ATLANTIC ZONE PROGRAMME

Working Document No. 9

ANNUAL REPORT FOR THE YEAR 1989

TROPICAL AGRICULTURAL RESEARCH
AND TRAINING CENTER - CATIE

AGRICULTURAL UNIVERSITY
WAGENINGEN - AUW

MINISTRY OF AGRICULTURE
AND LIVESTOCK - MAG

CONTENTS

1 GENERAL

1.1 Background

In March 1984, the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Costa Rica and the Agricultural University Wageningen (AUW) in the Netherlands signed a letter of intent as a first step towards long-term cooperation in the field of joint multidisciplinary research and training. The first joint activity to be undertaken was identified as research into structural transformation problems in the Atlantic Zone of Costa Rica, with the aim of agricultural planning. Within this context, the problems of sustained land use, small farm development and rapid deforestation were to be highlighted,

In April 1985, an AUW mission visited CATIE to formulate more specific research proposals that would fit within the general objective of studying structural transformations in agricultural systems prevalent in the Atlantic Zone. The region was visited and several institutions dealing with rural research and development in Costa Rica were consulted. The mission concluded that insufficient information was available for selection of specific research activities or specific geographical areas of study. Hence, for 1986 an exploratory survey was proposed, to be followed by a baseline study in 1987 before specific research projects would be formulated, to be initiated in 1988 or later.

In March 1986 the official cooperation agreement between CATIE and AUW was signed, followed by an agreement between CATIE, AUW -and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica in May 1986. Subsequently, additional agreements have been signed since with the Instituto Geográfico Nacional (IGN) and the Asociación Bananera Nacional (ASBANA).

The field work for the exploratory survey was carried out in May and June 1986. The survey resulted in the selection of study areas and in a more specific formulation of themes to be studied during the baseline study. For a summary of the results of the exploratory survey (SLUYS van et al., 1987). A programme document was prepared, outlining the research as envisaged (ANON.1987).

Baseline studies were carried out in four zones- Cocori, Rio Jimenez, Talamanca and Neguev. Major disciplines concerned were soil science, agronomy, rural sociology, forestry, animal husbandry, and agricultural For each of these, a monograph has been prepared, to be published in 1990. The outcomes were already discussed in a seminar in August 1988. On the basis of the results obtained, follow-up research lines have been developed. To avoid these becoming monodiciplinary regular programme discussions are being held.

1.2 Objectives

The long-term objective of the programme (henceforth called the Atlantic Zone Programme, PZA) is to contribute to ecologically sound, socially acceptable and economically viable ways of sustainable land use in the Atlantic Zone of Costa Rica. This is being worked out in three different ways: research, training and development planning, in the following manner:

- The research concentrates on major transformations in the agricultural production systems prevalent in the Atlantic Zone of Central America and Panama.
- The research is to be executed by researchers of AUW, CATIE and possibly other institutions with the aid of AUW, CATIE and other M.Sc. and Ph.D. students. The training of such students is the second objective of the Programme.
- The research is development-oriented and may be used by third parties to design applicable development policies for both government institutions and private organizations such as farmers' cooperatives and associations.

Although the general area under consideration is the Atlantic Zone of Central America and Panama, the research started focussing on the Atlantic Zone of Costa Rica, for this purpose defined as the entire Province of Limón.

1.3 Major events

Dr. Jan Wienk, who was since the start of the programme fully involved and permanently committed to it, left after three years of service to occupy a post at the Department of Tropical Agronomy at the AUW.

The embassador of the Netherlands visited CATIE. He expressed his appreciation for the programme underway.

The integration of activities of CATIE and AUW was further developed during a visit of Drs. Casas and Parisi to the AUW.

2 PERMANENT PERSONNEL

2.1 Staff from the Agricultural University Wageningen

The permanent staff of the Programme during the year under review comprised the following persons.

- Jeroen Huising M.Sc.	PhD. student in geodetics and soil science. Research theme: the use of remote sensing techniques for land use inventory;
- André Nieuwenhuyse M.Sc.	PhD student in soil science and Geology. Research theme: genesis of soils and landscapes of the Atlantic Zone;
- Henk Waaijenberg M.Sc.	Agronomist. Responsible for the analysis of the production systems;
- Dr. Wim G. Wielemaker	Soil Scientist. Responsible for the soil research, soil mapping and land evaluation;
- Dr. Jan F. Wienk	Agronomist. Coordinator until 5 September;
- Hans Bronkhorst M.Sc.	Coordinator since 5 September.

2.2 Local personnel

At 31 December 1989, 15 local personnel assisted the PZA, ten of whom were working in the Guápiles field office. Their functions are: administrative assistant, office assistant, technical assistants (4), cleaning woman and watchmen (3). At the coordinator's office at CATIE, Turrialba, a secretary and a driver and at the laboratory for soil analysis of the Ministry of Agriculture in San José two laboratory assistants and a part-time analyst. Their functioning has been satisfactorily and where possible delegation of more responsible tasks is taking place. The services of a part time editor are regularly being used. Local academic staff did not participate on a permanent basis.

3 TEMPORARY PERSONNEL

3.1 Staff from the Agricultural University Wageningen

During the year under review the following persons spent some time in Costa Rica and contributed to the Programme in their specific fields.

- Dr.J.H.A. Boerboom	Department of Silviculture
- B. Boerrigter M.Sc.	Office for International Relations
- Dr.J. Bouma	Department of Soil Science and Geology
- Dr.N. van Breemen	Department of Soil Science and Geology
- Dr.L. Brussaard	Department of Soil Science and Geology
- Dr.D. Gibbon	Department of Tropical Crops
- Th. Guiking M.Sc.	Department of Soil Science and Plant Nutrition
- Ms.S. Hüber M.Sc.	Department of Agrarian Law
- A. C. Jongmans Ing.	Department of Soil Science and Geology
- Dr.S.B. Kroonenberg	Department of Soil Science and Geology
- Dr.N.E. Long	Department of Rural Sociology of the Tropics and the Subtropics
- Dr.L. 't Mannetje	Department of Field Crops and Grassland Science
- Dr.A.P. Oosterom	Department of Soil Science and Geology
- Dr.L. de la Rive Box	Department of Rural Sociology of the Tropics and the Subtropics
- R.A. Schipper M.Sc.	Department of Development Economics
- A. Schoorl M.Sc.	Department of Rural Sociology of the Tropics and the Subtropics
- M.G.A.C. Smits M.Sc.	Department of Silviculture
- H.J.Stuiver	Department of Landsurveying, Photo grammetry and Remote Sensing
- Dr.M. Wessel	Department of Tropical Crops

These visits serve several purposes:

- backstopping the staff and students in Guápiles;
- discussing with colleagues of CATIE and MAG about developments in Costa Rica;
- giving classes in the M.Sc. courses of CATIE;
- doing research personally.

Some of these visits have been too brief, certainly to do some research, however for backstopping purposes they were sufficient.

Wim Koolhoven (from ITC) came in June to install the ILRIS computer programme.

3.2 Local personnel

W. Brooijmans M.Sc. assisted in the Cocori study and prepared a research proposal on: " Law in the struggle for natural resources in the Atlantic Zone ".

S. De Bruin M.Sc. returned to Costa Rica to write a research proposal on: " Design and validation of a simulation model of the yield of banana growing in the Atlantic Zone ".

