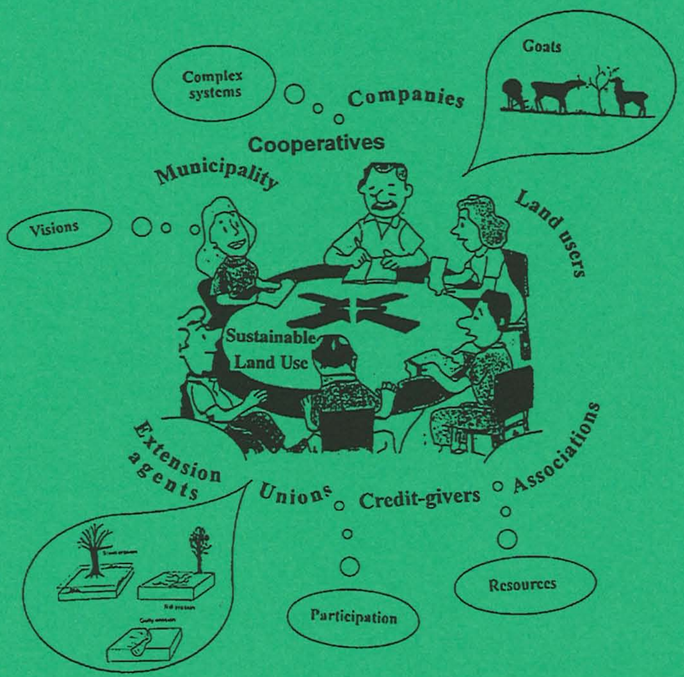
Land Evaluation Methodology

Small-Scale Agro-Pastoralist Farming Systems
Agricultural Community Case Study in the IV Region of Chile

Thomas Lustig



MSc Thesis (Examensarbete)
Supervisors (Handledare) **: Abraham Joel & Ingmar Messing**

Institutionen för markvetenskap
Avdelningen för lantbrukets hydroteknik

Swedish University of Agricultural Sciences
Department of Soil Sciences
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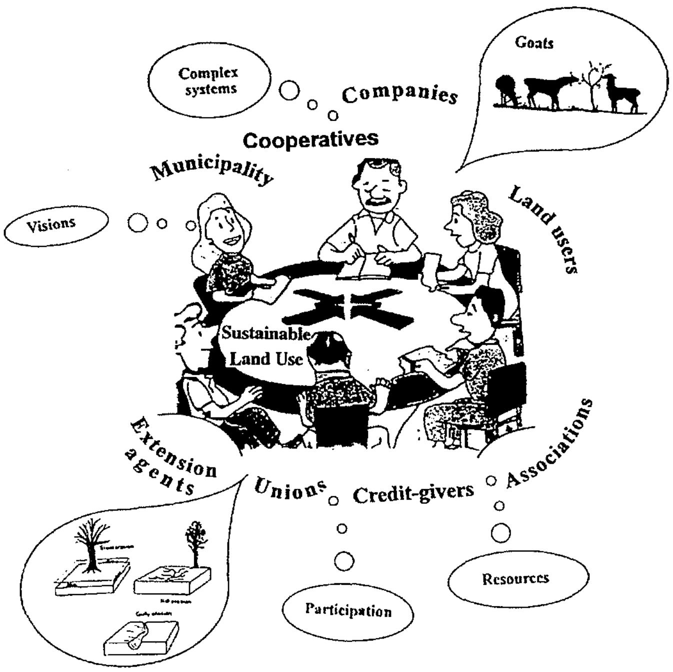

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CONTENTS

Abstract

This paper reviews non-computerised and computerised land evaluation methods or methodologies, and realises the difficulties to incorporate biophysical and socioeconomic factors from different levels. Therefore, this paper theorises an alternative land evaluation approach, which is tested and elaborated in an agricultural community in the North of Chile. The basis of the approach relies on holistic thinking and attempts to evaluate the potential for improving assumed unsustainable goat management practices. The concept of "potential for development methodology" (PDM) summarises this specific evaluation approach, of which, the soft systems methodology (SSM) is a crucial part. The purpose of SSM is to enhance the understanding of complex human situations that are perceived as problematic by stakeholders. Final results of PDM are potential classes, which indicate the ability of stakeholders to improve the actual situation. Comparing PDM with the land evaluation approach promoted by FAO, shows complementarity and possibilities to incorporate socioeconomic issues within the terminology of the agro-ecological zoning (AEZ) concept. Thus, this paper suggests a land evaluation approach that may facilitate the incorporation of socioeconomic characteristics from higher (e.g. governmental institutions) and local (e.g. NGOs and farmers) levels.

Resumen ejecutivo

Introducción

La gestión racional de los recursos naturales es vital a todos los niveles (mundial, nacional, regional y local). No obstante, Stomph *et al.* (1994) opinan que la planificación del uso de los recursos naturales frecuentemente no ha resultado según las expectativas, debido al método típico empleado: "top-down". Así, un problema importante de los gobiernos, investigadores, extensionistas y de los proyectistas involucrados en el Desarrollo Rural es: "cómo lograr soluciones sustentables en el uso de la tierra."

Obviamente, es necesario conocer el potencial de un área determinada para el llevar a efecto el desarrollo; por ejemplo, incrementar la capacidad para mejorar actividades presumiblemente no sustentables. No puede subestimarse la importancia de tener una metodología de Evaluación de Tierras, que permita un diagnóstico del potencial de un área específica.

Considerando que lo anterior constituye un punto complejo, este trabajo intenta encontrar una metodología manejable, orientada a evaluar el potencial de desarrollo de un área determinada. La base para el desarrollo de tal metodología, la constituye aquellos conceptos usados ampliamente por profesionales de ámbito del Desarrollo Rural.

La extensión de esta tesis para el grado de Master of Science fue de seis meses. De éstos, dos correspondieron a la campaña de terreno en Chile. El procedimiento de trabajo consistió en entrevistar, tanto a campesinos de la Comunidad Agrícola *El Almendro* (dos oportunidades) como a las instituciones que tienen actividades en o cerca de la Comunidad en cuestión. Los resultados obtenidos están dirigidos principalmente a profesionales e investigadores involucrados en la gestión sustentable de los recursos naturales.

