an economical value (and are left in the pasture, because they do not influence the pasture negatively and it is not feasible to cut them), or for a positive influence on the other components of the system: pastures and livestock.

The way that the system is managed in the field has important repercussions on the occurence of the trees, both in space as in time. If the system is focussed on economical gain, one can expect that the trees are actively managed. For instance, some form of fertilization may occur; the trees can be pruned for correction of form or branching; etc. If the system is focussed on the beneficial influences of the tree-component on the other components, one can also expect an active management of the trees to optimalize this beneficial effect. For instance pruning to achieve the best shading form of canopy, spatial arrangement of the trees, etc. It is obvious that the trees left in the pasture will not be managed actively.

However, this does not tell us anything about the sustainable aspect of this specific way of using land. It is the aspect of replanting or the encouragement of natural regeneration of trees, that decides if the system remains as it is, or if it changes into a pasture without trees. Sustainability in this context should be perceived as: the persistance of a specific land use will persist and not change into an entirely different way of using land. The replanting/encouragement of natural regeneration is the part of the management system of the LUT silvopastoral system, that incorporates a long term view into the system. This brings us to the main questions about dispersed trees as a LUT in this research:

Is the component "dispersed trees" in the pastures actively sustained or not? If they are not; what are the reasons for this? If they are, what is the perceived utility of these trees, regarding the future and can it be called an agroforestry system?

The trees that are established or left in the pasture, with as prime motive economical gain, are mostly timber trees, that do not have to much negative influence on the other components: it is feasible to keep them in the pasture. Other species used for economical gain are fruit-bearing tree species, whose fruit is either sold on markets or used for home consumption.

The second group consists of trees that are left standing in the pasture, because it is not worth wile to cut them: they do not represent any economical value. These trees will eventually dissappear out of the system, because they are not actively managed.

The third group of trees consists of trees that are actively managed, because they are considered to have a benificial effect on the other components of the system: this effect can either be shading, N-fixation, additional food source, soil conservation, etc. In this case, the trees can have some economic value, if they are timber species. The yield will probably not be high, because a lot of these trees have the habit of forming large and extensive horizontal branches, when managed in a wide spacing. Also they can be fruit-bearing trees, that may represent some economic value, for yield of fruits. But in both cases, the prime objective to manage them in the field is their benificial effect on the other components.

In this report, the assumption is made, that this last group of trees will become more and more important in the research areas in the future. The cattle herding system is gaining importance in the Atlantic zone of Costa Rica. The system as it is will probably evolve to two separate systems: the economic element will evolve to a system of plantation forestry, because the lack of wood is becoming more and more pressing. The other element, the benificial effect of trees on the other components of the system will evolve to a carefully managed system in which the interactions between the components are realized and cherrished, by an active sustaining of the tree-component and an optimalization of the beneficial effects. One of the most important effects of these beneficial trees in the silvopastoral system will probably be the shading effect. It is therefore my opinion that as the system evolves, the composition of the system will change in favour of the amount of trees for shade, when a starting point of the current situation is taken. This brings us to the following hypothesis:

As the ratio of cows/tree increases, the importance of the shade trees in the system increases as well, in relation with the trees for other purposes.

Based on this hypothesis, the farmers interviewed by Hulsebosch (1992) have been divided into 5 groups of farmers, consisting of two farmers with a ratio of cows/tree in the same order of magnitude. These different groups are:

1) The two farmers that have the most positive deviation from the average ratio;
2) The two farmers that are closest to the average ratio (one above, one beneath);
3) the two farmers that have a ratio closest to zero;
4) the two farmers that have a ratio of zero, with the highest tree-density;
5) the two farmers that have a ratio of zero, with the lowest tree-density;

For the three research areas, this division has resulted into 31 farmers; 10 for Rio Jimenez, 10 for Cocori and 10 for Neguev.

Rio Jimenez:

1) farmer n 185 99 and n 170 12
2) farmer n 169 83 and n 169 59
3) farmer b 2 and b 3 154
4) farmer n 167 14 and n 169 71
5) farmer n 185 46 and n 185 94 95

Cocori:

1) farmer cz 4 and cd 94
2) farmer cc 35 and cs 57
3) farmer cd 125 and cd 126
4) farmer cs 49 and cl 90
5) farmer cd 106 and cd 134: 4) & 5) are not much different.

Neguev:

1) farmer 146 and 297
2) farmer 128 and 268
3) farmer 20 and 199
4) farmer 61 and 82
5) farmer 1 and 165

<u>Reality</u>

The chosen farmers were checked with other investigators, that were conducting research in the area. For instance, another forestry student was investigating the motivations of the farmers to start plantations in the research areas. Marketing students were doing research in the chosen areas as well. To avoid molesting the farmers, the choice of farmers for this research had to be adapted. This resulted in 9 farmers for every area, but the division was not completely equal over the groups: groups 4 and 5 only had 4 farmers in their investigation. Somehow, especially farmers from these groups prooved interesting for the other researches, and therefore, it was thought better to exclude them from this research. However, it was hard to find substitutes. Eventually, the following farmers were chosen.