A. Rojas assisted in the study of the monography for the Neguev settlement.

R. Rivera wrote an extensive study on the farmers' participation in the banana region.

M. Smits M.Sc. prepared a research proposal on " Potential and constraints of commercial wood production in farm forestry systems in the Atlantic Zone ".

4 THE RESEARCH

4.1 The research approach

As a follow-up to the baseline study, the research approach for the programme was redefined, in order to take into account both monodiciplinary and interdisciplinary work. The objective of the research programme falls into two components, both essential contributions to sustainable land use:

- the development of a system for land use planning using a combination of geographical information systems and simulation models;
- a group of thematic studies in the fields of soils, production systems and socioeconomics.

The land use planning system requires the input of basic data generated during the thematic studies. However, implementing the land use planning system generates new questions which must be solved by thematic research. Thus, there is a complementary relationship between both components. Furthermore, fundamental research which is relevant to sustainable land use is necessary to solve problems which are not directly related to the land use planning system, but are related to soils, production systems and/or socioeconomics.

4.2 Land resource studies

4.2.1 Introduction

Research in this field is organized in two lines. Line 1 deals with effects of land use on the land itself. The results of this investigation are necessary to select land uses which are ecologically sustainable under the prevailing climate and soil conditions.

Line 2 deals with geographic aspects of land and its actual and potential uses. The evaluation of land for its actual and potential land uses requires the results of thematic studies executed under additional lines of research. Thus, in a future plan, the present lines of research will be reorganized. Land evaluation will then form part of a land use planning, which integrates economic, social, technical and ecological aspects of land use for prediction and presentation of land use scenarios.

4.2.2 Line 1: Short and long term changes - an evaluation of natural and anthropogenic effects

Background

After deforestation, most soils undergo rapid and sometimes irreversible changes. To study and quantify those changes, three

subprojects were proposed of which the first two have funding and the third has been forwarded for funding to the European Economic Community.
These subprojects have the general objective of the appraisal and quantification of the effects of land use changes on soil properties in the Atlantic Zone of Costa Rica.

Subproject 1 started in November 1988 and subproject 2 starts at the beginning of 1990. Some introductory research was carried out in subproject 3 which helped to formulate the EEC proposal.

Subproject 1 Landform and soil development in the Atlantic Zone of Costa Rica.

Objective

The objective of subproject 1 is to study long-term (100 - 1.000-.000 years) soil development, as a reference for short-term changes under different forms of land use.

Responsibilities

The following staff have implemented this project:

- Personnel full time: Ir. A. Nieuwenhuyse;
- Scientific guidance: Prof. Dr. S.B. Kroonenberg, Prof. Dr. N. van Breemen, Dr. W.G. Wielemaker (CATIE, daily supervision in Costa Rica).

Studies during 1987-1990

In 1988, soil development was studied in a chronosequence of lahar deposits on the footslopes of the Turrialba volcano which resulted in a M.Sc. thesis (DOOREMOLEN, 1989).

Also in 1988, a study was made of the physical and chemical characteristics of four soils on different parent materials in the Talamanca region. Results are summarized in a M.Sc. thesis (ZUNNENBERG, 1989). Both studies were guided in Costa Rica by Wielemaker.

In March 1989, fieldwork for the research assistant ad honorem (AIO) research started. A chronosequence on volcaniclastic beach deposits was sampled and nearly finished by the end of the year. Only dating of the chronosequence and analysis which are being carried out in The Netherlands, await completion. Micromorphological study of this sequence will start in spring 1990. Some sites of chronosequences on lava flows and alluvial deposits were sampled and partly analyzed. In order to find out whether volcanic ash influence on the lava flows is important, several trips on the slopes of the Turrialba and Irazu volcanoes were made. Samples taken during these trips are currently being analyzed.

Two students prepared a detailed soil map of a part of the La Lucha settlement, where one of profiles of the alluvial chronosequence is situated. In November a student started fieldwork to study mass movements which may be the source of the deposits on which some profiles of the alluvial chronosequence are formed.

Plans for 1990

Studies to establish rates of soil development in chronosequences on volcaniclastic beach deposits, lava flows in the slopes of the Turrialba volcano and on alluvial deposits will continue. Special emphasis will be given to dating of the profiles and to mineralogical aspects of weathering, which were delayed in 1989 due to logistic problems . First results of soil development on the beach deposits chronosequence will be published.

The relation between landscape and soil development in the Atlantic Zone will be studied in the northeastern coastal zone, on the slopes of the Turrialba and Irazu volcanoes and in the area where sheet-wash river deposits are found.

Subproject 2 Changes in organic matter content in tropical soils after clearing of lowland rainforest, principally on volcanic ash soils in Costa Rica.

Objective

The objective of subproject 2 is to set up a process-oriented simulation model describing the changes in soil organic carbon, following conversion of forest to agricultural land as a function of soil properties, climate and land management practices.

Responsibilities

The following staff have implemented this period:

- Personnel full time: Ir. E. Veldkamp
- Scientific guidance: Prof. Dr. N. van Breemen (AUW), Ir. W. Bouten (Amsterdam), Ir. Th. Guiking, Dr. C. Ramirez (CATIE), Dr. J. van Veen (ITAL), Dr. W.G. Wielemaker (CATIE).

Studies during 1987-1990

During 1987, soil degradation relative to land use in the Atlantic Zone was studied, resulting in a M.Sc. thesis and field report (DE WOLFF, 1989).

Plans for 1990

Veldkamp will arrive in February to select sites and organize the experiments.

Subproject 3 Effects of the soil fauna on soil properties after clearing of lowland rainforest.

Objective

The objective of subproject 3 is to analyze interactions between soil biota, soil morphology and soil physical properties of older and younger soils under different land uses in the Neguev area.

Responsibilities

The following staff has implemented this project:

- Personnel: To date only students of AUW and UNA participated;
- Scientific guidance: Dr. C. Burgos, Dr. D. Kass (CATIE), J. Fraile M.Sc. (UNA), Prof. Dr. L. Brussaard, Prof. Dr. N. van Breemen, Dr. R. Miedema (AUW) and Dr. W.G. Wielemaker (CATIE). Two french universities are also participating in the EEC proposal.

Studies during 1987-1990

Several studies were done regarding the effect of land use on physical and morphological characteristics of soils of differing fertility status (LANSU, 1987, BALTISSEN, 1988, WIELEMAKER, 1988; SPAANS et al, in press; SPAANS et al, 1989).

The following studies are concerned with the effects of land use on macro fauna, soil properties and organic matter composition:

- A M.Sc. study looked at the effects of earthworm activity on structure and related soil physical properties of a degraded soil. This began in September 1989 and is guided by Prof. Dr. L. Brussaard, J. Fraile and W. G. Wielemaker. Work continues in 1990.
- Effects of land use on numbers of earthworms in two soil types in the Neguev under pasture and forest, were studied by two AUW students in cooperation with the UNA (J.Fraile). Follow up research is done by two students from the UNA. This research work works with a more fertile soil growing both under annual and perennial crops.
- Above-mentioned AUW students also did a study in banana plantations of differing age to study the possible effect of pesticide application on organic matter decomposition and macro fauna population in cooperation with ASBANA (W. Herrera).

Plans for 1990

Reports of the studies currently being carried out will be completed.