La incorporación de datos biofísicos y socioeconómicos no es nueva en la Evaluación de Tierras, pero el enfoque metodológico de esta tesis puede generar conocimientos nuevos en este campo.

Métodos

Este trabajo fue estructurado en cinco etapas:

En primer lugar, se realizó una recopilación de información básica (datos biofísicos y socioeconómicos); para lo cual se efectuaron entrevistas con técnicas de diagnóstico rural participativo (PRA), combinadas con una revisión de literatura.

En segundo lugar, aquella información recopilada fue estructurada según el tipo de recurso (natural, social, equidad socio-económica, político, financiero, institucional, de infraestructura, conecciónes a otros sitios, productivos y humanos). Esta estructuración de los recursos proporcionó adicionalmente una orientación hacía puntos importantes, necesarios de incorporar en una Evaluación de Tierras.

En tercer lugar, se empleó la metodología de Zonas Agro-Ecológicas (AEZ) de FAO (FAO, 1981) para analizar el estudio de caso de *El Almendro*. Esta metodología considerada principalmente "hard", incluye información de carácter físico (datos "hard"); por ejemplo, datos del clima y los suelos. En este caso, el análisis de AEZ se hizo manualmente.

En cuarto lugar, se utilizó también la metodología de "soft systems" (SSM) para estudiar el estudio de caso de *El Almendro*. El uso de SSM en esta tesis es parte de una metodología considerada "soft", que contempla datos cualitativos; por ejemplo, las percepciones de los campesinos.

En quinto término, se compararon los resultados del caso chileno estudiado por ambas metodologías ("hard" y "soft"), a fin de evaluar tanto las diferencias, las fortalezas como los desafíos para el futuro.

Resultados

"Hard": La metodología de AEZ incluye dos clasificaciones de aptitudes del uso de la tierra: **1)** aptitud actual; **2)** aptitud potencial.

"Soft": La metodología "soft" de Evaluación de Tierras resultó en una clasificación potencial de las posibilidades para mejorar las actividades actuales no sustentables. En esta metodología no hay soluciones planificadas, como en el caso de la metodología "hard".

Discusión

Con las técnicas participativas (PRA) empleadas, los campesinos se concentraron en completar un cuadro de los recursos naturales, la infraestructura e instituciones de la Comunidad. Sin embargo, PRA no implicó automáticamente participación de los campesinos. Sin duda alguna, es importante explicar al entrevistado el propósito de la investigación, por qué se hacen ciertas preguntas, cómo los resultados van a ser usados y compartir experiencias.

Se debe enfatizar el hecho que la metodología de AEZ se aplicó en *El Almendro* en forma "top-down". La metodología en sí mismo no invita a la incorporación de los actores y de datos "soft". Estos últimos incluyen realidades sociales, percepciones de los campesinos, etc.

La fortaleza de la metodología "soft" radica en que pone los resultados dentro de un sistema de actividades humanas. El analista puede evaluar un sistema completo y no simplemente una actividad específica; por ejemplo, implementando medidas de conservación de suelo y aguas.

En el caso bajo estudio los subsistemas, incluidos dentro del sistema, se evaluaron desde niveles altos (instituciones gubernamentales, por ejemplo) y locales (ONG, el campesino, etc.), resultando "clases de potencialidad". Estas clases reflejan potencialidades de tomar acción hacia un estado deseado de actividades sustentables, en una perspectiva a largo plazo.

La debilidad experimentada por la metodología "soft" fue que la parte biofísica no consiguió mucha atención, al menos no en el sentido de evaluar la aptitud del suelo para producir cosechas. Por lo tanto, fue imposible evaluar las cifras económicas o hacer un análisis costo-beneficio de las medidas propuestas.

Las dos metodologías pueden complementarse, en términos que los resultados "soft" se pueden convertir a la terminología de la metodología "hard" (AEZ). Si bien la traducción de resultados entre ambas metodologías podría no ser apropiada, los subsistemas "educación-capacitación" y "marketing" son extraidos de la metodología "soft" para mostrar su utilidad. Como se aprecia en el Cuadro 1, las clases de potencialidad (muy baja, baja, moderada, alta) se hacen corresponder tentativamente a las clases de aptitud de AEZ (no apta, marginalmente apta, apta y muy apta).

La Evaluación de Tierras es un requisito para planificar el uso del terreno y asistir en el diseño de la gestión sustentable de los recursos naturales.No existe ningún diseño perfecto en una evaluación debido a falta de tiempo, financiamiento o competencia para analizar la compleja situación social. Los resultados empíricos provenientes de la teoría y del caso de estudio en *El Almendro,* sugieren **una Evaluación de Tierras tentativa** que incorpore actores.

Cuadro 1. Conversión de clases de potencialidad a clases de aptitud (AEZ)

Factores considerados	Metodología "soft" Clases de potencialidad	AEZ Clases de aptitud
Educación y capacitación	Moderada	Apta
Marketing	Baja	Marginalmente apta

Esta evaluación tentativa puede resumirse en el concepto de una Metodología para el Potencial de Desarrollo (Potential for Development Methodology, PDM). PDM no es una lista o una herramienta hecha, pero dirige la atención hacia puntos importantes para considerar durante el trabajo. El propósito de PDM es involucrar actores y evaluar las potencialidades para mejorar la eficiencia y aquellas actividades no sustentables. La metodología propuesta se resume brevemente como:

i) Uso de resultados: En esta etapa la estructura entera del trabajo depende de cómo los resultados van a ser usados y aplicados. Es entonces un requisito previo tener una visión de lo esperado para obtener resultados confiables e integrados. En este caso bajo estudio, los resultados van a ser usados para informar y negociar la realidad experimentada.

ii) Reunir información: Parece ser apropiado el uso combinado de revisión de literatura, entrevistas semi-estructuradas y un enfoque participativo. Lo importante es propocionar al analista información de diferentes disciplinas; pero además, éste debe involucrarse y compartir los pensamientos, percepciones y conocimientos de los actores.