Rio Jimenez:

1) farmer n 185 99 and n 170 12
2) farmer n 169 83 and n 169 59
3) farmer n 159 116 and b 3 154
4) farmer n 185 94 95
5) farmer n 169 71
x) farmer n 185 91

Cocori:

1) farmer cz 4 and cd 94
2) farmer cc 35 and cs 57
3) farmer cd 126
4) farmer cs 49 and cl 90

5) farmer cd 106 and cd 134: 4) & 5) are not much different.

Neguev:

1) farmer 146 and 297
2) farmer 159 and 262
3) farmer 20, farmer 124 and farmer 251
4) farmer 33
5) farmer 1: 4) & 5) are not much different.

One can see, that the selection that was eventually interviewed, was entirely different from the intended group of farmers that were to be interviewed, as stated above. Because the farmers of group 4 and 5 often did not differ much in cow/tree ratio, it was decided to analyse them as one group.

The division in groups and the selection was based on information, that was gathered in a previous study of the farms done by Hulsebosch (1992). From the data of this research, the amount of cattle and the amount of trees were used to calculate the cow/tree ratio. When checking these numbers in the general interview, this information was not found to be acurate.

A strawl through the field with the farmer has in almost all cases revealed a lot more species than noted in the research done by Hulsebosch (1992). When interviewed, farmers predominantly mentioned valuable timber species as dispersed trees. Only after requestioning, they also mentioned the fruittrees that were standing in the pasture. These almost always differed from the amounts that were noted by Hulsebosch (1992). And after the small excursion on the farm, again, a lot more species could be detected. The problematic part is, that the farmers never knew the exact amount of species, that were not already mentioned in the interview.

Another hamper was, that the composition and amount of cattle is fluctuating very rapidly in the research areas. The best indicator of this is, that of the farmers belonging to the last group (the ones without cattle) on basis of the interviews of Hulsebosch (1992), 4 out of 8 appeared to have cattle in the general interview held for the research presented here. Which means that only based on this criterium, almost half of one group of farmers were already belonging to another group, at the time of the interview.

To illustrate how this affects the original group division, the table below will show the change of cow/tree ratio. This is based on information out of the survey by Hulsebosch (1992) and the one held for this report.

Table 1: Comparison of the cow/tree ratio of the interview by Hulsebosch (1992) and the one done for this report.

farmer	formar ratio	new ratio	new group
Group 1.			
CO cs 4	180/ 6 = 30,00	164/ 16 = 10,25	1
CO cd 94	150/ 6 = 5,00	69/ 12 = 5,75	2
JI 17012	200/ 90 = 10,15	111/ 90 = 1,23	2
JI 185599	43/ 15 = 2,78	22/ 15 = 1,47	2
NE 146	15/ 2 = 7,50	40/ 3 = 13,33	1
NE 297	37/ 10 = 3,70	4/ 10 = 0,40	2
Group 2.			
CO cc 35	30/ 6 = 5,00	8/ 6 = 1,33	2
CO cd 57	60/ 10 = 6,00	46/ 19 = 2,42	2
JI 16959	41/ 52 = 0,98	13/ 108 = 0,12	3
JI 16983	7/ 5 = 1,40	16/ 111 = 0,14	3
NE 262	25/ 35 = 0,71	24/ 35 = 0,69	2
NE 159	17/ 56 = 0,30	17/ 56 = 0,30	2
Group 3.			
CO cd 126	2/ 23 = 0,13	40/ 286 = 0,14	3
JI 16916	80/ 541 = 0,15	260/ 541 = 0,48	2
JI B3145	24/ 899 = 0,03	22/ 899 = 0,03	3
NE 20	4/ 280 = 0,01	0/ 280 = 0	5
NE 124	32/ 710 = 0,05	23/ 710 = 0,03	3
NE 251	5/ 140 = 0,04	5/ 148 = 0,03	3
Group 4.			
CO cs 49	0/ 14 = 0,00	0/ 350 = 0	5
CO cl 90	0/ 7 = 0,00	0/ 130 = 0	5
JI 18594/95	0/ 115 = 0,00	7/ 115 = 0,06	3
NE 33	0/ 30 = 0,00	0/ 39 = 0	4
Group 5.			
CO cd 106	0/ 6 = 0,00	3/ 36 = 0,08	3
CO cd 134	0/ 5 = 0,00	7/ 11 = 0,64	3
JI 16971	0/ 15 = 0,00	25/ 220 = 0,11	3
NE 1	0/ 13 = 0,00	0/ 25 = 0	5
JI 18591	25/ 0 = -	24/ 95 = 0,25	3

Whenever there were more species noted than there were trees noted by Hulsebosch (1992), the amount of species is used. When there were less species, the figure given by Hulsebosch is used. A lot of the figures of the amount of trees in the list "new ratio" are minima: often there were more tree species mentioned by the farmer, but the amount of these was mostly unknown. The averages of each area, with which the ratio were compared, are still based on information from the survey of Hulsebosch (1992). This average cow/tree ratio is 1,04 for Rio Jimenez (JI), 0,62 for Neguev (NE) and 5,39 for Cocori (CO).

Regarding on this change of composition of all groups, it would be unwise to draw conclusions about a possible difference in tree-management system among the different groups, selected out of the survey of Hulsebosch (1992). What can be concluded is that the amount of cattle of the farmers in the three regions is highly fluctuating over time. Furthermore, the farmers usually have a lot more trees in their pastures, than they tell the researchers.