Publications of line 1

BALTISSEN, G. 1988: Effects of forest clearing and land use on soil properties of two land use sequences in Cocori, Atlantic Zone of Costa Rica. M. Sc. thesis and field report no 34.

DE WOLFF, S. 1988: Comparison of the soil degradation for some land use types in the Atlantic Zone of Costa Rica. M.Sc. thesis, Wageningen.

LANSU, A. 1987: Soil structure under four land use types in the settlement Neguev, Atlantic Zone of Costa Rica. M.Sc.thesis and field report no 18.

SPAANS, E.J.A., Bouma, J.H., Lansu, A. & W.G. Wielemaker (in press). Saturated and unsaturated flow in a Humitropept under forest and pasture in Costa Rica. Tropical Agriculture, Trinidad.

SPAANS, E.J.A, G.A.M. Baltissen, J.Bouma, R. Miedema, A.L.E. Lansu, D.Schoonderbeek and W.G. Wielemaker, 1989. Changes in physical properties of young and old volcanic surface soils in Costa Rica after clearing of tropical rain forest. Hydrological Processes 3: 383-392

VAN DOOREMOLEN, W.A. 1989: Bodemgenetisch en mineralogisch onderzoek van een chronsequentie op lahars in Costa Rica. M.Sc. thesis, Wageningen.

WIELEMAKER, W.G. 1988. Cambios en el suelo por el uso de la tierra, resumen de una presentación en el taller del 18 al 19 de agosto, 1988, Turrialba, Costa Rica.

ZUNNENBERG, W. 1989: Fysisch-chemische karakterisering van 4 profielen op 4 verschillende moedermaterialen in de Atlantische Zone van Costa Rica. M.Sc. thesis, Wageningen.

4.2.3 Line 2. Soil inventory and land evaluation for sustainable land use planning

Background

The Atlantic Zone of Costa Rica is characterized by rapid change. Most of the area has been deforestated and colonized during the last 50 years. Land suitable for agriculture is already in use so

that now specially areas not suitable for agriculture are threatened with deforestation. At the same time large tracts of land are under-utilized.

There is a lack of knowledge regarding sustainable forms of production (ecologically, socially and economically) and of sufficiently detailed and reliable soil and land suitability maps on which to base development. To help fulfill such needs three subprojects were started. Their objectives are:

- Methodology development for land evaluation, applicable for perhumid climatic zones
- A land evaluation for planning sustainable land use in the Atlantic Zone of Costa Rica

Subproject 1. A soil map and soil information system for the Atlantic Zone of Costa Rica.

Objectives

The objectives for this sub-project are:

- Study of soil and land characteristics; mapping of soils and assessment of their land capability class for a reconnaissance soil and landscape map of the Province of Limon. Several detailed and semi-detailed maps of pilot areas formed the basis of this map.
- Development of a soil and landscape info-system (using ARC-INFO) as a basis for a larger land use planning system. It aims at data structuring for flexible extraction and geographic presentation of soil and landscape information from the reconnaissance map (a).

Responsibilities

The following staff is responsible for this project:

- Personnel time: Dr. Ir. W.G. Wielemaker; students of AUW.
- Scientific guidance: Dr. W.G. Wielemaker, Dr. A.P. Oosterom, Prof. Dr. S.B. Kroonenberg, Prof. Dr. J. Bouma and Ing. H. Stuiver.

Studies during 1987-1990

A draft of the soil and landscape map of the is ready; one sheet is already introduced in ARC-INFO; a 6 -level physiographic and soil legend are introduced is the soil info system for data structuring and (geographic) data extraction. Single properties can be extracted as well.

A poster was presented at the Society of Agronomy's annual meeting in Las Vegas in October 1989 in Las Vegas titled:

- Legend structuring and data presentation with a soil and landscape INFO system. W.G. Wielemaker and A.P. Oosterom.

Paper presented at segunda conferencia Latinoamericana sobre Tecnología de los sistemas de información Geográfica en Mérida, Venezuela (september 1989)

Land capability appraisal of the Bajo Pacuare area. Execution by student Wim Bijsterbosch with supervision of Wielemaker.
Context and aim are to provide an essential contribution for the zonification (land evaluation) of the Bajo Pacuare protective area. Our contribution was requested by the commission installed for this purpose by the costarican government. A preliminary report with maps was ready by the end of 1989.

A detailed soil survey of the research station Los Diamantes of MAG, where the programme has its field station, was started in december 1989 and executed by Guillermo Valverde in cooperation with MAG. Supervision, guidance and correlation are provided by W.G.Wielemaker.

Six soil survey reports were prepared and studies were done at scales of 1:20000 to 50000.

Two reports deal with nutrient availability as follows:

ERENSTEIN, O., 1989. Nutrient availability classification of soils used for maize in Rio Jimenez District, Atlantic Zone of Costa Rica.

JANSSEN, J.W.H, 1989. De invloed van fosfaatbeschikbaarheid, zink- en kopertoxiciteit en bekalking op de groei van maize in vijf gronden uit de Atlantische zone van Costa Rica

One study deals with the application of models for prediction of potential production. The title is:

NIEUWENHUYSE. Application of wofost, duet and quefts for modelling maize and grass production, using data from the Atlantic Zone of Costa Rica.

One study deals with grassland vegetation in relation to soil management and soil type. The title is:

NOBBE, H.J., 198 . Grassland vegetation as influenced by soil and management. A study in the Rio Jimenez district, Atlantic Zone, Costa Rica.

Plans for 1990

Final fieldwork for ground control of soils and landscapes will be done by Wielemaker, followed by a three week visit to Wageningen to finalize the INFO part and the products for the soil and landscape map. There he will be aided by Oosterom and Stuiver.
The thesis about this subject will be presented in February.
Correlation and fieldwork will be finished the first half of 1990. The presentation of report and map will be done at seminar in Costa Rica in October 1990.

Subproject 2. Application of remote sensing and design of a geographic information system for natural resources inventory and regional development studies in the Atlantic Zone of Costa Rica.

This subproject comprises 6 activities, to be described separately. The personnel for all activities is the same.

Responsibilities

- Personnel: Ir. J. Huising
- Scientific guidance: Prof. Dr. J. Bouma and Prof. Dr. M. Molenaar.

Study 1 Land use and land cover inventory with the aid of satellite imagery

Background

Either up to date information on land use and land cover is missing for the Atlantic Zone of Costa Rica or if it exists it is not reliable. Satellite imagery might provide a useful tool to obtain this information.

Objectives

The objectives of this study are:

- To provide a land use and land cover map of the Atlantic Zone of Costa Rica;
- To investigate the usefulness of remote sensing for land use and land cover inventory in a per-humid tropical region and improve, if necessary, the classification methodology to obtain reliable data on land use and land cover.

Studies during 1989

The study was initiated in 1988 and in 1989 additional field work was done to complete the data. Special attention was devoted to

the inventory of forest types and grasslands. The emphasis however, was more focussed on data processing and classification methodology. In June the final classification was carried out and the result was printed on a 1:100000 scale. Part of the work which was carried out by C.Stiggelbout is presented in:

STIGGELBOUT, C., in press. Cobertura y uso de la tierra en la Zona Atlantica de Costa Rica: Un inventario por datos de senso remoto. Field report no. 47. Atlantic Zone Programme. CATIE, Turrialba, Costa Rica.

A final document is in preparation.

