ATLANTIC ZONE PROGRAMME

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LAND USE IN RIO JIMENEZ LINKED TO SOIL TYPES WITH THE ENCUESTA GENERAL AND AERIAL PHOTOGRAPHS

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Figure 1. Location of the study area.

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.

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	Forestal II	Forestal 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.

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1. INTRODUCTION

The work presented in this report was carried out within the context of the Atlantic Zone Program, a multidisciplinary research program that started in Costa Rica in September 1986. The program is a collaboration of the Tropical Agronomic Research Education Center (CATIE), the Costa Rican Ministry of Agriculture and livestock (MAG) and the Agricultural University of Wageningen (AUW). Following an exploratory survey, baseline studies were carried out in selected areas to identify important problems that beset agricultural development of the region so as to enable the selection of relevant development orientated research subjects.

In 1991 the program was prolonged. Objective is to develop a methodology for defining alternative scenarios for sustainable land use. The main tools will be a combination of modelling, experimentation and multiple goal planning resulting in computer generated maps depicting alternative scenarios for sustainable land use in Río Jiménez and Neguev areas.

A subsidiary scientific objective will be the elaboration of methods to define and quantify sustainable land use at different system levels. In the study three hierarchical levels of analysis are distinguished:

- the land use system,
- the farm system and
- the regional system.

At the level of the regional system, the question is what determines current land use and how should land be used to meet **sustainability and socio-economic feasibility.**

As part of the foregoing the question is posed to determine to what extend the spatial distribution of the crops is influenced by soils and farm size. In the present study this is done for the subarea of Río Jiménez (figure 1).

Two basic documents existed that could be used: one is the 'encuesta general' a survey held in 1987. And, for a smaller area, another in the form of a soil map and aerial photographs.

Chapter 2 discribes Río Jiménez and its land use. In chapter 3 the distribution of the crops on the different soil types is determined by combining and regrouping the data in the 'encuesta'.

In chapter 4 land use is assessed with aerial photographs. This is a smaller area for which a soil map exists (scale 1;20.000. DAM, 1987): the area between Cartagena and Río Jiménez. Farms are identified on the aerial photographs with maps of the individual parcels supplied by the cadastre.

The land use map derived from the aerial photographs is combined with the soil map in chapter 4.3. Land use west of Río Jiménez is described in chapter 4.4.

In chapter 5 the results of the aerial photo interpretatios are compared with the conclusions from the encuesta (chapter 3).

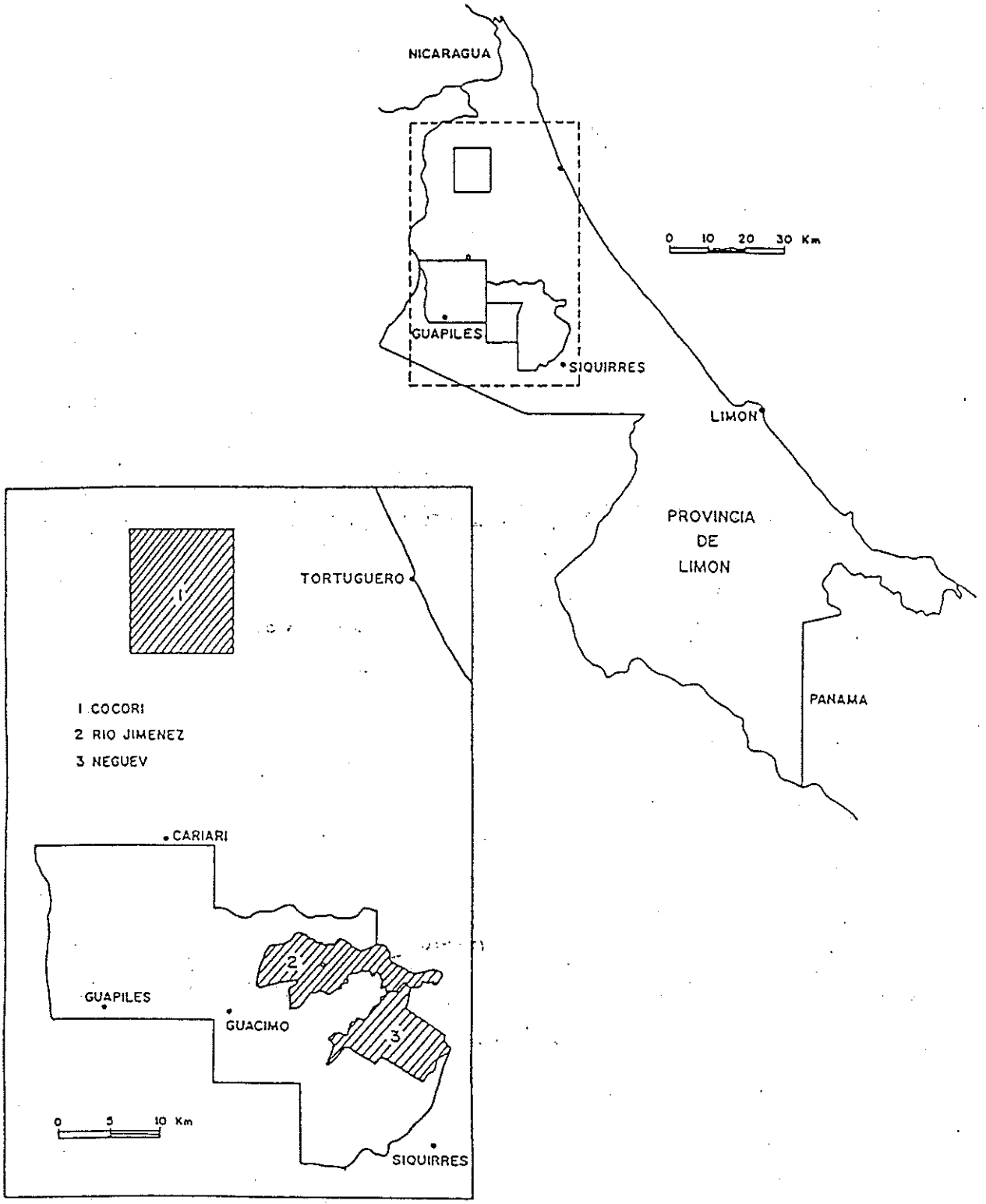


Figure 1. Location of the study area Río Jiménez.

2. THE SURVEY AREA: RIO JIMENEZ

2.1 Introduction

The district of Río Jiménez is located in the Atlantic Zone of Costa Rica. It is one of the three areas of study in the Atlantic Zone Program. The other areas are Cocorí and the Neguev. These are all found in the northern part of the Atlantic Zone (figure 1).

Río Jiménez is the area with the longest colonization history of the three. Banana estates began to dominate the area at the end of the last century. The panama disease initiated the withdrawal of the banana companies in the Atlantic Zone in the 30's.

The United Fruit Company started growing cocoa in the atlantic zone. It didn't turn out to be lucrative. In 1953 the United Fruit Company abandoned its estates and left the cocoa in the hands of the people. At that time, people colonizing the area started growing maize and cassava.

Land use in the last two decades is characterized by the cultivation of maize, cassava and cocoa by small and intermediate farms. Most farms have a few cows for the production of milk. Other agricultural activities are the nurseries for ornamentals and again the banana estates that came back in the 60's.

The extent of the area is approximately 1200 hectares. The altitude varies from 15 to 40 m above sea level. The climate is warm, humid, without a distinct dry period (HERRERA, 1985) Average temperature is 24.4 °C with a maximum of 30.9 °C and a minimum of 20.2 °C (WAAIJENBERG, 1990)

Precipitation varies from 113 mm in March to 555 mm in December with a total of about 4000 mm per year. The climate is not only characterized by a high precipitation but also a high incidence

of rain days. Average is 23 rain days a month with a minimum of 19 in March and a maximum of 28 in July.

2.2 Land Use

In February 1987 the Atlantic Zone Program realized a survey (hereafter referred to as 'encuesta') interviewing 150 farmers in three areas, notably: Neguev, Río Jiménez and Cocorí. Objectives were to gain insight in the problems and opinions of the producers and to classify farms to enable selection for more detailed studies at a later stage. This resulted in the Working Document: 'Base de datos de una encuesta de caracterización de fincas realizada en el norte de la Zona Atlántica de Costa Rica.' (BRINK & WAAIJENBERG, 1987) The report contains subjects ranging from history of the three subareas to land use, soil type, types of credits, livestock etc.

Forty-six farmers in the Río Jiménez area were interviewed. The encuesta served for several reports as a source of information. In:'Een kijk op de encuesta general.' (KAMMAN, 1988) an attempt was made to categorize farms. In 'Río Jiménez ejemplo de la problematica agraria de la Zona Atlántica de Costa Rica.' (WAAIJENBERG, 1990), the encuesta is used to describe Río Jiménez in a historical perspective.

Another analysis of the data in the encuesta was done in 'Una caracterización de fincas en Neguev, Río Jiménez y Cocorí.' (SCHIPPER, 1989). In the following these results are used to illustrate land use in Río Jiménez.

Table 2.2.1. Distribution of land size in the three subareas of the Atlantic Zone Project expressed in percentages. (Schipper, 1989)

		Farm size (ha)					
Sub Areas	n	<4	4-20	20-50	50-200	>200	Total
Neguev	53	0	100	0	0	0	100%
Río Jiménez	46	22	37	28	13	0	100%
Cocorí	50	2	6	36	34	22	100%
Total	149	7	48	22	15	7	100%

Table 2.2.1 shows that Río Jiménez is the area were farm size is most evenly spread i.e. you will find a fair amount of small farms as well as large farms. Río Jiménez is also the area dedicating more land to annual crops (Schipper, 1989) compared to Neguev or Cocorí. A near 20% of the area is cultivated with perennials in all three areas.

Table 2.2.2. Percentage of farms (per farm size categorie) cultivating more or less than 20% of their acreage with annual crops in Río Jiménez. (Schipper, 1989)

Percentage of the farm under annual crops	Farm size (ha)						
		<4	4-20	20-50	50-200	>200	Total
	n=	9	17	13	7	0	46
less than 20%	9	0	12	23	57	-	20
more than 20%	37	100	88	77	43	-	80
Total	46	100%	100%	100%	100%	-	100%

A relative smaller part of the farm is dedicated to annual and perennial crops when farm size increases.

Likewise there is a positive relation between percentage under pasture and farm size.

Table 2.2.3. Percentage of farms (per farm size categorie) with more or less than 40% of their acreage under pasture in Río Jiménez. (Schipper, 1989)

Percentage of the farm under pasture	Farm size (ha)					
	<4	4-20	20-50	50-200	>200	total
n=	9	17	13	7	0	46
less than 40%	21	78	47	31	29	-	46
more than 40%	25	22	53	69	71	-	54
Total	46	100%	100%	100%	100%		100%

Of the 46 farms participating in the encuesta 13 didn't have any livestock. The livestock of the other 33 farms were difficult to characterize (WAAIJENBERG, 1990). Most small farms had some cows primarily for milk. 10 of the interviewed farms sell their milk. Milk is collected with trucks in refrigirated tanks. Non of the 46 farms in the encuesta raises livestock for meat production. Intermediate farms were more dedicated to commercial milk and meat production. The main problems with livestock for meat and milk mentioned are the lack of money and knowledge.