iii) Estructurar la información: El uso que se dé a los diferentes "recursos" permite una orientación hacia puntos específicos, y ayuda a estructurar la información.

iv) Procesar la información: La base de PDM confía en actividades humanas y el sistema "soft" (SSM) incorpora un enfoque holístico y transparente de trabajo. Así entonces, se promociona una estrategia de recopilación de información como se ha explicado en **ii**).

v) Análisis de la información: El sistema "soft" contiene procedimientos fijos que permiten encontrar instituciones y/o actividades, para lograr la continuidad de un sistema con un fin determinado. Con este propósito se construye un modelo abstracto.

vi) Evaluación de la potencialidad de desarrollo: Se evalúan y agregan en clases de potencialidad las diferencias destacadas entre la situación actual y el modelo abstracto. Esto refleja la potencialidad del área estudiada para tomar acciones hacia un estado mejorado de actividades sustentables, en una perspectiva a largo plazo.

Muchas **limitaciones** pueden mencionarse con respecto al desarrollo y los resultados obtenidos por esta investigación. Estas limitaciones pueden ser abordadas como recomendaciones para desarrollar una Evalución de Tierra mejorada:

- A través de los años muchas investigaciones se han hecho sobre: energía soft y hard, pensamientos soft y hard, modelos soft y hard, "mujeres soft y hombres hard", soft-ware y hard-ware, etc. Sin embargo, lo difícil es definir realmente qué significan los términos "soft" y "hard".

- Investigaciones futuras deberían concentrarse en hacer más complementaria a la metodología soft dentro de la metodología hard, particularmente dentro de la nomenclatura de AEZ. Esto promoverá una manera de integrar datos de tipo socioeconómico, dentro de una terminología conocida de Evaluación de Tierras.

- La metodología "soft" puede ser de una gran potencialidad entre los mismos campesinos. Ellos podrían emprender un análisis de su situación de problema y destacar soluciones posibles. Los resultados podrían usarse en negociaciones con otros actores. Sin embargo, debido a diferentes razones ninguno de estas sugerencias se hizo en este trabajo.

- Una Evaluación de Tierras puede ser complementada con una Evaluación del Impacto Ambiental (Environmental Impact Assessment, EIA). De este modo se incluirían áreas fuera del ámbito del proyecto o investigación. Además, los EIA empieza a ser institucionalizado legalmente en muchos países y para el futuro será necesario investigar las relaciones entre una Evaluación de Tierras y una de Impacto Ambiental.

- No fue posible de investigar completamente la información básica (suelos, topografías, ingresos, etc.) de la comunidad de *El Almendro*. El área regada de la Comunidad no fue evaluada tampoco; esto es un debilidad por que el regadío es fundamental en un ecosistema semi-árido como éste.

- No se discute la incorporación de un Sistema de Información Geográfico (SIG).

PART I CONCEPTS AND LITERATURE REVIEW

1. Introduction

IFPRI (1996) states in a paper, "The 2020 Vision for Food, Agriculture, and the Environment", that more than 800 million people are food insecure, i.e. one in five people in the developing world. Over the next quarter of century the world's population expects to grow by ninety million people per year. The resulting strains on food supplies, agricultural production and environment will be enormous. Arnold (1992) says that of the worlds dryland areas used for agriculture, approximately 70 percent is affected by various forms of land degradation. Every year nearly six million hectares of previously productive land of the world dryland lose the capacity to produce food. Chidley *et al.* (1993) argue that the pressures on land infer a need to achieve a balance between the exploitation and conservation of land resources. Thus, rational management and use of resources are a vital issue at all levels such as, world, regional, national, sub-national and local. Nevertheless, Stomph *et al.* (1994) mean that land use planning efforts have often not lived up to expectations due to typical top-down approaches. Therefore, one main problem of governments, researchers, planners and development workers is *how* to achieve local sustainable land use solutions.

The suitability of a specific land use needs to be evaluated, which may be exemplified by FAO (1983): "The main objective of land evaluation is to put at the disposal of the user, whether farmer, planner, government official or politician, relevant information about land resources that is necessary for planning, development and management decisions." However, Beek *et al.* (1997) mean that placing land evaluation in the broader context of land use planning reveals "a potential gap between technology-oriented land resource specialists, concerned with the present and future performance of the land, and human-oriented scientists concerned with the land users and their well being."

This potential gap, as a consequence of difficulties in integrating knowledge by the land resource specialist and human oriented scientist, creates problems, misunderstandings and sometimes irrelevant land evaluation results. The importance of having a land evaluation methodology, which diagnoses a specific area and its potential for improving assumed unsustainable activities (development) cannot be underestimated. Therefore, this MSc paper intends to review concepts and appropriate land evaluation methods/ methodologies, widely used by development professionals. The issue is difficult to address and this MSc paper does not intend to solve the major complex issues but merely attempts to find a manageable methodology that can approach the challenge of integrating, e.g. agricultural production, social acceptance, financial feasibility and participation by stakeholders.

1.1 Aim and objectives

In total six months were spent on planning, reviewing literature, and undertake two months of field work in Chile and analyse the information. The results are mainly targeted towards professionals and researchers involved in sustainable land resources management. Analysing biophysical and socioeconomic factors is nothing new but professionals and researchers may regard the methodological approach of this paper as an attempt to produce new insights within the area of land evaluation.

The aim is to increase the knowledge in using a land evaluation methodology, which analyses the potential for development, incorporating biophysical- (e.g. soil, climate, crops, and crop requirements), social- (e.g. tenure regimes and stakeholders), and economic- (e.g. incomes, finances and employment) factors. The objectives are:

- to understand and use relevant concepts in the process of evaluating the potential for development of a specific area;

- to review land evaluation methods/ methodologies and test, in a case study, the appropriateness and suitability of one common, widely used land evaluation methodology;

- to review computerised models and their ability to incorporate the complexity of biophysical and socioeconomic factors;

- to test an alternative land evaluation methodology based on the theory from the literature reviews in the same case study as the widely used land evaluation methodology, and compare results.