Study 2. Grassland mapping with remotely sensed data

Background

This study revealed a large variety of grassland types and therefore a large variation in their spectral characteristics. Relating the spectral response to the actual field situation was difficult, due to the timelapse between recording of the image and the actual study in the field. Therefore there was a need for direct measurement of the spectral characteristics of grassland.

Objectives

The objectives of this study are:

- The spectral characterization of the different grassland types encountered in the zone;
- To investigate the possibility to inventory soil under a grass cover through the use of remotely sensed data.

Studies in 1989

Measurements were made in the field with a hand-held spectrometer of different grassland types and on different soil types. Furthermore satellite imagery data of 1985 and 1986 was used. The work was carried out by F.Stolle and the results are presented in:

STOLLE, A.E.D, 1990. Reflectance characteristics of grass lands in the Atlantic Zone of Costa Rica. Field report no.43. Atlantic Zone Programme. CATIE, Turrialba, Costa Rica.

Study 3. Aerial photo interpretation for land use mapping

Background

The term 'land use' can be interpreted in different ways. Beside

the rather narrow meaning in terms of 'for what the land is used' (ie.identification of current crop or cover) it has also significance as to 'how the land is used', referring to, for example farming system, farm sizes and the spatial division of the land. Since spatial characteristics are difficult to extract from satellite imagery, aerial photographic interpretation was deemed useful to inventory the more spacial characteristics related to land use.

Objectives

The objectives for this study are:

- To investigate the applicability of the 'land use zones' concept, which are areas which can be characterized by a certain land use pattern;
- To make a land use zone map of the Atlantic Zone of Costa Rica and on a more detailed level to produce a land use zone map of the Guacimo-Rio Jimenez-Siquirres area.

Studies during 1989

Photographic interpretation of the Atlantic Zone was carried out based on a black and white photograph of the satellite image. The map has been digitized. A aerial photo interpretation was also carried out for the Guacimo-Rio Jimenez-Siquirres area, based on infrared aerial photos at a scale 1:80000. The data has been digitized. In the same area an inquiry was held to obtain data on farm sizes and farm management. A start was made with the elaboration of the data.

Plans for 1990

Further elaboration of the data as well as analyses of the land use zones with regard to their assumed homogeneity in land use and farm practices.

Study 4. Land use mapping based on integrated aerial photo interpretation and classification of remote sensing data.

Background

Classification of remote sensing data with regard to land use and land cover results in information which can not directly be used, except for visual interpretation. A land use map should provide more aggregated data. The land use zone as mentioned earlier might provide a useful context.

Objectives

The objectives of this study are:

- To design a methodology for the classification and mapping of land use and land cover based on both aerial photo interpretation and satellite imagery.
- To provide a land use and land cover map of the Atlantic Zone (scale 1:200000) and of the Guacimo-Rio Jimenez-Siquirres area (scale 1: 100000).

Studies during 1989

Land use zone data (referring to both the small scale and medium scale products) on land use and land cover has been obtained. As well, data on farm sizes, among others, are available as a result of the earlier mentioned studies.

Plans for 1990

The methodology for the classification of the land use zones (i.e. labelling of the zones) will be designed. For this purpose, classification rules will be defined which use both the results from the aerial photographic interpretation and a related inquiry on the land use classification based on the remote sensing data.

Study 5. Soil variability study

Background

Soil variability plays an important role concerning the accuracy with which one can infer soil suitability or capability. Accurate statements are very important with regard to land evaluation and land use planning. The effect of soil variability taken in the context of the level on which one wants to make these inferences and the accuracy and reliability as consequence of the variability should therefor be investigated.

Objectives

The objectives of this study are:

- To investigate the soil variability in a few characteristic soil units or land units.
- To investigate the effect of the variability on statements concerning soil suitability (applying different models for suitability assessment).
- To determine the type of statements which can be made at the different scale levels.

Studies during 1989

Detailed auguring and sampling has been carried out on two characteristics, physiographic/soil units. The samples have been send to the laboratory for analyses.

Plans for 1990

These include not only elaboration of the data gathered the previous year, but also continuation of the variability study on some additional physiographic/soil units. Attention will also be devoted to the accuracy of soil unit boundary positioning.

Study 6. Other studies and plans for 1990

One study planned is the evaluation of actual land use with regard to soil suitability. In 1989 a preliminary soil map (1:200000) was digitized and the soil units were provided with a suitability class. As well, the preliminary soil map (1:100000) for the Guacimo-Rio Jimenez-Siquirres area was digitized. However, due not only to the preliminary character of both maps, but also to the doubts which existed about the accuracy of the maps, no work was done on the evaluation of the actual land use with regard to its soil suitability. Depending on the availability of the final maps in 1990, the study will be continued. The objective is to give an example of a possible application of soil- and land use data. The study will not be very extensive.

Depending on the availability of more recent satellite imagery, activities are planned concerning the inventory of land use changes. A try-out has been done in 1989, however until now acquisition of new data has failed due to cloud cover.

Publications in 1989

In 1989, one international publication was written. The following article has been accepted for GEODERMA, but has yet to be published:

VELDKAMP E., E.J.Huising, A.Stein & J.Bouma, in press.
Variability of banana yields as expressed by remote sensing data and soil data.

Subproject 3 Simulation of potential and water limited photosynthesis of banana, applied to Costa Rican circumstances.

Background

Banana is one of the most important export products of Costa Rica. Its cultivation is concentrated in the Atlantic Zone, where not only many people find employment in the plantations, but also more and more land is being occupied by banana plantations. A very important characteristic determining the aptitude of a soil for banana growth is its drainage condition. In order to obtain high yields, much money is invested in constructing artificial drainage systems.

Objective

Until now only a qualitative evaluation of the aptitude of soils for banana growth has been possible. Thus, the objective of this project is to develop a banana growth simulation model in order to enable quantitative evaluation of various production situations, especially for the less suitable soils according to the qualitative evaluation system.

Responsibilities

The following staff has implemented this project:

- Personnel time: Ir. S. de Bruin.
  ASBANA has been invited to participate;
- Scientific guidance: Prof.dr.J. Bouma, Dr.W.G. Wielemaker.

Studies during 1988-1989

In August 1989, a report on modelling of banana photosynthesis that applies to Costa Rican circumstances was finished.This is described in:

BRUIN, S. de, 1989. Simulation of potential and water limited photosynthesis of banana, applied to Costa Rican circumstances. Field Reports No. 45. Atlantic Zone Programme. CATIE. Turrialba, Costa Rica.

This report describes a preparatory study for the design of a banana growth simulation model. Physical soil properties and data that were reported by weather stations in the Atlantic Zone of Costa Rica have been processed in the study.

As a continuation of the research, a study was initiated in October 1989 to investigate the correlation between simulated

photosynthesis and banana production as it is reported by plantations in the Atlantic Zone.

Contacts have been made with ASBANA to establish a co-operative agreement and to find external funding for future research towards the design and validation of a banana growth simulation model.

Plans for 1990

In January, a pot experiment with young banana plants will be carried out. Its purpose is to define the decline in transpiration rate by banana leaves with increasing water contents in the rooted zone. A draft article is to be completed in March.

A proposal will be presented to ASBANA before the end of March.

Publications

" Simulation of potential and water limited photosynthesis of banana, applied to Costa Rican circumstances " (article).