In the encuesta, farmers were asked which crops were of primary, secondary and tertiary importance. Only a few crops were of importance to a majority of the farmers. This in spite of the large number of crops mentioned (33). The majority of the farmers depended on a small number of crops. Four of the 46 farmers didn't cultivate anything at all, 15 had 1 crop, 14 had 2 crops and only 13 cultivated 3 or more crops. Maize was the most important crop in acreage, as well by number of farmers cultivating it. Little rotation was used. Maize was mostly alternated with cassava. Agriculture was of greater importance than cattle in terms of income. Investments and labor input were higher in agriculture than in livestock, although the area cultivated was smaller than the area under grassland. Cultivated crops did not only support animal or domestic consumption but

were also an important source of income. Nearly all farms sold part or all of their harvest (WAAIJENBERG, 1990). The Atlantic Zone of Costa Rica is not very suited for maize growing. There is not an outspoken dry period and therefor problems with harvest exist (BRINK, 1988). The humid climate favors the occurrence of pests and diseases. Reasons for growing maize as mentioned by the 30 producers in the encuesta were: Short growing cycle(8) , easy crop to cultivate(5), rentability(6) and secure market(6).

In 1986 a new agricultural policy was announced; 'The agriculture of change', meaning that the subsidies and technical extension, till that time oriented towards basic grains like rice and maize, would be lifted. This caused a lot of insecurity amongst farmers. Aerial photographs show however that in 1989, three years later, still large areas were cultivated with maize.

3 LAND USE RELATED TO SOILS AS DESCRIBED IN THE ENCUESTA GENERAL.

3.1 Introduction

The following data were used from the encuesta:
-a classification of the land use
-a classification of the soils by the interviewer as well as by the farmer
-a classification of the cultivated crops in order of importance according to the farmer

An attempt is made to asses the acreages of the different crops, pasture and forest on the different soils for the 46 farms in the encuesta. Columns containing information on cultivations and soils were linked and sorted; results are found in the tables and bargraphes in chapter 3.2. Some comments on the difficulties encountered with the encuesta are given in Appendix VI.

3.2 Land Use according to the Encuesta

The encuesta contains two classifications of the soils. One is done by the interviewers, the other by the farmers.

It is mentioned in the encuesta that the classification done by the farmer probably is the most reliable. This because the other classification, proposed by the interviewers, forces the farmer to classify in terms strange to him.

It is however interesting to see what differences occur when they are compared. The terms used by the farmer to describe the soils were classified as is given in table 3.2.1.

Table 3.2.1. Soil classification according to farmers' descriptions. (Brink & Waaijenberg, 1987)

Soil number	Characterization
1	'Tierra negra':black soil, soil without problems. Suited as well as arable landa and perrenials as for pasture. It's fertile, though after many years, fertilization is inevitable. Very low parts and sites adjacent to the rivers are badly drained and are inundated by times.
2	'Tierra colorada/rojiza/roja': red soil.It has a reddish color and is of low fertility. It is not suited for maize but can be used for cassava or pineapple. Most commonly used for pasture.
3	'Suampo':Swamps, can be black soil. Poorly drained, mostly of dark color. Is found in the lower parts and near the rivers. It is usually under natural vegetation or pasture but relative dry parts can be used in dry times for maize.
4	Occasionally inundated soil, usually black soil.
5	Fertile soil, color not specified.
6	Soil of low fertility, color not specified.
7	Other; don't know, for example soil under forest.

The classification used by the interviewers distinguishes six categories as in table 3.2.2.

Table 3.2.2. Classification according to the interviewers.

Soil number	Characterization
1	Good soil,without problems
2	Soil of low fertility
3	Soil full of stones
4	Soil on steep sites
5	Badly drained soil
6	Swampy soil

The classification derived from farmers descriptions is called classification 1. The classification used by the interviewers is called classification 2. Soil type 1 in classification 1 corresponds with 1 in classification 2, 2 with 2, 3 with 6, 4 with 5, 5 with 1 and 6 with 2. Number 7 can't be matched.

The two classifications are compared in table 3.2.3. Soil numbers and their relative area with the same characterization are put on the same line.

Table 3.2.3. Soils expressed in percentages of total farm area.

Classification 1		Classification 2	
1:'Tierra negra';black soils without problems + 5 :fertile soils,colournot specified	48.4%	1:good soil,without problems	60.7%
2:'Tierra colorada/roja;red soil of low fertility + 6 :soil of low fertility, colour not specified	39.6%	2:soil of low fertility	12.9%
3:'Suampo';Swamps, can be black soil	9.1%	6:swampy soil	19.6%
4:Occasionally inundated soil	0.5%	5:badly drained soil	6.3%
7:Other;don't know, for example soil under forest	2.1%		
		3:soil full of stones	--
		4:soil on steep sites	0.2%

Soils type 1 plus 2 form in both classifications more than 70% of the total area; though more soil of type 1 is distinguished in the second classification, even if we take soil 1 and soil 5 together in classification 1. Badly drained and swampy soils form some 25 % of the total in classification 2, while just merely 10% in classification 1.

The combined data from the encuesta give the following picture: Total acreage of the 46 farms was 1093.9 ha of which 21.8% was cultivated with maize; 26% of the area was improved[a] pasture.

[a] The term improved pasture refers to the practice of sowing grasses, not the inclusion of leguminous species or the construction of drainage systems. Grasses most commonly sown are Ratana (Ischaemum ciliare) and Estrella (Cynodon nlemfuensis). Grasses are sown to compete with weeds or for their nutritional value. (Harmsen, 1989)

Improved and not improved pasture together form a 61.5%. Just 3.4% was cultivated with not less than 5 other crops. Thus Río Jiménez could be typified as a maize area (KAMMAN, 1988)

The acreage of the different crops mentioned in the encuesta are expressed as percentages of the total, in tables 3.2.4.A and 3.2.4.B. The total in the table is not 100%. Although the totals add up to nearly 100%, it must be noted that:
-only crops that are mentioned more than one time in the encuesta are taken into consideration.
-the tables contradict in acreage on certain crops.
-compound area was not included in the tables.

Table 3.2.4. Acreage of different forms of land use expressed in percentages of total area.

A classification 1

	maize	cassava	forest	pasture			cacao	beans	rice	shrub	total
				not improved	improved	sum					
soil 1	13.4	0.6	1.3	9.2	9.8	19	0.4	0.8	0.2	0.5	36.2
soil 2	2.3		4.5	16.8	14	30.8		0.2		0.7	38.5
soil 3	2.8	0.1	2.7	1.9	0.2	2	0.1			1.3	9.1
soil 4	0.5										0.5
soil 5	1.6	0.2	1.9	7	1.3	8.3	0.2				12.2
soil 6	0.2	0.2		0.1	0.5	0.6			0.1		1.1
soil 7	1	0.1	0.1	0.2	0.6	0.8		0.1			2.1
	21.8	1.2	10.5	35.2	26.4	61.5	0.7	1.1	0.3	2.5	99.7

B classification 2

	maize	cassava	forest	pasture			cacao	beans	rice	shrub	total
				not improved	improved	sum					
soil 1	20.3	1.2	1.3	24.8	10.6	35.4	0.5	1.3	0.2	0.5	60.7
soil 2	0.6		3.1	5.4	3.1	8.6	0.2			0.5	12.9
soil 3											0
soil 4				0.2		0.2					0.2
soil 5	0.9			4.6	0.8	5.5					6.3
soil 6			6.1	0.1	11.8	11.9				1.6	19.6
	21.8	1.2	10.5	35.1	26.3	61.6	0.7	1.3	0.2	2.6	99.7

Maize is, as one would expect, cultivated in both classifications primarily on soil 1, black soil. This does also hold for the other crops. According to Purseglove (1987) cassava will produce

an economic crop on exhausted soils unsuitable for other production, provided that they are not waterlogged. Still, only 17% of the cassava is cultivated on soils of low fertility (class.1).

Classification 2 places more crops on the better soil 1. A clear contradiction is the classification of pasture. Both improved and not improved pastures are in the majority on the red soils (soil 2) according to classification 1. Classification 2 however considers the majority of the pastures to be on soil 1.

It is not surprising that 50% (cl.1) respectively 60% (cl.2) of the total area shrubs are found on the swampy soils. Maize, pasture and forest form together more than 90% of the total farm acreage but the ratio between the areas of these 3 forms of land use differ with farm size.

That a relative smaller area is dedicated to crops when farm size increases, as stated in paragraph 2.2, is illustrated when table 3.2.4.A is split up according to farm size (table 3.2.5.).

If maize, as most important crop, is taken for example we see that the relative acreage decreases with increasing farm size.

Table 3.2.5. Land use in 4 categories of farm sizes. Expressed in percentages of total farm area per categorie.

1-4 ha

	maize	cassava	beans	peanuts	rice	cacao	pasture not improved	pasture improved	forest	shrub	total
soil 1	54.9	1.2						4.9			61
soil 2	9.8										9.8
soil 3							7.3			10.7	18
soil 4											
soil 5	7.3		2	1.8							11.1
soil 6											
soil 7											
	72	1.2	2	1.8			7.3	4.9		10.7	99.9

4-20 ha

	maize	cassava	beans	peanuts	rice	cacao	pasture not improved	pasture improved	forest	shrub	total
soil 1	15.5	1	0.8		0.2	1.3		20.5			39.3
soil 2	4.7							7.1			11.8
soil 3								0.9	0.1	4	5
soil 4									0.9		0.9
soil 5	7.3	1			0.2	0.9	6.9	16	2		34.3
soil 6											
soil 7	5.3	0.3	0.6				0.6	0.9	0.7		8.4
	32.8	2.3	1.4		0.4	2.2	7.5	45.4	3.7	4	99.7