1.2 The hypothesis

The basic assumptions of the hypothesis are that: **i)** compiling an interdisciplinary research team is difficult due to costs and time; **ii)** organising results is difficult due to different working concepts, definitions, and time- and spatial scales; and **iii)** making a synthesis of the research is difficult due to lack of a common platform, or vision, of how to use the results.

The hypothesis is that the basic assumptions show the necessity to have a strategy of action that provides direction in evaluating complex issues. Therefore, the ideal is to have a fruitful strategy that concentrates on a holistic approach. This assumes the whole being something more than its parts and the analyst tries to jump in and focus on details and then resume the whole perspective again. It is like working on micro level moving to a meta-level where the different parts are assembled. As part of the hypothesis, a single analyst expects to be able to conduct a holistic approach. The case study in Chile tests the hypothesis by using and evaluating the idea of "potential for development".

1.3 Case study in Chile

Two months were spent in Chile reviewing literature, interviewing actors such as, farmers, governmental institutions and NGOs. Most of the time was spent in Santiago complemented with field work in the IV Region of Coquimbo (Fig. 1).

The IV Region of Coquimbo, part of the Norte Chico (Small North), is situated between latitudes 29°02' and 32°16' S, and between longitudes 69°49' and 71°45'W. The territory constitutes of 40,658 km^2 and equals 5.4 percent of the total land area of Chile. Extensions of the area vary from sea level up to 5000 metres in the Cordillera of the Andes (INE, 1988). The region is divided into three provinces Elqui, Limarí and Choapa, which are further subdivided into fifteen communes and several communities. The regional population was 420 thousand in 1982/83 and estimated to be 553 thousand (1997) and 617 thousand by year 2005 (INE, 1996). In the region 120 thousand live in rural areas (INE, 1982).

More specifically the field work consisted of interviewing farmers of the agricultural community of El Almendro twice, and institutions and organisations having activities in or near El Almendro. El Almendro resides in the upper part of the catchment El Almendro, which is part of the commune of Canela and the Province of Choapa. The unit of analysis was agro-pastoralist households and interested farmers, both men and women, were interviewed. The interviewees are called farmers, land users or "comuneros" and used interchangeably in this paper. Canela has a population 1997 of 10 thousand persons of which approximately 31 percent live in poverty. The population is divided in 1,300 urban residents and 8,700 rural residents. There are 18 percent illiterates and 4.2 percent unemployment (MIDEPLAN, 1997). INE (1996) estimates the population of Canela by year 2005 to be approximately the same as in 1997, i.e. 10 thousand.

Collaborating institutions were the Department of Geography, and the Faculty of Agronomy and Forest at the University of Chile in Santiago.

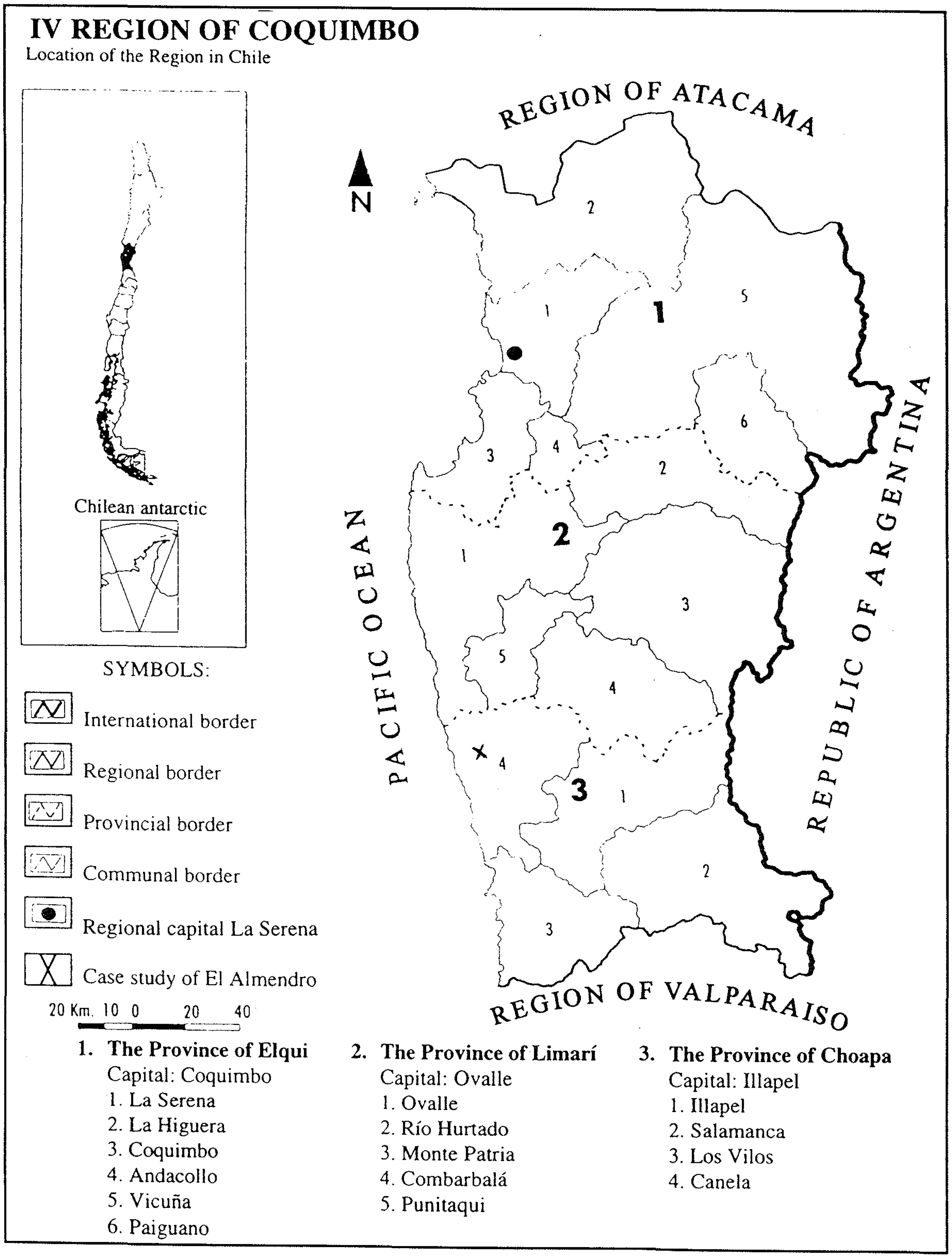

Fig.1. Chile and the IV Region of Coquimbo (adapted from: INE, 1995).