" Diseño y validación de un modelo de simulación del rendimiento del cultivo del banano en la Zona Atlántica de Costa Rica " (research proposal).

4.3 Studies of production systems

Three major agricultural land uses of the Atlantic Zone are studied: cocoa, plantain and tuber crops. They are widely different with regard to their interaction with ecological conditions, their agronomic bottlenecks and socioeconomic problems. Their study involves a range of objectives, approaches and methods. Some goals include the diagnosis of bottlenecks, testing of alternatives and preparation of a feasibility study. The study methods consist of informal and structured interviews, (participatory) qualitative and quantitative observations, and researcher managed, adaptive and farmer designed and managed experiments.

The binding elements of the studies are their emphasis on sustainability, their systems approach and their orientation on small scale farming. The research is aimed at improving the sustainability of the land uses studied - their ecological stability, economic feasibility and social attractiveness. Land uses are seen as systems in which ecology and society interact; even where only a part is studied this should be done within the context of the larger whole, a production system, farming system or regional system. The land uses under study are highly relevant for small farmers, directed at bottlenecks in their production

systems, and intended to help them device alternatives to having to become labourers on large scale (banana) plantations. These, due to their unbalanced socioeconomic structure and excessive use of chemical inputs, do not offer a sustainable solution for the agrarian problems of the Atlantic Zone.

All PZA production systems studies complement the research priorities of MAG and CATIE. Information on and understanding of the ecology, agronomy and socioeconomics of the studied systems is also an essential element for the land evaluation and land use planning.

4.3.1 Inventory and analysis of cocoa production systems

Background

The appearance of the monilia disease a decade ago has caused a strong drop in cocoa yields, areas and production in Costa Rica. The introduction of hybrids developed by CATIE have contributed to the reversal of this trend. However, many farmers complain that the hybrids yield much less than expected.

Objectives

The objective of this study is to inventory and analyze the bottlenecks in cocoa production systems in the Atlantic Zone of Costa Rica with the aim of improving research orientation and extension packages.

Responsibilities

The research forms part of the "Improvement of Tropical Crops" programme of CATIE and is supervised by Dr. J.J. Galindo (CATIE) and Prof.dr. M. Wessel (AUW). The selection of plots is done in cooperation with the Centro Agricola Regional of MAG in Siquirres. Daily responsibility rests with Ir. H. Waaijenberg (CATIE/UAW/MAG), 30 % of his time is charged to this project.

Studies during 1987-1989

In 1987 a study was made of cocoa production systems in the northern part of the Atlantic Zone, with emphasis on the transfer of technology. Results are summarized in:

GROOT, A. de. 1989. Cocoa knowledge networks: the emergence of formal and informal articulation. In BOX, L. (ed.), 1989.

From common ignorance to shared knowledge: knowledge networks in the Atlantic Zone of Costa Rica. Agricultural University Wageningen. Wageningen, the Netherlands.

During February and March 1989 the life and farm histories of two cocoa farmers - supposedly the "best" and the "worst" - in the Neguev settlement scheme were studied in order to provide insight into what motivates people to grow the crop, but also how to do it.

In April, a study started with the aim to design and test a rapid methodology for the quantitative diagnosis of limiting factors for growth in hybrid cocoa fields. Field work consisted of a detailed quantitative study of five cocoa fields across the Zone in order to collect data for the elaboration of appropriate sampling methods. In July a preliminary analysis was completed and is described in:

WIGBOLDUS, S.A., 1989. Caracterización estadística de cinco parcelas de cacao en la Zona Atlantica de Costa Rica. Un analisis preliminar. Field Reports No. 41. Atlantic Zone Programme. CATIE. Turrialba, Costa Rica.

During the second half of 1989, the analysis was continued, sampling methods were chosen, and sample trees in the fields of 20 farmers in the cantons of Guacimo and Talamanca were selected. The phenology and yields of these trees will be recorded every three months during at least one year in order to identify and quantify yield limiting factors. The results can be used to suggest improvements at the farm level (for the sample fields only), in extension messages and in research orientation.

Parallel to the agronomic work between July and December of 1989, a study was made of the marketing of cocoa, first within Costa Rica in general and later within the Sixaola valley of Talamanca canton, in detail.

Plans for 1990

The trimonthly quantitative observations on sample trees in farmers' fields will be continued until October 1990. Some alternative sampling methods will be tried and the farmers will be interviewed about their crop management methods. Follow-up depends on the results obtained. Student input for this study will be 18 months (+ perhaps 12 months M.Sc. CATIE).

Main products

These include:

- The diagnosis of their fields will be discussed with the farmers;

- Methodology and general results will be discussed with MAG researchers and extensionists and made available in Spanish and English;

- Reports will be produced on:
  " Diagnostico cuantitativo de parcelas de cacao hibrido en la Zona Atlantica de Costa Rica. (Informe CATIE/UAW/MAG) ";
  " Diagnostic methodology for the quantitative analysis of yield limiting factors in cocoa: a study in the Atlantic Zone of Costa Rica (Article) ".

4.3.2 Phenology and agronomy of plantain cropping systems

Background

Plantain is one of the principal small farmers' cash crops of the Talamanca canton of Costa Rica, and is grown not only for the national, but also for the export market. Yields are low due to continuous rat cropping which favours pests and diseases and exhausts the soil.

During field work in the Sixaola valley in 1988, a farmer was met who was experimentally evolving alternative ways of growing plantain, based on rotation and relay-cropping instead of ratooning. His alternatives may enable continuously high plantain yields with low use of chemical inputs.

Objectives

The objective of this project is to evaluate the usefulness of the changes proposed by the experimental farmer.

Responsibility

The research is linked with genetic improvement of plantain by the "Improvement of Tropical Crops" programme of CATIE. It complements both CATIE projects on agroforestry and conservation in the same geographical area and efforts by MAG to improve the production and marketing of plantain in the Sixaola valley. It is coordinated by Ir. H. Waaijenberg (CATIE/UAW/MAG), 40 % of whose time is charged to this project.

Studies during 1987-1989

In 1987, a multidisciplinary team made a regional analysis of two districts of Talamanca canton and published the following report:

BOK A.M. et al., 1988. Analisis regional de la problematica agraria de los distritos Cahuita y Sixaola del canton de Talamanca, Costa Rica. Working Documents No. 3. Atlantic Zone Programme. CATIE. Turrialba, Costa Rica. (to be summarized in article in Revista Turrialba)

A review was made of the major small farm cropping system, the growing of plantain, in the Sixaola valley. During this study an experimenting farmer was met. The following report was published:

ROSEBOOM, P., 1988. El cultivo de platano en el valle de Sixaola, Costa Rica. Field Reports No. 27. Atlantic Zone Programme. CATIE. Turrialba, Costa Rica.

In August 1989 a study was initiated to compare two of the experimenter's plantain plots with two much better than average plots of nearby farmers and with a demonstration plot of MAG. The work consists of:

- determination of the history of the plots and crops by interviews and observations;
- trimonthly characterizations in terms of plant arrangement and density, leaf area, soil fertility and nematodes;
- biweekly observations of flowering and harvesting and interviews about crop husbandry and marketing;
- informal talks with farmers to find out what determines their choice of activities and the manner in which they carry those out.

Between October and December 1989, in the same area, a survey with structured interviews and case studies was made of the marketing problems of cocoa, root and tuber crops and plantain.