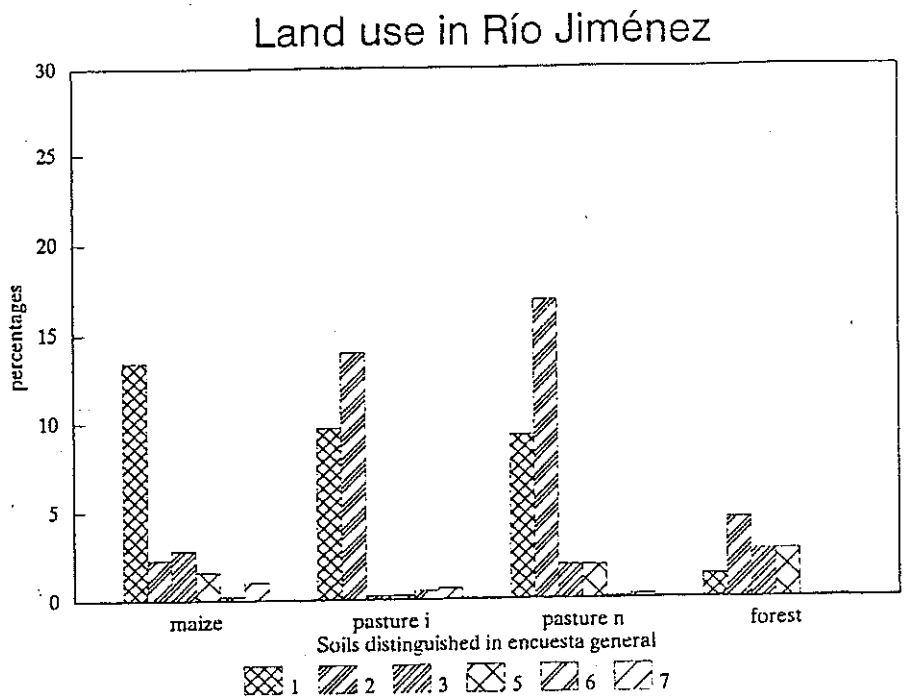
20-40 ha

	maize	cassava	beans	peanuts	rice	cacao	pasture not improved	pasture improved	forest	shrub	total
soil 1	11	1.1	0.4		0.4		8.3	8.1	3.8		33.1
soil 2	7.2		0.7				7.7	12			27.6
soil 3	5.2	0.3				0.3	0.9	5.2	3.1		15
soil 4											
soil 5	1.8							12.3	5.9		20
soil 6	0.7	0.7			0.2		0.6				2.2
soil 7							1.7				1.7
	25.9	2.1	1.1		0.6	0.3	19.2	37.6	12.8		99.6

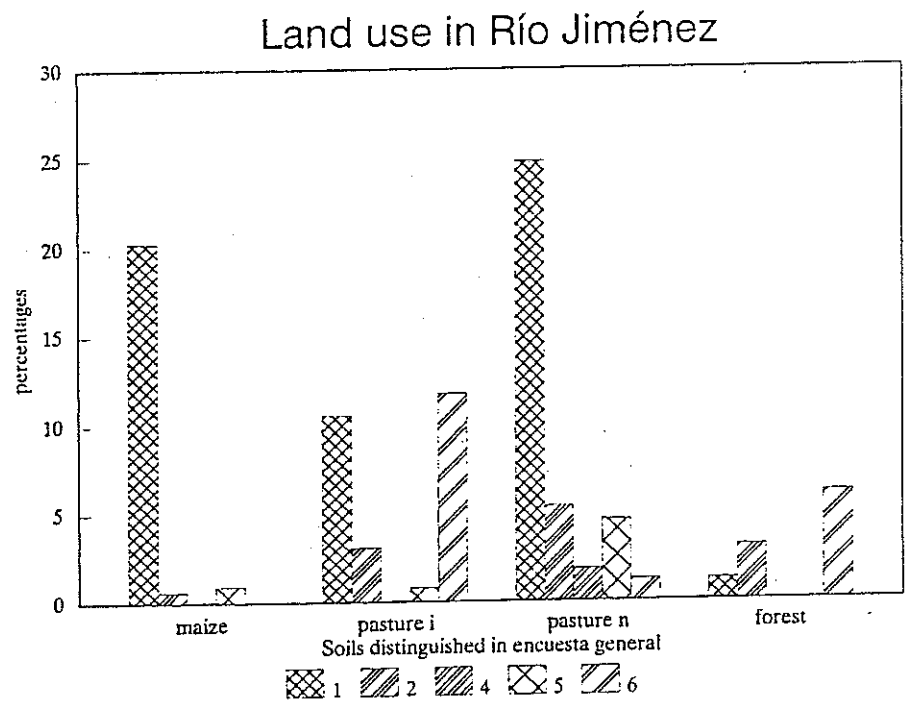
40-> ha in percentages

	maize	cassava	beans	peanuts	rice	cacao	pasture not improved	pasture improved	forest	shrub	total
soil 1	12		1.2			0.3	14.8	5.9	6.7	1	41.9
soil 2							24.4	24.7	4.6	2.5	56.3
soil 3								0.3			0.3
soil 4								0.3	0.8		1
soil 5									0.5		0.5
soil 6											
soil 7											
	12		1.2			0.3	39.2	31.2	12.6	3.5	100

CLASSIFICATION 1



CLASSIFICATION 2



pasture i: improved pasture

pasture n: not improved pasture

Figure 3.2.1. Most important forms of land use according to classification 1 and 2 expressed in percentages of the farm total area.

In figure 3.2.1 the percentages for maize, forest and pasture of table 3.2.4. are set out in bar graphs. In the bar graphs we see that:
-according to classification 1 maize is on the better soil 1, where pasture (and forest) are found mainly on soil 2,
-but that in classification 2 not only maize but also the greater part of pasture are on soil 1.

Conclusion must be that interviewers and farmers had different opinions on the soils considered, and that the two classifications can't be matched.

To see if acreage of maize is a parameter of the acreage good soil and the total farm size, a relation was applied:

$$\textit{acreage maize} = a + b1*(\textit{good soil}) + b2*(\textit{total farm size}) + b3*(\textit{good soil}*\textit{total farm size}) \quad (1)$$

With a=0.325, b1=0.116, b2=0.319 and b3=-0.006, 64% of the variation can be accounted for by a linear function at a 1% significance level. 'Total farm size' seems to explain more than 'good soil' (b2>b1).

Therefor: farms were split up to see if the equation fitted better for a part of the sample. The equation used above was applied for farms ≤25 ha and >25 ha. For the first part R^2 was 0.62. For farms larger than 25 ha, R^2 was 0.67. These R^2's don't differ much with the R^2 for the whole range. R^2 was also calculated for both ranges when leaving out resp. b3 and b1&b3. Thus calculating:

$$\textit{Total area of maize} = a + b1*(\textit{total area good soil}) + b2*(\textit{total farm area}) \quad (2)$$

and

$$\textit{Total area of maize} = a + b2*(\textit{total farm area}) \quad (3)$$

R^2 for farms ≤25 ha is resp. 0.59 (2) and 0.56 (3). For farms >25 ha however R^2 decreases from 0.67 (1) to 0.48 (2) and 0.31 (3). Taking into consideration that only a smaller part of the relation is explained by the linear equation, one could say that for the farms under 25 hectares total acreage of maize is less a function of the total of good soil and the interaction b3. Thus acreage of maize is more related to the farm size for the smaller farms. Explanation is that the small farmers cultivate maize for their own consumption and as a cash crop. Maize is only economically interesting for the larger farms when they have a sufficient area of good soil.

In the last 3 categories of farm sizes in table 3.2.5 'not improved pasture' constitutes 45.4%, 37.6% and 31.2%. The importance of 'improved pasture' however increases with farm size, because the larger farms keep cows for milk production (resp.;7.5%, 19.2% and 39.2%). A part of the improved pasture is on the badly drained and the swampy soils while a lot of not improved pasture is on soils 1 and 2. The improved pastures on the badly drained and swampy soils belong to the smaller farms.

The relation between pasture and farm size & bad soils fits better than the equations tried above. Improved and not improved pasture were summarized in the following equation:

area pastures=a+b1(area red and/or badly drained soils)*
+b2(total farm area)*
+b3(area red and/or badly drained soils*total farm area)*

(a=-5.552, b1=-0.377, b2=0.876, b3=0.003, Significant at 1%). 93% of the variation can explained with this linear equation.

The question could be posed why such a steady percentage of the farms is under pasture while obviously so little farms take advantage of it economically. The answer is the lack of resources to put it to use economically and the availability of off-farm

work. Pasture is also the result of the cutting for timber; they didn't really choose for pasture.

No relation could be established for the area under forest and the soils. This could be due to the fact that the soil types under forest are not well known.

4. LINKING THE AERIAL PHOTOGRAPHS TO THE SOIL MAP

4.1. Introduction

The soil map of 'A detailed soil survey of the Río Jiménez area in the Atlantic Zone of Costa Rica' (DAM, 1987) is used in combination with aerial photographs to determine the relation between land use and soils.

Chapter 4.2 gives a short description of the soils. A more detailed description can be found in Appendix I. The interpretation of the aerial photographs and the information on parcels collected at the cadastre is given in chapter 4.3. Ultimately chapter 4.4 combines the information of the parcels and the soil map.

4.2 The Soil Map

Aerial photographs of a scale 1:35,000 enlarged to a scale of 1:17,500 formed the base map on which the geographical extent of each soil phase was drawn. (DAM, 1987) Photo nrs. used were; 24873,24874 and 24875 Run 177, series 1 248, scale 1:35,000.(IGN17-3-1981). Nrs.23 and 24, Run 3, series L 17E, scale 1:80,000, infrared (IGN, 1985).

The soil map however covers only the area between Cartagena, Río Jiménez and the banana estate 'Finca Esmaralda' (before Finca Río Jiménez).

The following is an explanation of the soils on the map in "A detailed soil survey of the Río Jiménez area in the Atlantic Zone of Costa Rica" (DAM, 1987).

> The classification of the soils in the map legend are based on those soil properties which reflect best management and potential use of the soil.

The lowest category in the final soil legend is composed of 'suelos'. 'Suelos' have a range in characteristics equivalent to the 'Soil Series of the Soil Taxonomy' (1975). This unit is uniform concerning horizon sequence, horizon characteristics and has developed on the same type of parent material (Soil Survey Staff, 1962). On the first level soil orders are distinguished according to the Soil Taxonomy (Soil Survey Staff, 1975) using the given differentiating taxonomic characteristics: presence or absence of diagnostic horizons or features that are marks in the soil of the differences in the degree and kind of dominant sets of soil forming processes that have gone on.(Soil Taxonomy, 1975.)

Classification of the different soils in the area in the category of Soil Taxonomy soil orders, separates those soil types which have clearly different properties. It is based on the most complete combination of profile characteristics thus giving a justifiable subdivision, leaving the possibility open to classify according to a specific important property on a lower level in the legend. This is done on the second level of the soil map legend.

In addition to the general type of soil and soil development (type of soil order) the most typical soil characteristics, (thixotropy, texture, structure, soil depth and in some cases drainage) are directly related to the type of parent material in which the soil is developed. Soils were therefor grouped together which have comparable parent material. Three groups can be distinguished based on this criterium, for the Río Jiménez area:
-Soils developed in material with a volcanic origin and deposited by lahars.

-Soils developed in material deposited by interacting laharic-fluvial processes or developed in material deposited by fluvial processes, but with properties, related to the volcanic origin of the parent material.
-Soils developed in material deposited by fluvial processes without special properties indicating a typical volcanic origin.

The soil map is found in Appendix II. When the map image is studied, the following can be remarked.
-Laharic fluvial, coarse textured soils seem to occur mainly in the Western, Southwestern, and central Southwestern part of the survey area (except mapping unit Milano)
-Pattern of occurrence of the different soil types seems to be closely related to the drainage pattern, at least in the major part of the area.
-Many soil types apparently occur in complexes

A detailed description of the soils can be found in Appendix I or in DAM (1987). In that report also a Land Capability Classification is found according to the 'Manual para la determination de la capacidad de uso de las tierras de Costa Rica' (1985).