1.4 Disposition of the paper

The mode of working stimulated a mixture of results and comments, therefore, dividing the paper into three parts seemed appropriate.

PART I treats the concepts of sustainability, indicators, complex systems and soft systems methodology. The literature review consists of land evaluation methods/methodologies, computerised models, techniques for information gathering and a summary of chosen methods to analyse the case study.

PART II treats the case study results and discussions.

PART III treats the conclusions and recommendations.

2. Sustainability

The concept of sustainability raises many complicated and complex questions and this MSc paper only use it as a basis for further reasoning.

One of the most quoted definitions is the one by the World Commission on Environment and Development (WCED, 1987). WCED defines sustainable development that meets the needs of current generations without compromising the ability of future generations to meet their own needs. Lawrence (1997) thinks this definition provides an incomplete range of factors and is narrow, for instance, any characterisation of sustainability should encompass social, economic, physical, and environmental factors. The question of which "needs" to fulfil may be expressed in many ways depending on, who defines it, e.g. an economist, sociologist, psychologist or another profession.

The FAO Council (1988, cited in FAO, 1994) elaborated the concept of sustainability as: "Sustainable development is the management and conservation of natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development (in the agriculture, forestry and fishery sectors) conserves land, water, plant and animal genetic resources, is environmentally non degrading, technically appropriate, economically viable and socially acceptable."

The words "...to ensure the attainment and continued satisfaction of human needs..." imply a dynamic structure. Lawrence (1997) means that recognising the concept of sustainability as dynamic and derived from contextual factors helps to understand the many forms of interactions between different components. One definition derived from the discipline of ecological economics treat sustainability as boundaries and system thinking "Sustainability is a relationship between dynamic human economic systems and larger dynamic, but normally slower-changing ecological systems, in which 1) human life can continue indefinitely, 2) human individuals can flourish, and 3) human cultures can develop; but in which effects of human activities remain within bounds, so as not to destroy the diversity, complexity, and function of the ecological life support system (Costanza *et al.,* 1990, cited in Brorsson, 1995)."

Brorsson (1995) summarises sustainability as an idea treated differently by different people and professionals. However, as Brorsson puts it, the main core is the same, which means to make compromises and fulfil the current and future generations' materialistic needs. This leads back to the definition by WCED (1987) and the issue of finding the core of sustainability. The question is how to measure this core of sustainability? What is to be sustained in the first place? What resources, strategy and time perspective are necessary and available?

FESLM (Framework for evaluating sustainable land management) uses clear objectives as a foundation for sustainable land management (SLM). FESLM defines SLM as a combination of technologies, policies and activities aimed at integrating socioeconomic and environmental characteristics simultaneously resulting in five objectives: **i)** productivity - maintain or enhance production/ services; **ii)** security - reduce the production risk; **iii)** protection - protect the potential of natural resources and prevent degradation of soil and water quality; **iv)** viability - economic feasibility; and **v)** acceptability - social acceptance. Sustainability within the FESLM context is a measure of the extent to which a form of land use is expected to meet the requirements of productivity, security, protection, viability and acceptability. Thus, sustainability is a dynamic concept assuming that the conditions will change with the passage of time. Only if there is a positive balance of effects of interacting conditions with respect to the requirements will the land use remain sustainable (Smyth *et al.,* 1993).

In a report by Hinchcliffe *et al.* (1996) the authors state that significant improvements in agricultural production and food security in East and Southern Africa can be achieved with more sustainable agriculture. According to the same report, the literature does not show any clear integration between proponents of agricultural production and proponents of food security. This is a major obstacle to promoting sustainable food security. Hinchcliffe *et al.* make a link between sustainable agriculture and food security (Fig. 2) in which three conditions must be met: sustainable food production; environmental sustainability; and entitlements or access to food. These conditions take place within a certain policy context, which is partly decisive for the outcomes of achieving sustainable agriculture and food security.

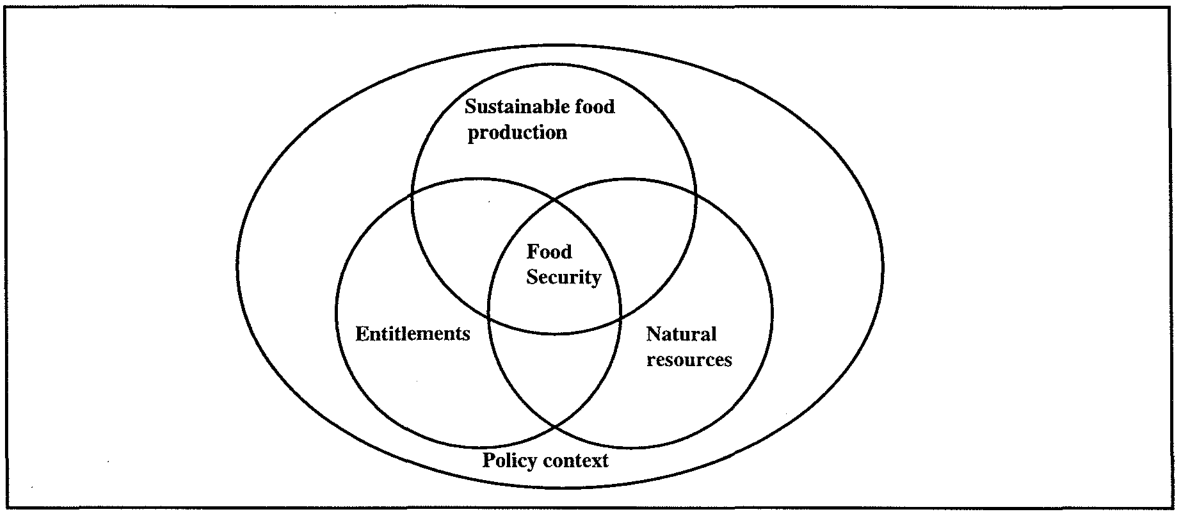

Fig. 2. Making the link of sustainable agriculture and food security (from: Hinchcliffe, Thompson and Pretty, 1996).