Plans for 1990

The phenological and agronomic observations and interviews will be continued until October 1990. Student inputs during 1989: 12 months.

Main products

These include:

- Group meetings with Talamanca farmers and MAG researchers and extensionists to discuss findings;
- Aspectos agro-económicos del cultivo de platano en el valle de Sixaola, Costa Rica: discusión de un experimento campesino. (Informe CATIE/UAW/MAG);
- Agronomic aspects of plantain growing in the Sixaola valley,

Costa Rica: discussion of farmers' experiments (article).

4.3.3 Root and tuber crops based sustainable cropping systems

Background

For many decades, maize and cocoa have been the principal cash crops for small farmers in the Atlantic Zone. The monilia disease of cocoa and marketing problems in maize have stimulated interest in alternative crops like root and tuber crops. These are among the few annual crops (rapid return) that can be grown successfully in the Zone.

Objectives

One of the best adapted to the hot and humid climate, Eddoe (Colocasia esculenta var. antiquorum) has low yields. The objective of this project is to study the ecophysiology of this Araceae as a basis for the design of both profitable and sustainable (multiple-) cropping systems.

Responsibilities

The research forms part of the "Improvement of Tropical Crops" programme of CATIE and is supervised by Dr. V. Villalobos (CATIE) and Dr. M. Wessel (AUW). It is carried out in cooperation with Ing. E. Aguilar (MAG), Ing. C. Calderon (MAG) and Ir. F.C.T. Guiking (UAW). Daily responsibility rests with Ir. H. Waaijenberg (CATIE/UAW/MAG), 30 % of whose time is devoted to this project.

Studies during 1988-1989

In 1988, an inventory was made of cultivation practices and the importance of the main root and tuber crops of the Zone. A preliminary report has been completed:

STOLZENBACH, A., 1989. Notas sobre raices y tuberculos en la Zona Atlantica de Costa Rica. Field Reports No. 40. Atlantic Zone Programme. CATIE. Turrialba, Costa Rica.

From March to December 1989, a field experiment to study the production and distribution of biomass in eddoe was carried out, in preparation for a detailed study of the ecophysiology of the crop (see below). Understanding the ecophysiology of this little studied crop will support the interpretation of agronomic experiments by CATIE,MAG, ITCR and UCR.

A related date-of-sowing trial with maize laid the basis for an experiment to investigate the potential of relay-cropping for weed control in eddoe and the competition for nutrients between the crops.

Plans for 1990

In January a relay-cropping experiment with maize-eddoe will be started, having the following activities:

- planting maize in January and March, eddoe in March and May;
- harvesting maize in May and July, eddoe in October and December.

Student input will be nine months (+ perhaps six months M.Sc. CATIE).

In May 1989, a Ph.D. project was formulated and submitted to WOTRO for funding, called " the ecophysiology of eddoe (Colocasia esculenta var. antiquorum) ". If funding is obtained field work may start by mid 1990.

Main products

Products expected from this project are:

- Producción y distribución de biomasa en chamol (Colocasia esculenta var. antiquorum): un experimento en el canton de Guacimo, Costa Rica. (Informe CATIE/MAG, con E. Aguilar y C. Calderon)

- El cultivo en relevo de maíz y chamol: un experimento en el canton de Guacimo, Costa Rica. (Informe CATIE/UAW/MAG; article)

- Production and distribution of dry matter in eddoe (Colocasia esculenta var. antiquorum): an experiment in the Atlantic lowland of Costa Rica. (Summarizing article, with E. Aguilar)

- Evaluación de un metodo para estimar el area foliar en chamol (Colocasia esculenta var. antiquorum). (artículo en Revista Turrialba)

5 CONTACTS WITH CATIE, MAG AND OTHERS

5.1 CATIE

In the first half of the year, there was some commotion at CATIE about another way of dealing with project leadership and an evaluation of its personnel. At the same time, most of the staff at the Dutch embassy was renewed and needed also some information about CATIE, certainly now that there were some negative rumours. In July the embassador, Mr. D. van Houten, paid a visit to CATIE and expressed afterwards that he was most impressed by various activities under way. Dr. Wienk played an active role in the preparation of the visit. It was considered of the utmost importance for a further development of the cooperative programme between CATIE and AUW, for which external funding is needed and the Dutch Technical Cooperation a natural donor.

The proposal for a course on Nematology, to be financed by the Dutch Government was at first rejected. After the visit of the embassador the AUW started new negotiations with the Dutch Ministry of Development Cooperation and the case was reopened.

Oswaldo Torres left in December for a M.Sc. course in crop production (with emphasis on crop protection) at the AUW in Wageningen. Upon his return he will be strengthening the staff of the Nematology course.

During 1989, steps were taken to come to a further integration into the programmes and activities of CATIE, both by CATIE and the AUW. Dr. Wienk was appointed as coordinator of the interdisciplinary working group for the area piloto of the Atlantic Zone.

Drs. Casas and Parisi visited the AUW in September and came back with proposals for follow-up actions. The three main conclusions of the visits were:

- A mutual interest in multidisciplinary research in management and planning for natural resources;
- a further support from the AUW for the socioeconomic programme of CATIE would be appreciated;
- a broadening of the cooperation with new activities, for instance in biotechnology.

During the visit by Boerrigter in December, it was agreed that visits in 1990 would occur from CATIE to AUW, two regarding education and two in research.

Drs. Casas, Burgos and Mujica paid a one day visit to Guápiles to learn more in detail about the PZA. In the morning, an office review was given by Waaijenberg and Wielemaker; in the afternoon the progress of some research in the Neguev was shown. The visit

was combined with the project of Dr. Frank Romero and Mohammed Ibrahim M.Sc. The relation with this project is a close one and interchange of students regularly happens.

Bronkhorst attended the fourth meeting of CATIE's regional network on cooperation in higher education and training in agriculture and natural resources (REDCA). The meeting was held at the end of August in Tegucicalpa, Honduras.

5.2 Ministerio de Agricultura y Ganaderia

The excellent relationship which exists with the landlord, the experimental station "Los Diamantes" at Guápiles, continued in 1989. A close working relation has been established with the Soil Conservation Service and conversations have been held to develop a joint project. Unfortunately, the proposed funding by FAO has not been assured.
The programme continues using the services of the soil laboratory in Guadelupe. This gives the personnel there the advantages of both in-service training and possibilities of working with material the Ministry cannot afford.

When the Director General for Research and Extension returned from abroad, discussions were held to identify joint research activities. These will be further elaborated in 1990.

5.3 Others

The PZA has reviewed cooperative projects with the UNA/RUU/ECA project on Desarrollo Rural. Joint research through student activities seems promising. A possible objective might be joint research in the area piloto.

6 TRAINING

6.1 Costarican students

One of the objectives of the PZA is training. The participation of students from regional and Costarican institutes of higher education has been sought through the postgraduate courses of CATIE and in 1990 result are expected.
One student from the Universidad de Costa Rica has done his thesis work within the PZA and is nearing graduation.
Two students from the Universidad Nacional Autonoma de Heredia came to do soil fauna studies, for a half year each, starting in August.

6.2 Dutch students

Twenty eight Dutch students did their practicals or their thesis research in Costa Rica. Twenty two were from the Agricultural University Wageningen, the other six from the University of Utrecht (4), the Free University of Amsterdam and from the Catholic University of Nijmegen.