This land classification system groups the land in 10 capability classes, according to expected capability of the land, for a specific level and type of use. It is a hierarchical system and classification is based on a number of evaluation parameters i.e. life zone, precipitation characteristics, cloudiness, windiness, soil characteristics, erosion, drainage, slope, and risk of flooding. The first (best) class of the system has no limitations for highly productive annual crops (Appendix III).

Table 4.2.1 gives the distinguished soils, the capability class, drainage and most limiting factor. Soil type Milano is not present because it is not included in the area studied.

Table 4.2.1 Soils and their properties.

soil	soil code	capability class	drainage	most limiting parameter
Chirripó	5	II	moderately to well	soil depth drainage
Christiana	6	II	well	soil depth
Unión 1	3	II	well to excessively	soil depth
Unión 2	4	III	well to excessively	soil depth stoniness
Ligia	7	II	moderately	soil depth drainage
Aluvial	2	IV	moderately	pH/drainage
Jardin	9	IV	poorly to very poorly	pH/drainage soil depth
Toro Amarillo	8	VI	poorly to very poorly	pH/drainage soil depth

Unión 1&2: Two phases of the same soil.

4.3 Combining the Land Use Map with the Soil Map

At the time of writing, no map with parcels of Río Jiménez was available. Measurement of the farms and their fields was not feasible. Such a map is needed to be able to link the crops cultivated to farm size. One can obtain maps at the cadastre with registration numbers or names. The maps of the individual parcels do not only have the name of the owner but also have the names of the owners from adjacent parcels. This makes it possible to obtain the maps of an area. Problems arise when parcels are sold or split up. Apparently this is not always registered at the cadastre. Maps registered at the IDA couldn't be found at the cadastre. Ultimately maps of 31 parcels in the area of the soil map were obtained.

Aerial photographs were used to recognize the cultivated crops. Two series of aerial photographs cover the area of the soil map. This makes it difficult to determine the crops on a few parcels because it is only possible to see stereo within a run. Aerial

photographes used: Nrs.463871-46387 R 261 L3 and Nrs. 45052-45055 R 265 L4. Both in scale 1:10,000 (IGN 13-2-'98). They run from SE to NW.

The soil map and the map of the parcels must be topographically correct in order to be able to asses the proportion of each soil type per farm. The graphical rectification procedure to correct for errors due to tilt displacements can be done with an optical instrument, the Sketchmaster. For this a map of the area is needed, or when in absence, a framework of four control points. The parcels plus the identified crops (Appendix IV) couldn't be adjusted with a sketchmaster because of the lack of a topographical map. The soil map of Dam (1987) is not adjusted either.

The map of the parcels and the soil map were brought to the same scale (1:10.000). Soils in each parcel were thus estimated with the soil map and the aerial photographs. The areas per soil type and per crop, pasture or forest are estimated with squared paper. Results could be checked through summarizing areas for one farm while farm areas are known from the individual parcel maps. Differences between summarized areas and given areas range between 6 and 10% of the real acreage. These differences are the result of the inaccuracy of counting squares and of the roads and compounds on the parcels. Figure 4.3.1 to 4.3.5 give an example of this procedure for a few of the parcels:

The district of Río Jiménez is given in figure 4.3.1. Figure 4.3.2 places the parcels in the area covered by the soil map. For a part of this, figure 4.3.3 and 4.3.4 give respectively the soil map and the parcels. The latter two are matched in figure 4.3.5 making it possible to count the areas of each soil and the different crops. Most crops are univocal recognizable on the photographs after some training (MUECHER, 1991). Maize and pasture for instance can be of the same tone, maize however is characterized by a fine linear pattern. Crops on very small areas are hard to recognize. Bean and rice plots are often very small

and probably resemble pasture too much on the photographs to be distinguished. Similarly fruit trees and cocoa are also impossible to distinguish from each other.

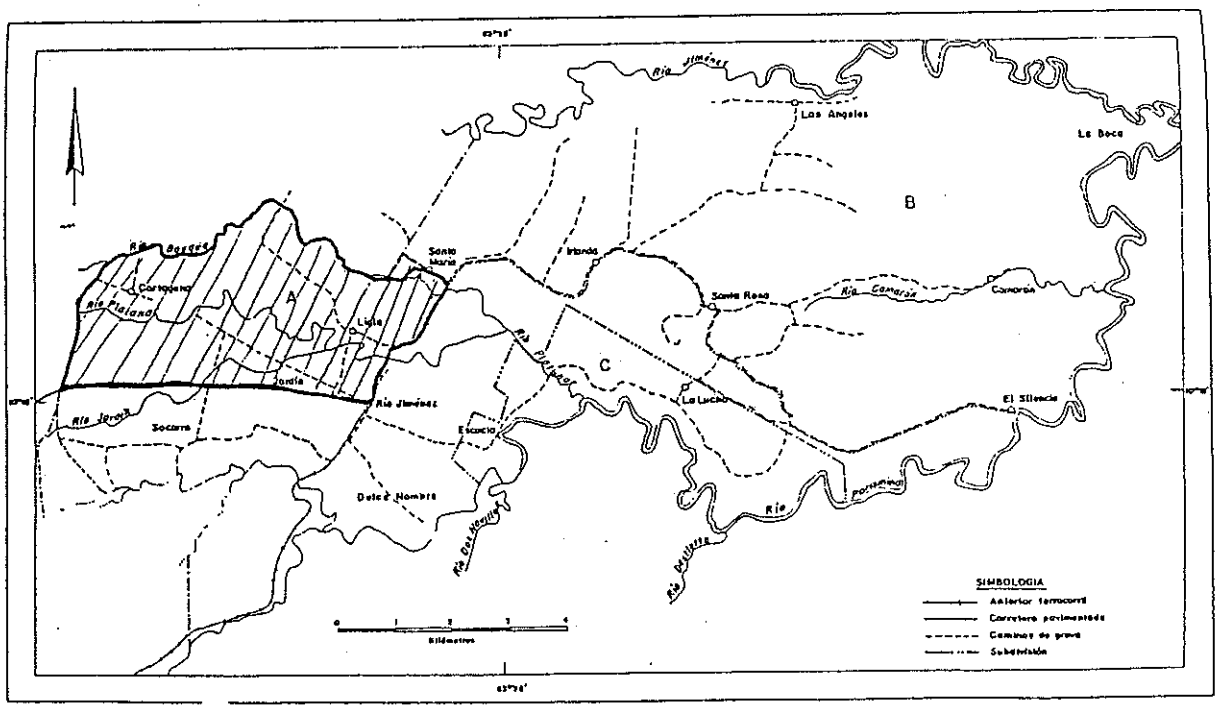


Figure 4.3.1 The district of Río Jiménez. The outlined part is the area covered by the soil map; the survey area.

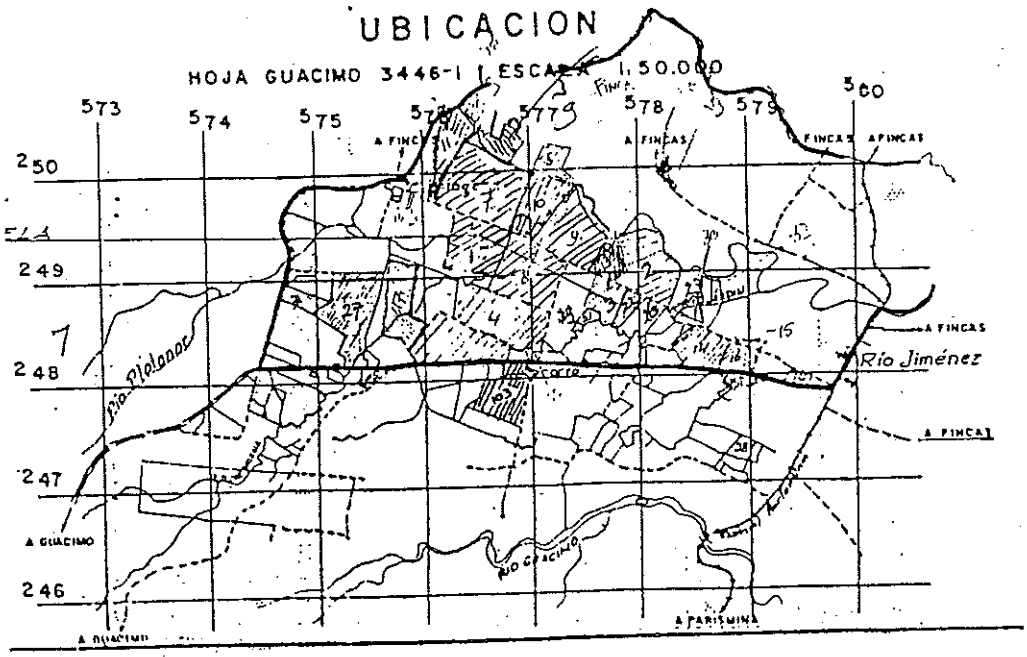


Figure 4.3.2. Parcels in the survey area.

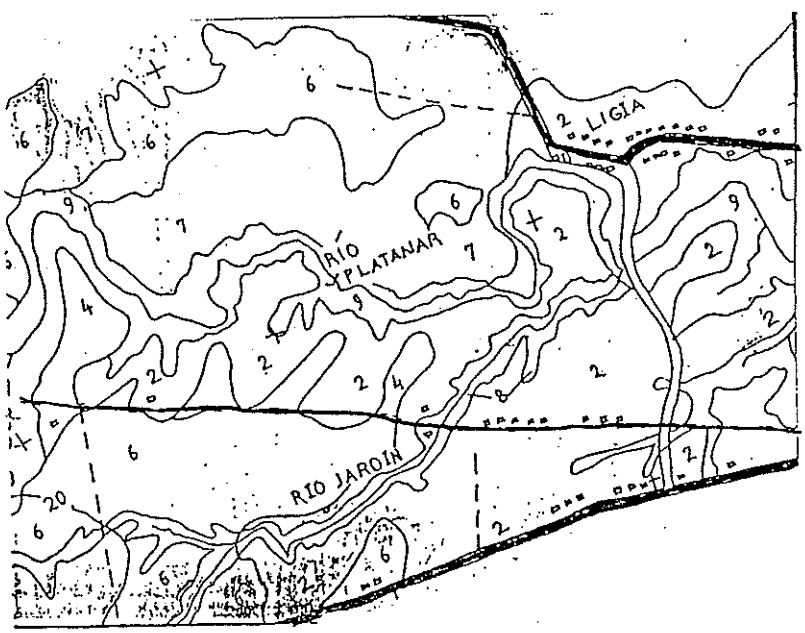


Figure 4.3.3. Part of the soil map. The bold lines are the roads coming from the village Río Jiménez.