Fig. 2 infers complex connections and interactions consisting of biophysical, social and economic factors (Fig. 3). These factors are nested within a policy context partly deciding the outcomes. The area where the spheres intersect can be seen as a meeting place, or a platform, where different stakeholders meet for discussions on mutual problems. One main problem, however, is to arrange meetings between stakeholders on common grounds. Presumably, the success of achieving local sustainable land uses by addressing biophysical and socioeconomic factors, increases on a common platform.

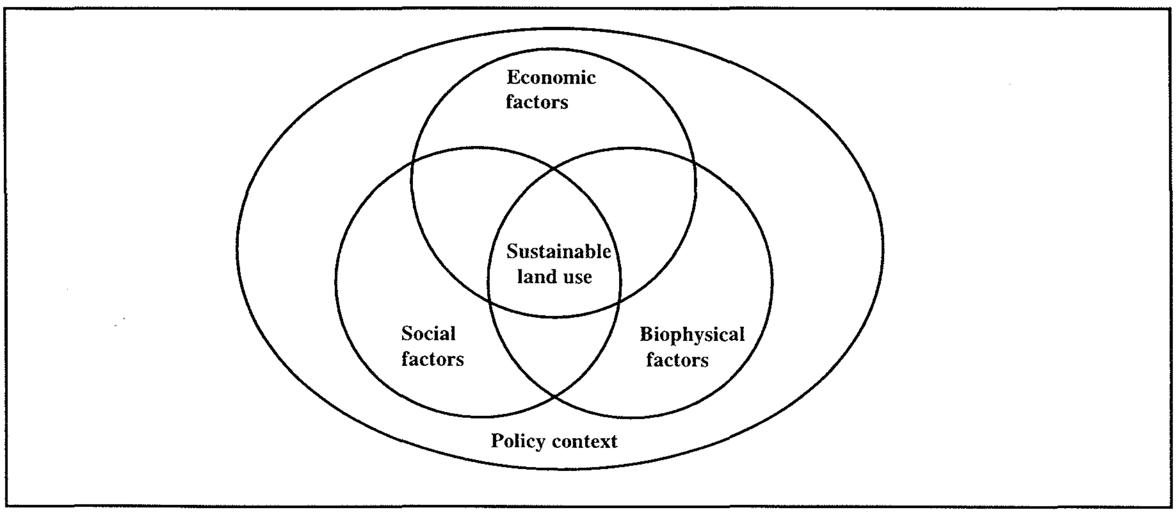

Fig. 3. Making the link between sustainable land use, biophysical, and socioeconomic factors within a policy context (adapted from: Hinchcliffe, Thompson and Pretty, 1996).

These factors are difficult to analyse separately and fruitfully evaluate the importance of interactions affecting each sphere. Conditions and knowledge change; communities and farmers should be encouraged and allowed to change and adapt too. "Sustainable agriculture is, therefore, a process for learning (Pretty, 1995a, cited in Pretty, 1997)." Therefore, Pretty (1997) states that there should not be prescribed and concretely defined packages of technologies, practices, or policies.

The theoretical reasoning of the sustainability concept within the context of this paper, shapes the further exploration of finding a manageable methodology to evaluate "the potential for development". Points to bear in mind are: **i)** the variety of sustainability definitions; **ii)** sustainability is a dynamic concept; **iii)** measuring sustainability is difficult; **iv)** links and interactions between factors are complex; and **v)** there is a possible meeting place or platform of socioeconomic and biophysical factors within a policy context.

Analysing the sustainability concept does not give the analyst a prescribed strategy, which according to the World Commision on Environment and Development (1987) is important for promoting "...harmony among human beings and between humanity and nature." There needs to be a principle that directs attention to important issues and factors to consider. The following Section 3 treats the concept of indicators and analyses its usefulness as a principle that may provide direction towards important considerations.

3 Indicators

The FAO treats the concept of indicators in Sustainable agriculture and rural development (SARD) and the World Bank treats monitoring indicators.

3.1 Sustainable agriculture and rural development

Tschirley (1996) mentions that indicators are pointers, which may reveal conditions and trends, and help in development planning and decision-making. These indicators integrate economic, social and environmental information and are growing in importance with the advent and follow-up to Agenda 21. They challenge the world community to (Tschirley, 1996): **i)** develop better information and reporting systems, especially for environmental indicators; **ii)** integrate socioeconomic and environmental indicators for greater sensitivity while planning and deciding; and **iii)** report regularly on trends and conditions.

Developing sustainability indicators must be closely tied to the development of national and sub-national information systems for agricultural planning and programming. Interactions between the environmental, social and economic components of sustainability need considerable field research to understand better how they affect each other and the driving forces that need to be measured. There is a need for participation and exchange between land users, institutions, planners and decision makers. This infers an essential participatory and transparent approach, which is fundamental to develop sustainable agriculture. Four thematic areas of SARD, which could be a useful starting point for indicator priorities and information needs are: **i)** policy adjustment and planning assistance, e.g. agricultural policy analysis, food security, forest use and management; **ii)** strengthening human resources and institutional capacity, e.g. nutrition and food quality, participation in rural development, training and education; **iii)** improved management of natural resources, e.g. land conservation, rehabilitation and efficient use of water resources, biodiversity; and **iv)** sound uses of agricultural inputs, e.g. plant nutrition and soil fertility, application and management of technology, pest and pesticide management (Tschirley, 1996).

Finally, the question is how to incorporate biophysical, environmental and socioeconomic factors into indicators? Tschirley says one could develop indicators for each of the four thematic SARD areas, but then lose interactions between important factors. Also, one critical factor is to include the performance of humans and institutions, i.e. including the stakeholders.