Twenty two students participated in the PZA. Four worked in other programmes, MSc-courses or projects of CATIE, and two stayed with other institutions in the country. The cumulative time spent by these students in Costa Rica amounted to 141.5 months.

The numbers of students per discipline were as follows:

Agronomy	6*	Grassland Science	2
Biology	1	Nematology	1
Development Economics	-	Marketing	2
Forestry	2	Rural Sociology	3*
Geodetics	2	Soil Science	10

* : one student did a combined study both in agronomy and rural sociology.

6.3 Local personnel

Emphasis has been placed on training local personnel during 1989. All administrative and technical assistants have taken computer courses (Lotus 123 and WordPerfect 5.0). Other opportunities will be considered in 1990, taken into account their usefulness for the programme.

6.4 Other

Two members of the Soil Conservation Service of MAG participated during three to four weeks each in soil mapping, which is considered a type of in service training for them.

Some trials of eddoe and maize were jointly executed with people from MAG.

On two occasions, a group of CATIE students took a field trip in the Atlantic Zone to review the soil projects of the PZA.

7 INFRASTRUCTURE

7.1 Buildings

The Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) in Turrialba served as the official headquarters of the PZA.

The Ministry of Agriculture (MAG) of Costa Rica provided the PZA with field office space and lodging facilities at the premises of " Los Diamantes ", its experimental station in Guápiles in the Atlantic Zone. Further modifications and improvements were started to these accommodations, which should result in increased office space and a field lab.

7.2 Equipment

In the course of the year, a PC/AT computer was purchased. At the end of the year, three more personal computers (PC/XT) were acquired, of which two portables. This brought the total number of PC's to thirteen. Two of these are installed in the coordinator's office in Turrialba, and nine in the PZA's field offices in Guápiles and the two portables are being used in the field, principally in the remote canton of Talamanca. An additional uninterruptable power supply unit was purchased to match the increased number of personal computers.

Furniture and electrical appliances were purchased for the house of the programme coordinator. An electronic balance (0-5000 gram; x 1 gram) was bought for agronomic research purposes. The programme purchased a polarization microscope for the geological research of Nieuwenhuyse.

7.3 Transportation

The PZA still has seven four-wheel drive vehicles and a station-wagon. In the first half of the year, all two year old vehicles were traded in for new ones.

Since very few people hold an appropriate driver's license there seemed little point in maintaining four motor cycles. Two were donated to CATIE at the end of the year, as the agreement specifies.

7.4 Other facilities

This year, most of the soil analytical work was done by the laboratory for soil analysis of the Ministry of Agriculture; only samples for special analyses were sent to Wageningen. Chemicals, spare parts and some minor pieces of laboratory equipment were bought to enable MAG to carry out this work, particularly when specific analyses were required. The PZA paid salaries for two laboratory assistants and a part-time (50%) analyst.

7.5 Expenditures

The expenditures for 1989 are shown below:

Personnel	ƒ 246.000
Housing	9.000
Office	18.900
Travelling	68.000
Research	123.200
General	9.500
Capital equipment	57.600
Total	ƒ 532.000

The funds budgeted for the PZA for 1989 were adequate. However, as in 1988, programme expenditures were less than had been expected. The favorable exchange rate of the US dollar against the dutch guilder and the regular devaluations of the Colon against the US dollar (15% for the year), mostly explained for the underrealization.

8 PRESENTATIONS AND PUBLICATIONS

8.1 Presentations

In March, both Waaijenberg and Wielemaker attended the presentation of the PZA in Wageningen. Here also Dr. Rodrigo Tarté and Dr. José Luis Parisi of CATIE gave acte de présence.

In September Wim G. Wielemaker attended the second Latin American course on the application of the technology of geographical information systems and participated in the subsequent conference on the same theme, in Caracas, Venezuela. Half october he participated in the annual convention of the American Society of Agronomy, the Crop Science Society of America and the Soil Science Society of America in Las Vegas, USA, where he presented a poster.

8.2 Publications

The PZA distinguishes three series of reports: Programme Papers, Working Documents and Field Reports.

The Programme Papers form a series of official publications while the Working Documents comprise papers with limited distribution. Opinions expressed and conclusions presented in the Working Documents are not necessarily those of the PZA.

The Field Reports form a series of unpublished reports prepared by students or staff of the PZA and similarly to the Working Documents opinions expressed are the author's own.

See Annex 1 for a complete list of these documents and their respective dates of publication.

Towards the end of the year a start was made with the upgrading of some of the field reports with the aim of converting them into readable and presentable publications.

By the end of the year drafts were ready of the monographs on each of the three subareas. The draft monograph on Río Jiménez was complete by september and sent to the editorial committee of CATIE. Observations and comments received so far have been partially incorporated. Professional correction and editing is only for the Neguev study still under way.

ANNEX I

PUBLICATIONS

ANNEX I PUBLICATIONS

PROGRAMME PAPERS

SLUYS, F. van et al. 1987. Agriculture in the Atlantic zone of Costa Rica. Summarizing report of an exploratory survey. Serie Técnica. Informe técnico No. 123. CATIE-UAW-MAG. Programme Paper No.1. Turrialba, Costa Rica.

ANONIMO. 1987. Agricultural research programme in the Atlantic Zone of Costa Rica. CATIE-UAW-MAG. Programme Paper No. 2. Turrialba, Costa Rica.

ANONIMO. 1987. Programa de investigación agropecuaria en la Zona Atlántica de Costa Rica. Atlantic Zone Programme CATIE-UAW-MAG. Programme Document No. 3. Turrialba, Costa Rica.

SLUYS, F. van; H. Waaijenberg; W.G. Wielemaker & J.F. Wienk. 1989. Agricultura en la Zona Atlántica de Costa Rica. Informe de estudio exploratorio. Serie técnica. Informe Técnico No. 141. Turrialba, Costa Rica. Programme Papers

WORKING DOCUMENTS

ANONIMO. 1986. Estudio exploratorio de la Zona Atlántica de Costa Rica. Informe Preliminar. Atlantic zone Programme CATIE-UAW-MAG. Working documents No. 0. Turrialba, Costa Rica.

WIENK, J.F. et al. 1987. Workplan first half 1987. Atlantic Zone Programme CATIE-UAW-MAG. Working Document No. 1. Turrialba, Costa Rica.

WIENK, J.F. et al. 1987. Workplan second half 1987. Atlantic Zone Programme CATIE-UAW-MAG. Working Documents No. 2. Turrialba, Costa Rica.

BOK, A.M. et al. 1988. Análisis regional de la problemática agraria de los distritos Cahuita y Sixaola del Cantón de Talamanca, Costa Rica. Atlantic Zone Programme CATIE-UAW-MAG. Working Documents No. 3. Turrialba, Costa Rica.

BOLAÑOS, C. & C.E. Ulate. 1987. Los problemas jurídicos agrarios de la provincia de Limón. Atlantic Zone Programme CATIE-UAW-MAG. Working Documents No. 4. Turrialba, Costa Rica.

WAAIJENBERG, H. 1988. Ejemplos de la similitud y de la diversidad del agro en la provincia de Limón, Costa Rica. Contribución al sondeo del Programa de Incremento de la Productividad (PIPA) del Ministerio de Agricultura y Ganadería (MAG). Atlantic Zone Programme CATIE-UAW-MAG. Working Documents No. 5. Turrialba, Costa Rica.