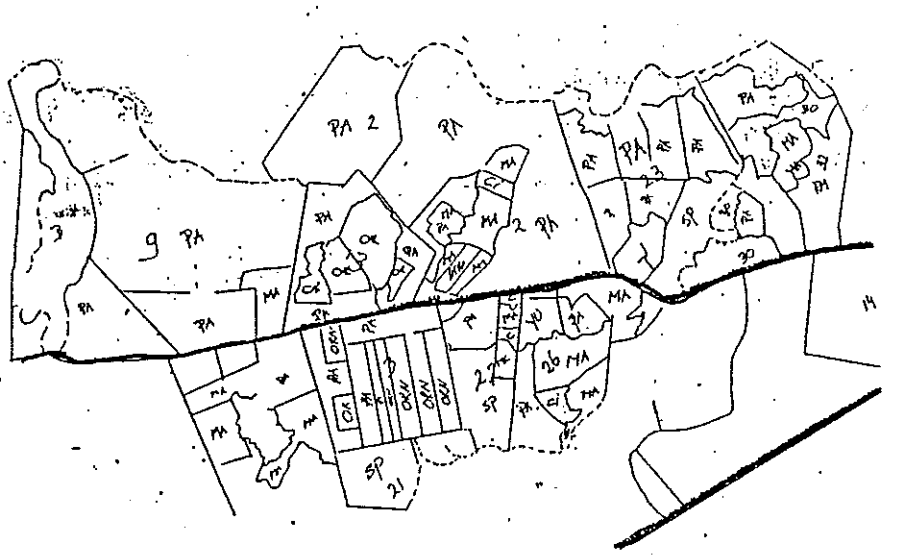


Figure 4.3.4. Parcels and the land use for the same part as given in figure 4.3.3. The bold lines are the roads coming from the village Río Jiménez.

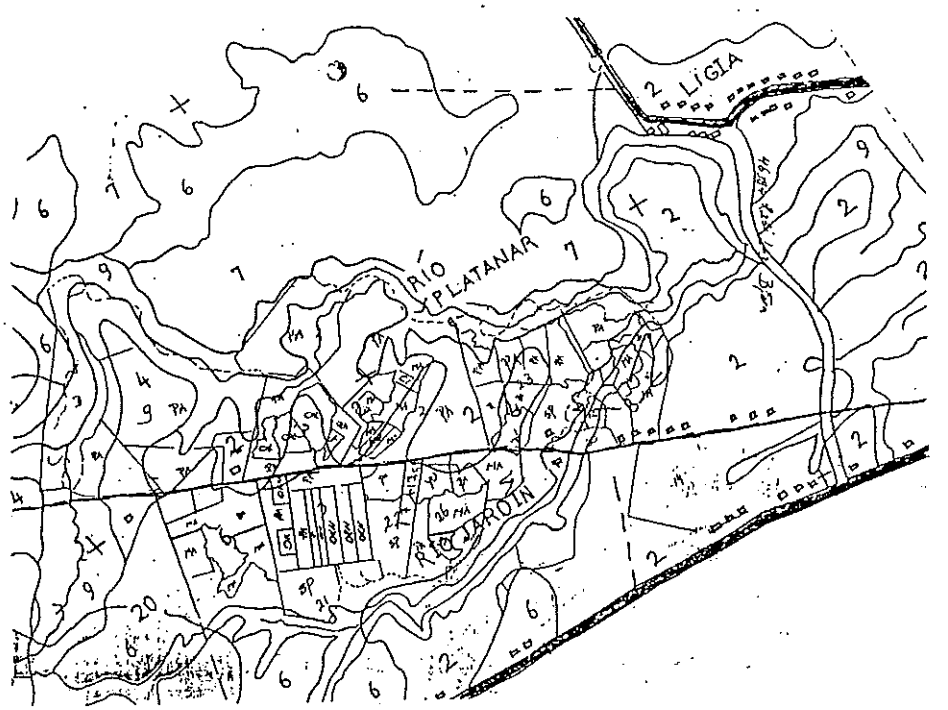


Figure 4.3.5. Parcels placed on the soil map. The bold lines are the roads coming from the village Río Jiménez.

4.4 Land Use West of Rio Jiménez

The area summarized for each land use and soil are given in table 4.4.1.

Table 4.4.1. Land use linked to soils as derived from the aerial photographs and the soil map. Expressed in percentages of the total area.

	maize	cassava	forest	ornamentals	pasture	silvo pasture	cacao	sweet pepper	papaya	compound area	total
2 Aluvial	2.6	1.3	3.4	3.8	10.7	1	0.1		0.4		23.3
3 Unión 1	1.5		0.1	0.4	1.4						3.4
4 Unión 2	1				9.7				0.3		11
5 Chirripó	0.9		0.3		5.1	0.2					6.5
6 Christiana	6.3	0.3	1.7	7.5	10.2	1.5		0.5	1.1	0.1	29.2
7 Ligia					1.7	0.6					2.3
8 Toro Amarillo	0.4		1.7	0.1	1.6	0.2					4
9 Jardin	0.7		3.4	3	12.6						19.7
sum:	13.4	1.6	10.6	14.8	53	3.5	0.1	0.5	1.8	0.1	99.4

These figures are also given in bar graphs in Appendix V. Soils classified higher than class III (Appendix III and Table 4.2.1) are not considered suitable for annual crops. Soil Aluvial falls in Class IV which is suited for perennial and semi-perennial crops. Soil Jardin and Toro Amarillo fall in class VI:'Soils that don't meet required conditions to cultivate annual or perennial crops'. Toro Amarillo is encountered in strips bordering the major rivers and creeks in the area, soil Jardin is also found here, and borders smaller creeks and temporarily active streams. Their occurrence is strongly related to the drainage pattern of the area (DAM, 1987).

Still, in spite of this, 27.6% of the cultivated maize is found on soil 2,8 and 9. Farmers with little or no other soil on their parcel will have no choice than to use it for whatever they need. **Soil 2,8 and 9 represent respectively** 23.3, 4 and 19.7% of the aera; together not less than 47% of all the soil types found on the parcels. Thus not only the smaller farms cultivate their maize on these soils since they only have 10.6% of all the Jardin, Toro Amarillo and Aluvial soils. Table 4.4.1 is split up in 4 categories of farm sizes to illustrate this.

Table 4.4.2. Land use in 4 categories of farm sizes expressed in percentages of total farm area (per categorie) as derived from the aerial photographs.

1-4 ha	maize	cassava	papaya	cacao	ornamentals	pasture	forest	silvo-pasture	total
2 Aluvial		2.6				4.4	21		28
3 Unión 1	19					1.5	1.6		22.1
4 Unión 2	2.4					0.4			2.8
5 Chirripó						4.2	2.4	2	8.6
6 Christiana								4	4
7 Ligia									0
8 Toro Amarillo	4.6					1	12	0.8	18.4
9 Jardin	4					3	7.8		14.8
	30	2.6	0	0	0	14.5	44.8	6.8	98.7
4-20 ha	**maize**	**cassava**	**papaya**	**cacao**	**ornamentals**	**pasture**	**forest**	**silvo-pasture**	**total**
2 Aluvial	2	3.5	1.4	0.4		23	2.6	3.2	36.1
3 Unión 1									0
4 Unión 2	0.5		1			0.9			2.4
5 Chirripó									0
6 Christiana	8	0.5			3.6	22	3.6	4	41.7
7 Ligia						5.6	2.4	2.1	10.1
8 Toro Amarillo	0.2	0.1				0.8		0.5	1.6
9 Jardin						5.7	2		7.7
	10.7	4.1	2.4	0.4	3.6	58	10.6	9.8	99.6
20-40 ha	**maize**	**cassava**	**papaya**	**cacao**	**ornamentals**	**pasture**	**forest**	**silvo-pasture**	**total**
2 Aluvial	0.6	0.3			12.8		2.2		15.9
3 Unión 1							4.4		4.4
4 Unión 2	2.4			0.2		18			20.6
5 Chirripó						16			16
6 Christiana						6.6			6.6
7 Ligia									0
8 Toro Amarillo						4.3			4.3
9 Jardin						26.7		5.2	31.9
	3	0.3	0	0.2	12.8	71.6	6.6	5.2	99.7
40-> ha	**maize**	**cassava**	**papaya**	**cacao**	**ornamentals**	**pasture**	**forest**	**silvo-pasture**	**total**
2 Aluvial	5.7					9.1	3		17.8
3 Unión 1					1.3				1.3
4 Unión 2						12.9			12.9
5 Chirripó									0
6 Christiana	2.2	0.5			23.6	5.3	1.7		33.3
7 Ligia									0
8 Toro Amarillo					3.1				3.1
9 Jardin	0.9				9.4	8.9	2.1		21.3
	8.8	0.5	0	0	37.4	36.2	6.8	0	89.7

Acreages are expressed as percentages of the total farm acreage per category. It shows that the relative acreage of maize decreases with increase of farm size except for the last category. This is caused by one large scale maize cultivator. Improved pasture cannot be distinguished from not improved pasture on the aerial photographs. Thus pasture represents only one category. More land is under pasture when farm size increases. This figure is however somewhat different in the last category (>40 ha) , because a relative large acreage (37.4%) is cultivated with ornamentals. Río Jiménez has three large ornamentals farms. One of them 'Costa Flores' is in the sample area.

5 COMPARING THE ENCUESTA GENERAL AND THE PHOTO INTERPRETATIONS

The encuesta and the aerial photographs were both used to asses the land use in the Río Jiménez area. The encuesta was not always very accurate and consistent on acreage cultivated. It was however a random sample of the whole Río Jiménez area. The aerial pictures could only be used for a smaller part of the area, due to the area covered by the soil map. The parcels collected in this area don't form a random sample. Differences occurring in the data sets could also be due to the difference in time. The encuesta was held in 1987 while the aerial pictures were from 1989. The problem when comparing the encuesta and the results from the aerial pictures is also the two classifications in the encuesta. Since these two aren't consistent on the occurring soils, outcome depends on which classification is chosen. It was stated in the encuesta that the classification based on terms used by the farmers (cl.1) probably was the most accurate. Thus hereafter this classification is used.

Obvious is that trends for land use are the same when the totals are compared. Forest takes in both tables about 10.5%. Pasture 61.5% in the first resp. 53% in the second table and so is maize in the first 21.8% and 13.4% in the second table. This lower relative figure for maize in the second table is because the area on the aerial pictures comprises an ornamental enterprise. Papaya is a crop of importance compared to the other small crops mentioned in the second table. It is strange that this crop was not mentioned in the encuesta.

When the crops are not taken on the whole but also with regard to the different soils, it becomes much harder to make a comparison.

All the soils from the soil map in the survey area are black soils (soil type Milano on the soil map is a red soil but it is outside the sample area).