3.2 Monitoring indicators

Mosse and Sontheimer discuss in a World Bank Paper performance and monitoring indicators. Indicators function as measures of project impacts, outcomes, outputs, and inputs during project implementation to assess progress towards project objectives. Indicators are also used later to evaluate a project's success. A normal way of evaluating a project is by economic rates of return, cost-benefit analysis, etc., but these methods are not feasible or meaningful for every project. More adequate supervision and reporting system are needed that include the use of performance monitoring indicators derived from a project's development objectives and implementation plan (Mosse and Sontheimer, 1996).

Advantages of using performance indicators are to: **i)** help in clarifying the objectives and logic of the project; **ii)** inform resource allocators to take decisions and promote the most efficient use of natural resources; **iii)** provide feedback to revise plans, to identify areas needing improvement, and suggest what can be done; **iv)** measure what a project has achieved relative to its objectives; **v)** show officials and the public of the project's performance; **vi)** compare with other projects and generate data to improve the performance of other projects; and **vii)** assess whether and how the project has improved the beneficiaries' lives (Mosse and Sontheimer, 1996).

Having a logical framework to follow is necessary; otherwise it is nearly impossible to develop and use performance indicators. Mosse and Sontheimer describe the framework as a methodology for understanding complex projects, which can express clearly and understandably a project on a single sheet of paper. Information about project objectives, inputs, outputs, risks and critical assumptions and outcomes may then be viewed easily (Table 1). The framework does not replace, e.g. environmental impact assessment (EIA), cost-benefit analysis (CBA) but is only one of several tools to use. In Section 10.6.3 the conceptualisation by Mosse and Sontheimer explains a complex, hypothetical project.

Table 1. This is an example of how to understand a complex project with many components easily. Outputs and outcomes are the performing indicators given risks and critical assumptions (adapted from: Mosse and Sontheimer, 1996)

Objectives	Inputs (resources provided for project activities)	Outputs (goods and services produced by the project)	Risks and critical assumptions (the outcome is dependant on...)	Outcomes and impacts of project activities

The indicators suggested by Tschirley (1996) and Mosse and Sontheimer (1996) concentrate on different levels of action from global and national to local projects. As said before indicators monitor performances, reveal conditions and trends that help to take regulatory actions and change present states. Within the context of this paper the indicators should provide direction on what to concentrate on evaluating the potential for development. At the same time the indicators should structure the information of a specific area and be of help in development planning and decision-making. In short, definitions of concrete and useful indicators are necessary.

3.3 Useful indicators and resources

The reviewed literature treats subjects from various disciplines such as, "development", and related important factors, constraints and possibilities. Common features of the literature, i.e. useful indicators are aggregated into different "resources" to have a clear overview (Table 2). Reviewing many authors may be problematic since the whole spectra of opinions are included. This means that an analyst should not omit none of the mentioned indicators, because it may hamper the trustworthiness of an evaluation.

The division of the indicators can be argued and sometimes it is not clear-cut. For example, the "productive resources" contain employment as one indicator, but as such it generates money and could be divided into "financial resources". The division between "infrastructure and institutional resources" is diffuse. Why is banking services part of the infrastructure and not the institutional resources? At the moment these questions do not have importance for the further exploration of a manageable land evaluation methodology. The important thing was to depict relevant indicators and resources to use and test in the case study in Chile.

Table 2. Useful indicators aggregated into resources (from: Thompson and Pretty (1996), Hildyard (1996), Daily *et al.* (1995), Stern (1996), de Vylder (1995), Barraclough (1995), Hudson (1991), Scherr and Hazell (1994), Pieri *et al.* (1995), Pretty (1995b), Berkes and Folke (1992), and FAO (1997)

Resource	Indicators
Natural resources	Soil, water, minerals, air, flora, fauna
Fnancial resources	Money
Productive resources	Technology used, machines, site specific solutions, employment
Infrastructure resources	Roads, harbours, sewage, hospitals, banks, schools, tele-communications, airports, market structure - whether formal or informal
Human resources	Knowledge, abilities, extension, research
Institutional resources	Democracy, media, laws and justice, tenure regimes, owner and user rights, statistic bureau, credits - formal and informal, NGOs, local farmer organisations
Social resources	Active participation ability, history of target groups, e.g. "grass-root" activities such as unions, political, social, other formal and informal organisations, trust, values, perceptions, needs
Political resources	Decision makers, policies
Linkage resources	Linkages with high-potential areas and urban areas, roads, policies stimulating exchanges, processing industry, off-farm generating activities, to decision-makers and capacity of making these linkages
Socioeconomic equity resources	Gender sensitivity in households, between households, between age groups, power relationships

Several problems appear using resources to evaluate the potential for development.For instance, disaggregated analysis might conceal a larger complexity and the other way around, i.e. aggregating many indicators might conceal important differences. Can the use of resources imply and exclude vulnerable groups such as, women, landless, children, old people and the extremely poor? The question is relevant since research shows (Carlsson, 1992) that a village with traditions of collective actions (social resources) has bigger chances of positive short-term results. Of course this is highly favoured, both by the villagers themselves and development experts, instead of waiting for presumed long-term effects. The issue for the development expert is to decide who the target group is and what is feasible. Most probably that is an issue open for debate.

Existing indigenous land tenure, political institutions, and democratic local institutions (institutional resources) might not ensure a high potential for development. For example, institutions may be subordinate to land owners, national-, or transnational elites. The situation is complicated, on one hand a local, recognised institution organises collaborative actions, but is strongly controlled. On the other hand, a newly formed and informal institution may have troubles in organisation, but is active and innovative. The potential for development depends on power relationships (socioeconomic equity resources) and making careful evaluations are necessary. Capacities of local institutions should be considered in detail, e.g. manpower, education and constraints.

Other problems are to find out linkages between the depicted resources? How much does one resource mean for another and vice versa? How much will it affect the whole potential for development if one resource changes? These questions are important, but too complex to answer within the scope of this paper. Also, the intention is not explicitly to analyse the different resources and draw conclusions about the potential for development. The resources are mainly used as a tool to systemise gathered information.