ANONIMO. 1989. Taller investigación y desarrollo en la Zona Atlántica de Costa Rica. Organizaciones resúmenes y resultados de los grupos de trabajo. Atlantic Zone Programme CATIE-UAW-MAG. Working Documents No. 6. Turrialba Costa Rica.

FIELD REPORTS

No. 1 KLOOSTERMAN, H., J.S.A. Slijkhuis & W.G. Wielemaker. Exploratory survey in the Atlantic Zone of Costa Rica. Contribution of the land group.

No. 2 VRIES, P. de. Exploratory survey in the Atlantic Zone of Costa Rica. Sociological report.

No. 3 WEIDE, A.P.A. VAN DER. Exploratory survey in the Atlan tic Zone of Costa Rica. Animal production.

No. 4 SCHIPPER, R.A., Exploratory survey in the Atlantic Zone of Costa Rica. Development economics.

No. 5 WAAIJENBERG, H., Exploratory survey in the Atlantic Zone of Costa Rica. Cropping systems.

No. 6 ROMEIJN, P., J. Slijkhuis & F. Staudt. Exploratory survey in the Atlantic Zone of Costa Rica. Contribution of the forestry disciplines.

No. 7 EE, S. VAN, M.P. Grundeman, T.M. van der Hel, J.J. Ottens. The Atlantic Zone of Costa Rica. Agriculture in the Talamanca and Pococi/Guacimo study areas.

No. 8 JANSSEN, J.W.H., H.J.M. Meuffels. Detailed soil survey of Hacienda Breemen.

No. 9 BEKS, J.P., P.E. van Olst. Un levantamiento detallado de los suelos de parte del Asentamiento Neguev.

No.10 DAM, R. A detailed soil survey of the Rio Jiménez área in the Atlantic Zone of Costa Rica.

No.11 ROMEIJN, P. C. Driving forces behind the deforestation of Costa Rica's Atlantic Zone. A socioeconomic evaluation.

No.12 MUDDE, H. Interacciones entre funcionarios del IDA y parceleros del Asentamiento Neguev.

No.13 KRUITER, A.H. El banano en el norte de la Zona Atlántica de Costa Rica.

No.14 ZAMBON, E.P. El componente arboreo en fincas en el norte de la Zona Atlántica de Costa Rica.

No.15 OTTENS, J.J. To Borden or not to Borden. Developments in dairy farming in the Atlantic Zone of Costa Rica.
No.16 BRINK, M. Doblar o quitar. Sistemas de producción de maíz en la parte norte de la Zona Atlántica de Costa Rica.

No.17 NOBBE, H.J. Grassland vegetation as influenced by soil and management. A study in the Río Jiménez district, Atlantic Zone of Costa Rica.

No.18 LANSU, A. Soil structure under four land use types in the settlement Neguev, Atlantic Zone of Costa Rica.

No.19 KAMMAN, Ch. A. Een kolonisatiedorp. Een kijk op de encuesta general.

No.20 NIEUWENHUYSE, A. & Q. de Jong van Lier. Estudio semidetallado de la geomorfología y los suelos de Cocori, Zona Atlántica de Costa Rica.

No.21 BROOIJMANS, W.J.A.M. La colonización espontánea de Cocori, Zona Atlántica de Costa Rica. Un estudio con enfoque socio-histórico.

No.22 ROSEBOOM, P. El cultivo de plátano en el Valle de Sixaola, Costa Rica.

No.23 HAAN, J.C.M. de. El cultivo de pejibaye en la Zona Atlántica de Costa Rica.

No.24 BRUIN, S. de. Estudio semidetallado de los suelos del Asentamiento Neguev y áreas adyacentes.

No.25 NIEUWENHUYSE, A. Application of wofost, duet and quefts for modelling maize and grass production, using data from the Atlantic Zone of Costa Rica.

No.26 PASCHA, H.J. Ornamentales en la Zona Atlántica de Costa Rica.

No.27 GROOT, A.A. de. Kennisoverdracht rond cacao in de Atlantiche Zone van Costa Rica.

No.28 HAAN, J.C.M. de. El cultivo de macadamia en la Zona Atlántica de Costa Rica.

No.29 ERENSTEIN, O. Los cultivos de maíz y yuca en el distrito de Rio Jimenez, Zona Atlántica de Costa Rica. Un estudio con énfasis en clima, operatividad y rendimiento.

No.30 KOFFEMAN, A.I. La ganadería en pequeña escala en el norte de la Zona Atlántica de Costa Rica.

No.31 HIJFTE, P.A. van. La ganadería de carne en el norte de la Zona Atlántica de Costa Rica.

No.32 WOLFF, S. de. Soil degradation in relation to land use in the Atlantic Zone of Costa Rica.

No.33 VERBRAEKEN, J.A.A. Deforestación, vegetación y manejo (Agro) forestal en la Zona Atlántica de Costa Rica.

No.34 BALTISSEN, G. Effects of forest clearing and land use on soil properties of two land use sequences in Cocori, Atlantic Zone of Costa Rica.

No.35 ERENSTEIN, O. Nutrient availability classification of soils used for maize in Río Jiménez district, Atlantic Zone of Costa Rica.

No.36 EE, S.B. van. & J.M.M. Helmer. La fruticultura en el norte de la Zona Atlántica de Costa Rica.

No.37 SPAANS, E. Fysische karakterisering van compactie als gevolg van vegetatieverandering in twee ontbossingssquenties in Costa Rica.

No.38 JANSSEN, J.W.H. De invloed van fosfaatbeschikbaarheid, zink - en kopertoxiciteit en bekalking op de groei van mais in vijf gronden uit de Atlantische zone van Costa Rica.

No.39 HERMSEN, M.H.H. Niet alleen maar groen samenstelling, beheer en productiviteit van graslanden in Pococí en Guacimo, Costa Rica.

No.40 STOLZENBACH, A.F.V. Notas sobre la producción de raíces y tubérculos en la Zona Atlántica de Costa Rica 1986-1988.

No.41 WIGBOLDUS, S.A. Caracterización estadística de cinco parcelas de cacao en la Zona Atlántica de Costa Rica.

No.42 LEEUWN, H.J.C. VAN; E.J.A. Spaans & J.J. Stoorvogel. Estudio semidetallado de los suelos en el área de Guápiles y Guácimo.

No.43 SCHELTEMA, T.G. La auto-incompatibilidad en los híbridos de cacao del CATIE. Un estudio en la finca "La Lola", Zona Atlántica de Costa Rica.

No.44 HEMMES, C.L. Primeros resultados de un experimento con chamol (Colocasia esculenta var. antiguorum) en la Zona Atlántica de Costa Rica. Selección de cormelos para uso como semilla. Fórmulas para estimar las superficies de las hojas. Producción de biomasa durante los primeros tres meses.

No.45 BRUIN, S. DE. Simulation of potential and water limited photosynthesis of banana, applied to Costa Rican circumstances.

No.46 BRUIN, S. DE. Uso y cobertura de la tierra dictaminada por datos de sensores remotos. Estudio preliminar realizado en la Zona Atlántica de Costa Rica.

No.47 STIGGELBOUT, C. in press. Cobertura y uso de la tierra en la Zona Atlántica de Costa Rica: Un inventario por datos de senso remoto.