Table 5.1. Land use linked to soils according to the encuesta and as derived from the aerial photographs. (Tables 3.2.4 A and 4.4.1)

	maize	cassava	forest	pasture			cacao	beans	rice	shrub	total
				not improved	improved	sum					
soil 1	13.4	0.6	1.3	9.2	9.8	19	0.4	0.8	0.2	0.5	36.2
soil 2	2.3		4.5	16.8	14	30.8		0.2		0.7	38.5
soil 3	2.8	0.1	2.7	1.9	0.2	2	0.1			1.3	9.1
soil 4	0.5										0.5
soil 5	1.6	0.2	1.9	7	1.3	8.3	0.2				12.2
soil 6	0.2	0.2		0.1	0.5	0.6			0.1		1.1
soil 7	1	0.1	0.1	0.2	0.6	0.8		0.1			2.1
	21.8	1.2	10.5	35.2	26.4	61.5	0.7	1.1	0.3	2.5	99.7

	maize	cassava	forest	ornamentals	pasture	silvo pasture	cacao	sweet pepper	papaya	compound area	total
2 Aluvial	2.6	1.3	3.4	3.8	10.7	1	0.1		0.4		23.3
3 Unión 1	1.5		0.1	0.4	1.4						3.4
4 Unión 2	1				9.7				0.3		11
5 Chirripó	0.9		0.3		5.1	0.2					6.5
6 Christiana	6.3	0.3	1.7	7.5	10.2	1.5		0.5	1.1	0.1	29.2
7 Ligia					1.7	0.6					2.3
8 Toro Amarillo	0.4		1.7	0.1	1.6	0.2					4
9 Jardin	0.7		3.4	3	12.6						19.7
sum:	13.4	1.6	10.6	14.8	53	3.5	0.1	0.5	1.8	0.1	99.4

The encuesta however distinguishes at least 38.5% of red soils. Thus possibilities are that :

- the area on the soil map is not representative for the Río Jiménez area; it constitutes only a part of the Río Jiménez area. It is possible that the reddish soil types like Milano are situated in the most western part of the Río Jiménez area. The area that is not covered by the soil map nor by the aerial pictures.
- farmers and interviewers on the one hand and DAM (1987) on the other hand have different opinions on black and red soils.

6. DISCUSSION

Methodology

Land use needs to be assessed for the goal of developing alternative scenarios for sustainable land use. There are however severe constraints on the information available at the moment of writing. The information collected with the aerial photographs and the soil map cannot be extrapolated for the whole area for several reasons. The scale of the soil map is not fit for the methodology. The suggestion that the scale is 1:20,000 is somewhat misleading because it is derived from aerial photographs of a scale of 1:35,000. The number of augerings is low. The map is not adjusted to a topographical map and covers only a part of the Río Jiménez. The information collected with the aerial photographs is difficult to extrapolate for the whole area because soil types from the encuesta are hard to match with the soil types on the soil map.

There is no map with parcels for the Río Jiménez area neither is there quantitative information on the cultivated crops. The accuracy strived for should be the same for all sub areas when developing a methodology. Therefor information is needed as is available for the subarea Neguev: a detailed soil map and a map with the parcels. Despite the inaccuracy of the data, some general conclusions can be drawn.

Conclusions

The conclusions on the land use in the Río Jiménez area from the two data sets support each other. As was expected from earlier information most general conclusions are:

- Río Jiménez can be typified as a maize area though
- the most important land use is pasture when land use is expressed in hectares.
- both pasture and maize are related to farm size and soil type.

- the cultivated crops (except maize) are large in number but constitute a very small acreage: 2.7% of the total farm area.
- off-farm work is important in the farmers'strategies.

These characteristics are the result of a very specific situation found in the Atlantic Zone. The area was only recently colonized by the majority of the farmers. Most of them have very little experience in agriculture. The very humid climate and the large variation of soils make farming difficult. The small farmers suffer from a lack of recources to make investments in livestock raising or large scale cultivation of crops. Large scale production of bananas and ornamentals are a source of income because of the possibilities of off-arm work they offer. In the longer run they are a threat to the small farmers.

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APPENDIX I: LEGEND FOR THE 1:20,000 SOIL MAP OF THE RIO JIMENEZ AREA (DAM 1987).

LEGEND FOR THE 1:20.000 SOIL MAP OF THE RIO JIMENEZ AREA

FINE TEXTURED SOILS WITH CLAY ILLUVIATION (ULTISOLS/ALFISOLS)

Soils developed on laharic deposits

A moderately deep to deep, well drained fine textured soil with a clayey dark brown A-horizon and clay illuviation in the B-horizon. Without thixotropic properties in A and B-horizons, but with thixotropy in the C-horizon due to weathering of very coarse lahar deposits (volcanic).

Suelo Milano

Soils developed on fluvial deposits

A moderately deep, moderately well drained loamy to clayey soil, with a clayey loam to clayey A-horizon and with clay illuviation and some Fe/Mn concretions in the B-horizon. This soil has no thixotropic properties.

Suelo Aluvial

SOILS WITH CLEAR ANDIC PROPERTIES (ANDISOLS)

Soils developed on laharic deposits

A shallow to moderately deep, well drained soil, with a well developed, humic, very thixotropic A-horizon, overlying unaltered parent material composed of coarse to very coarse sand, gravel and stones. Stones can occur high in the profile.

Suelo Unión, phase $\frac{Un-3P3}{A}$

Soils developed on laharic-fluvial deposits

A shallow to moderately deep, well drained soil with a well developed, sandy loam to sandy, very humic and thixotropic A-horizon, overlying coarse sandy, slightly gravelly parent material. No stones occur in the profile.

Suelo Unión, phase $\frac{Un-3}{A}$

A moderately well drained soil, with a silty sandy clay loam, humic, very thixotropic A-horizon, overlying a slightly cemented, massive, very thixotropic, cambic B-horizon, developed in coarse sandy parent material.

Suelo Chirripo

A well drained, moderately deep soil with a sandy loam to clay loam, humic, very thixotropic A-horizon, overlying a well developed cambic B-horizon, also very thixotropic. Parent material consists of coarse sand.

Suelo Christina

A moderately well drained, moderately deep soil with a moderately well developed, loamy, humic A-horizon, overlying a weakly developed B-horizon, often showing grey mottling in the lower part. The soil material, sandy loam to clay loam, is thixotropic.

Suelo Ligia

SOILS WITH LITTLE OR NO DISTINCT MARKS OF PEDOGENETIC PROCESSES BUT WITH ONE OR MORE HORIZONS WHICH SHOW ALTERATION OR CONCENTRATION (INCEPTISOLS)

Soils developed on laharic-fluvial deposits

A moderately well to very poorly drained, shallow soil with little profile development, on coarse sandy fluvial deposits with distinct thixotropic properties. In most augerings an A-C profile is observed. Locally this soil contains stones and gravel, (phase $\frac{To-3P2}{A}$)

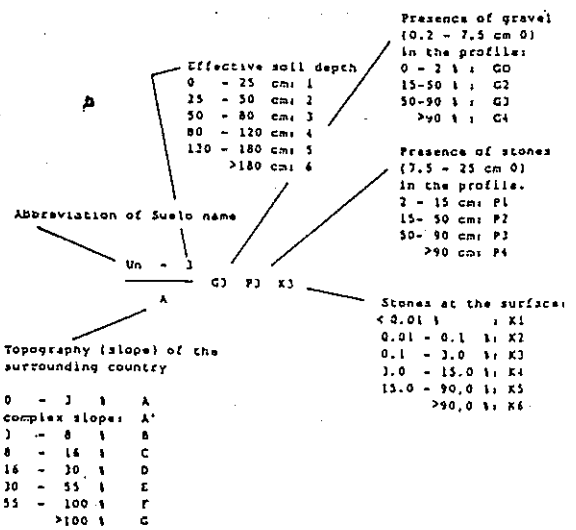
Suelo Toro Amarillo

Soils developed on fluvial deposits

A moderately well to very poorly drained, shallow, loamy to sandy clay soil, with Ah, Ag and C horizons, without thixotropic properties.

Suelo Jardin

EXPLANATION OF THE MAPPING SYMBOLS:



1 = $\frac{Mi - 5}{A}$

2 = $\frac{Al - 4}{A}$

3 = $\frac{Un - 3 P3}{A}$

4 = $\frac{Un - 3}{A}$

5 = $\frac{Ch - 4}{A}$

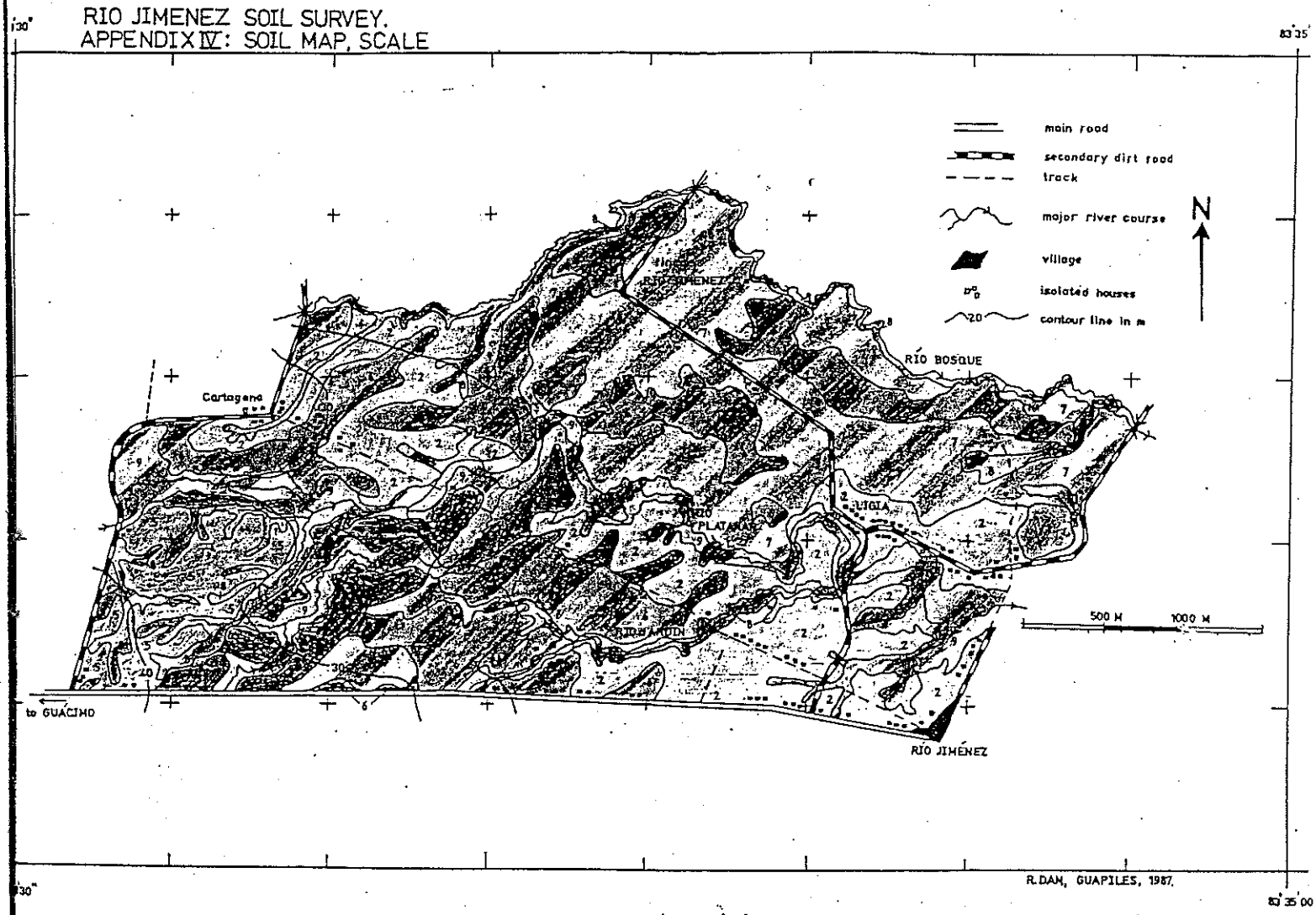
6 = $\frac{Cr - 4}{A}$ 60 % + $\frac{Un - 1}{A}$ 40 %

7 = $\frac{Ci - 4}{A}$ 35 % + $\frac{Al - 4}{A}$ 65 %

8 = $\frac{Ja - 3}{A}$ 50 % + $\frac{Ta - 1}{A}$ 50 %

9 = $\frac{Ja - 3}{A}$ 40 % + $\frac{Ta - 3}{A}$ P2 60 %

APPENDIX II: THE SOIL MAP. (DAM, 1987) Scale approximately 1:40.000



1: Soil Milano
2: Soil Aluvial
3&4:(very dark on copy;numbers not visible)association of Soil Unión phase Un-3p2/A and Unión Un-3p2/A
5: Soil Chirripó
6: Soil Christina
7: Soil Ligia
8&9:Association of Soil Toro Amarillo and Soil Jardin.

APPENDIX III: CAPABILITY CLASSES

Class I: Annual crops (very high yield).
The soils in this class don,t have any limitations and the agroecological conditions permit sowing, tillage and harvesting for all kinds of annual crops, that are ecological suitable, without decreasing the productive capacity of the soil.

Class II: Annual crops (high yield).
Soils that have agroecological conditions that permit sowing, tillage and harvesting of a majority of annual crops that are ecologically suitable, without decreasing the productive capacity of the soil.

Class III: Annual crops (moderate yield)
Have agro-ecological conditions equal to the foregoing class but with more severe limitations. In spite of these limitations the production of the selected annual crops is economically manageable, without decreasing the productive capacity of the soil.

Class IV: Perennial crops, or semi-perennial crops.
Soils with agroecological conditions that don't always allow use of annual crops as defined before, but do allow the sowing, tillage and harvesting of crops with a period of growth of more then 2 years, or grasses and shrubs that do not frequently need tillage and that protect the soil against erosion, except for a few and short periods, without decreasing the productive capacity of the soils.

Class V: Intensive grazing.
Soils that don't meet the minimal conditions for classification suited for crops as defined before, but are adequate for continuous grazing at a high level, without decreasing the productive capacity of the soil.

Class VI: Extensive grazing.
Soils that don't meet the required conditions to cultivate annual or perennial crops, but do allow continuous grazing at moderate or low level, without decreasing the productive capacity of the soil.

APPENDIX III: CAPABILITY CLASSES (continued)

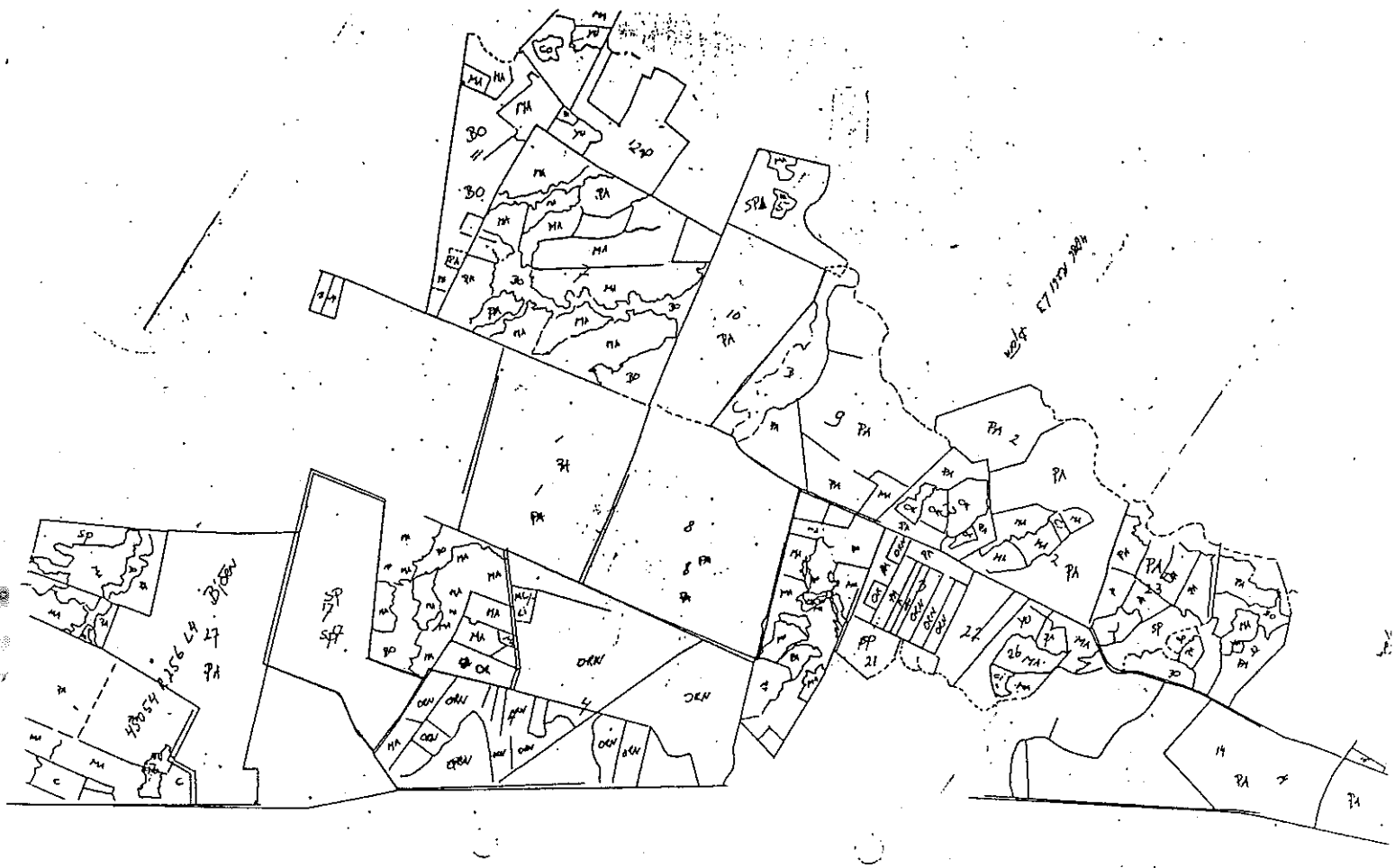
Class VII: Tree crops.
Soils that don't meet the minimal conditions to classify them as suitable for annual or perennial crops or pasture as defined before, but do present favourable conditions for the establishement of species of trees that give a protective plant cover, without decreasing the productive capacity of the soil.

Class VIII: Intensive forestry.
Soils that don't meet the minimal required conditions for crops or pasture, but do allow an intensive and permanent production of wood and other forest products of natural forest that can be technically managed, without decreasing the productive capacity of the soil.

Class IX: Extensive forestry.
Soils that don't allow use for crops or permanent pasture, but are suitable for extensive and permanent production of wood and other forestry products of natural forest that can be technically managed, without decreasing the productive capacity of the soil.

Class X: Protection.
Soils that don't meet the minimal required conditions for crops, pasture or forestry and do not fit in any of the given classes above.

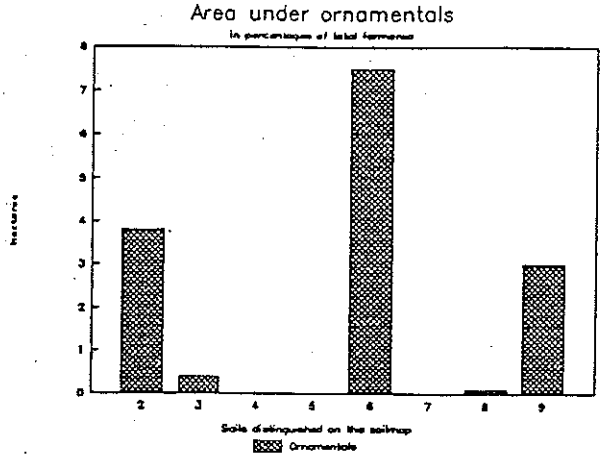
APPENDIX IV: PARCELS AND THEIR LAND USE IN THE SURVEY AREA.

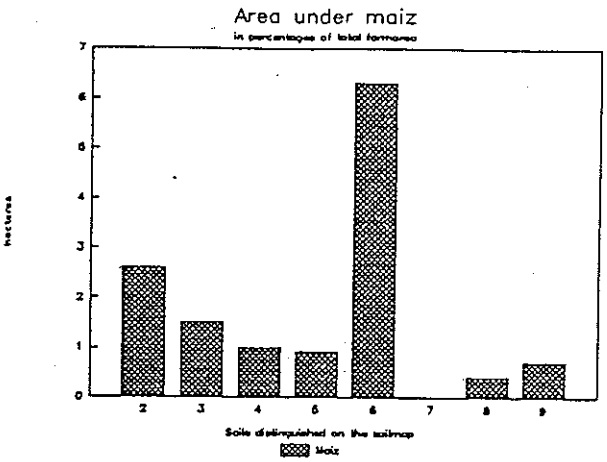


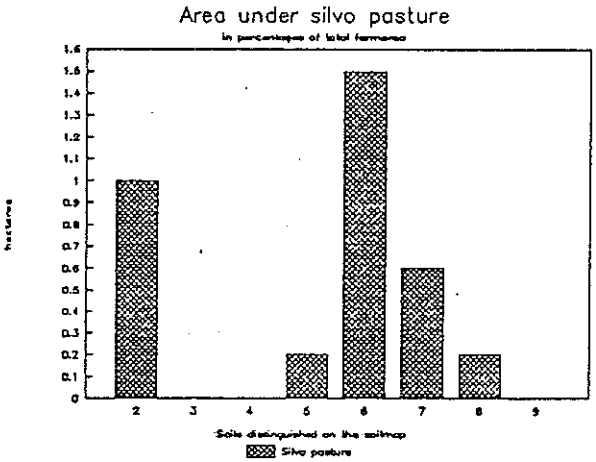
Example of the sheets drawn from the aerial pictures. They are put together in order to place them over the soil map. The abbreviations are for the cultivations found on the pictures (PA=pasture,MA=maize,BO=forest etc.). The numbers are numbers given to the farms.

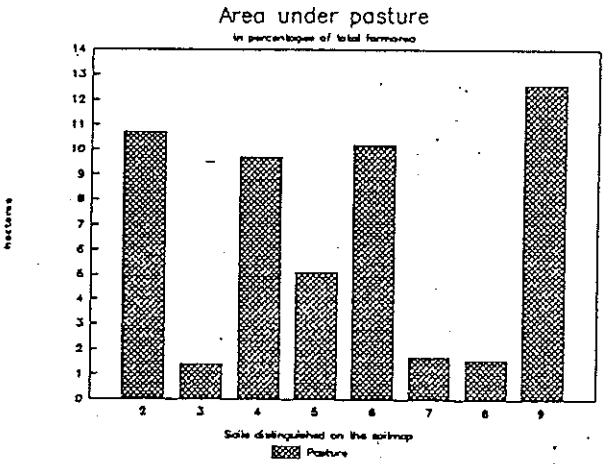
APPENDIX V: LAND USE AS DERIVED FROM THE SOIL MAP IN BAR GRAPHS.

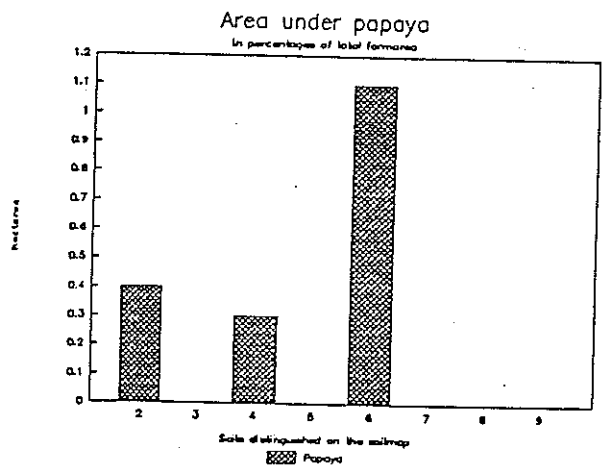
The scales of the figures are different!



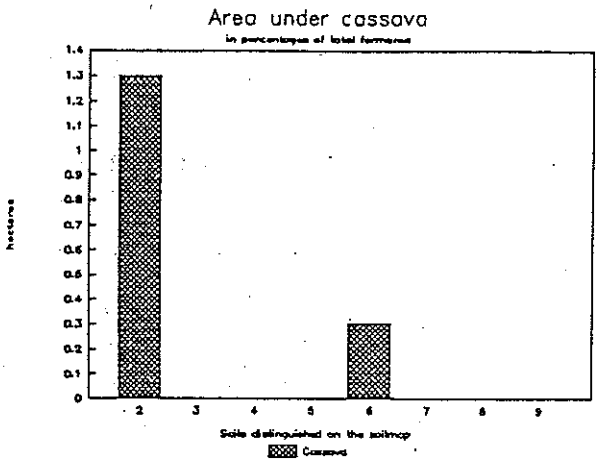


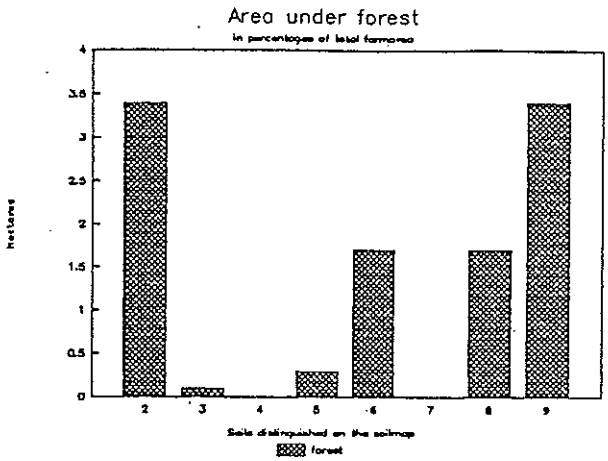






APPENDIX V: (continued) LAND USE AS DERIVED FROM THE SOIL MAP IN BAR GRAPHS. The scales of the figures are different!





soil	soil code	capability class	drainage	most limiting parameter
Chirripó	5	II	moderately to well	soil depth drainage
Christiana	6	II	well	soil depth
Unión 1	3	II	well to excessively	soil depth
Unión 2	4	III	well to excessively	soil depth stoniness
Ligia	7	II	moderately	soil depth drainage
Aluvial	2	IV	moderately	pH/drainage
Jardin	9	IV	poorly to very poorly	pH/drainage soil depth
Toro Amarillo	8	VI	poorly to very poorly	pH/drainage soil depth

Unión 1&2: Two phases of the same soil.

APPENDIX VI: THE ENCUESTA GENERAL

The data collected with the encuesta are stored on 17 files. 5 files are used notably 'usotierr.dat'; a classification of the land use. 'Suelo04.dat'; a classification of the soils done by the interviewer as well as by the farmers plus the crops on the different soils. 'Cultiv01.dat'to 'cultiv07.dat' are concerned with the primary, secondary and tertiary most important crops for the farmer plus the acreage sown.

Not all columns from the files were used to combine a table only total acreage and grassland,improved and not improved, were taken from 'usotierr.dat'. Soils distinguished by the farmers and the interviewers, area and use per type of soil, were taken from suelo04.dat. Primary, secondary and tertiary most important crop and their acreage were derived from the 'cultiv01.dat', 'cultiv04.dat' and 'cultiv07.dat' files.

Both columns in 'suelo04.dat' and in the cultiv files contain information on the crops cultivated. Sometimes these don't correspond. In those cases information is taken from the cultiv files because these are more specific. The soil types mentioned in suelo04 are often more than one. Gaps appear when combining this file with the cultiv files where each farm only represents one row. This is solved where possible by placing the crop on the right soil with help of column 10 in 'suel04.dat'.

In the column soil types distinguished by the farmer occur a lot of question marks. In such cases soil type is taken from the classification done by the interviewers.

REPORTS PHASE 2

1. Work Plan 1991-1993 - A methodology for analysis and planning of sustainable land use, a case study in Costa Rica.

2. Practical technologies for the improvement of Pastures in Central America (L. 't Mannetje).

3. Deforestation, Colonization and utilization of land resources in the Atlantic Zone of Costa Rica (Fred R. van Sluys; Willem G. Wielemaker; Jan F. Wienk).

4. Soil hydraulic conductivity on two tropical soil types under forest and a 25 years old pasture (G.J. Weerts).

5. Geomorphology and soils of the area limon - Cahuita, Atlantic Zone of Costa Rica (F. Luijekx; W. Zunnenberg)

6. Investigation about the farm activities of women and the importance of their activities for the family income in El Indio (K. Hooijschuur).

7. Farm systems in the Neguev settlement (J.M. Finnema).

8. Diagnóstico sobre el manejo del cultivo y compatibilidad del cacao en la Zona Atlántica de Costa Rica (D. Cruz Choque; J. Morera).

9. A study on the spatial distribution of land use in the settlement Neguev (C.A. Mucher).

10. Pérdidas de Cosecha del Plátano; Un estudio exploratorio en el Valle de Sixaola, Costa Rica (A.T.M. Bouma; H. Waaijenberg).

11. Estudio detallado de suelos de la finca experimental Los Diamantes (Luis Guillermo Valverde - Asesorado por Dr. Willem G. Wielemaker).

12. Estudio del posible riesgo de deslizamientos y procesos aliados en la cuenca del Río Toro Amarillo (Margriet W. Hartman).

13. Intervenors intervened: Organizational predicaments and institutional contradictions in the production of export plantains in the Atlantic Zone of Costa Rica (G. Verschoor).

14. Atlas of the Atlantic Zone (Zuring, Wielemaker).

15. World food production through sustainable agriculture (Rabbign).

16. Distribution of landuse and soil types Rio Jimenez (Bourn Veltman).

17. Generación y aplicación de la información de suelos de la Zona Atlántica de Costa Rica (Actas del Taller Información de Suelos. Guápiles - Exposiciones y Guía de Excursión (Willem Wielemaker, S.B. Kroonenberg; ISBN 9977-57-124-4).

18. Early growth of palmito (Raymont Tonyschaar).

19. Rob Schipper

20. Palmito (Don Jansen).

21. Annual Report for the year 1991

22. Wielemakers legend of soil map

23. Ed Veldkamp (Forestration)

24. Andre Nieuwenhuysen (Soil Formation).

25. Estudio Detallado de los suelos del Asentamiento Neguev (Sytze de Bruin).

26. Quantification of farming systems in the Neguev Settlement (Berg and Droog).

27. Sistemas de Producción Bovina en la Zona Atlántica de Costa Rica con enfasis en los cantones de Pococí y Guácimo (Carlos Aragon).

28. El cultivo de Frijol Tapado en Costa Rica Un resumen de Investigaciones, 1978-1991 (Rodrigo Alfaro; ISBN 997757-123-6).

29. Flujos de fondos entrados y de fondos saliendos relacionados con estado del suelo y con disponibilidad de crédito - Una investigación entre 30 fincas en el asentamiento Neguev, Zona Atlántica, Costa Rica (Oskar E. Jansen; Dr. W. Wielemaker; D. J. Bouma).

30. El cultivo del Pejibaye (Bactris gasipaes) Zona Atlántica de Costa Rica, 1988 (J.C.M. de Haan, H. Waaijenberg; ISBN 9977-57-126-0).

31. Mineral transformatiion and clay Neoformation in two profiles on an andesitic chronosequence under humid tropical conditions (Paul Verburg).

32. El enfoque de sistemas: Algunos conceptos y aplicaciones en la zona Atlántica de Costa Rica (Henk Waaijenberg).

33. Determination of losses of nutrients and nematicides on a banana plantation in the Atlantic Zone (Alban Rosales, Pascal Maebe, Robert Sevenhuysen).

34. Respuesta del pasto elefante enano (Pennisetum purpureum cv. Mott). A diferentes intensidades y frecuencias de pastoreo en el Trópico húmedo (Guápiles) de Costa Rica. (Arno Maas)

35. Demographic Profile of the Northern Part of the Atlantic Zone (Rossanna Lok).

36. Sistema de Información Técnica (SIT) Part I y Part II (José Arze Borda, Leopoldo Gómez).

37. Weathering of fluvial deposits containing volcanic material under humid tropical conditions (Frank van Ruitenbeek).

38. Estudio del uso del la tierra, suelos y paisajes del Nueva Guinea, Nicaragua (Efraím Acuña, Ignacio Rodriguez, Willem G. Wielemaker).

39. Drainage observations in poorly drained soils in the Atlantic Zone (Pascal Maebe).

40. Soil physical characterization of two soil types under four different land use forms inl the Atlantic Zone of Costa Rica (A.M. Weitz).

41. Establishment and adoption of Bracharia brizantha/ Arachis pintoi associations in the Atlantic Zone of Costa Rica. (Andres van Schaik).

42. Sustainability. (Marian Hulshof).

43. Análisis de inventario en una comunidad campesina de la Zona Atlántica de Costa Rica: El caso de Agrimaga. (Rodrigo Alfaro Monge).

44. Land use in Rio Jimenez. Linked to soil types with the encuesta general and aerial photographs.

45. Selectividad de A. pintoi asociado con B. brizantha y B. humidicola por bovinos en pastoreo en condiciones del trópico húmedo. (A. Martínez, M. Ibrahim, D. Pezo y L. 't Mannetje).