After having retrieved information and analysed the importance of resources, the question arises if a common and widely used land evaluation method may incorporate the complexity of necessary information. The following Section 4 reviews methods and computerised models commonly used to conduct land evaluations that assist in land use planning. Clarifying is necessary that the boundary is not sharp between land evaluation and decision-taking on land use planning and management. A land evaluation itself does not take such decisions but make recommendations on appropriate types of land use with their consequences.

4 Land evaluation methods

van Duivenbooden (1995) mentions different land evaluation methods, which collect land use data, make scenario analysis, or their combination. In addition, this section describes the AEZ methodology and land capability classification in more detail due to their worldwide use. As a development to these widely used methods, a complementary land evaluation is described. Also, various computerised models are presented.

4.1 Methods and methodologies

AC (Agricultural census) involves collecting, processing and analysing data from many agricultural holdings and provides essential structural data for small areas to prepare plans and formulate policies for rural development (FAO, 1986, cited in Duivenbooden, 1995). **FSR** (Farming system research) and **FSA** (Farming systems analysis) is a method, which examines necessary and possible improvements in combination with tests of adapted technology. FSA looks into the entire farm of resource-poor farmers and farm components. A major drawback is the absence of relation to higher levels of spatial integration, e.g. agro-ecological zone, and lack of quantitative data (Fresco *et al.*, 1990). **LE** (Land evaluation) is a physical land suitability assessment method including socioeconomic aspects. LE compares properties of a given geo-referenced land unit with the requirements of a specific land use. LE aims at analysing potential land uses in the future, regarding changes of different factors, e.g. improved drainage, better trafficability and so on. The interdisciplinary method examines the consequences of changes and classifies the land into different suitability classes (Dent, 1993, cited in van Duivenbooden, 1995), i.e. the fitness of a given type of land for a specific kind of land use (FAO, 1976).

LEFSA (Land evaluation and Farming systems analysis) is a combination of LE and FSA and integrates agronomic and socioeconomic aspects (Fresco *et al.*, 1990). **AAD** (Agro-ecosystem analysis and development) is an interdisciplinary method focussing on interactions between people and natural resources, often at community level. AAD includes identification of tradeoffs between uses of different land (Lightfoot *et al.*, 1989, cited in van Duivenbooden, 1995). **EIA** (Environmental impact assessment) is a tool for considering impacts on the environment. EIA is used for, e.g. forming policies (World Bank, 1991, cited in van Duivenbooden, 1995), analysing and planning rural sectors (FAO, 1996a).

RRA (Rapid rural appraisal) is an interdisciplinary systematic method that quickly finds new information and hypotheses about possible interventions in the rural environment (Fresco *et al.*, 1990). **PRA** (Participatory rural appraisal) developed from RRA and includes participating farmers in the process from diagnosing, planning, designing, decision making and implementation. Various techniques empower local people to find out their own problems and solutions (Absalom *et al.*, year unknown).

FESLM (The framework for evaluating sustainable land management) does not include planning or development. FESLM analyses land use sustainability through interactions between environmental, economic and social conditions (Smyth *et al.*, 1993). **ITM** (Integrated transect method) is an alternative method to techniques that generate data on land use mainly as a by-product (van Duivenbooden, 1995). According to van Duivenbooden, the ITM is composed of a multidisciplinary team that generates data at semi-detailed level, and bridges gaps between disciplines, scales and agro-ecological zones.

4.2 The AEZ methodology

FAO (1976) developed a Framework for land evaluation and with the International Institute of Applied System Analysis (IIASA) they developed the idea of an agro-ecological zoning (AEZ) methodology (FAO, 1978, 1981). The aim was to find the potential of land to feed the world population by the year 2000 (FAO, 1978). A soil/climate inventory, scale 1:5 million, formed the physical basis of the assessment.The developed framework for land evaluation and AEZ methodology are used today to assess food production and potential population supporting capacity in developing countries.

The AEZ methodology consists of: **i**) Selection and definition of land utilisation types (LUTs), e.g. crops, products, by-products, input level (high, intermediate or low) and management practices;
ii) Matching the crop requirements against the soil according to a qualitative approach. The results are called suitability ratings and divided into four classes of: S1 (very suitable and the requirements are fully met), S2 (marginally suitable and the conditions are sub-optimal), N1 (not suitable but limitations ameliorable) and N2 (not suitable with limitations of permanent character). Phase, texture and slope rules modify the suitability ratings;

iii) Matching thermal zones with the temperature requirements of the crops, and where these are met, anticipated constraint free crop yields by length of growing period (LGP) zones are computed. If the thermal requirements are not suitable the zone is not further evaluated. An LGP regards precipitation, potential evapotranspiration and temperature data to determine beginning and end of a possible growing season (Driessen and Konijn, 1992). The anticipated constraint free yield depends on climate-related crop requirements matched against radiation and temperature data;

iv) Constraints such as, pests, moisture stress, weeds and workability decrease yields and infer calculations of constraint free yields to attainable yields. These constraints are classified as slight, moderate or severe and anticipated yield reductions are assumed to be 0, 25 or 50 percent, respectively. The new yield is called the agro-climatically attainable yield. This can be done for low input agriculture, as well, but first one has to put the constraint-free yield as 25 percent of the high-input constraint-free yield (FAO, 1981);

v) Subsequently the agronomic possible yield range is called the agro-climatic suitability assessment. Zones capable of yielding 80 percent or more of the maximum attainable yield without constraints, are classified as very suitable (VS). Zones yielding between 80 and 40 percent are classified as suitable (S), 40 to 20 percent as marginally suitable (MS), and less than 20 as not suitable (NS) (Driessen and Konijn, 1992); and

vi) In the last step these classes are superimposed with the soil assessment from **ii)** and give the land suitability classification. Thus, a soil adjudged S1 does not change the assessment of the agro-climatic suitability. Soils adjudged S2 downgrades the agro-climatic suitability one class and soils adjudged N1 and N2 result a final judgement as not suitable due to severe soil conditions. The final outputs are: very suitable (VS), suitable (S), marginally suitable (MS), and not suitable (N) (FAO, 1981).

4.3 Land capability classification

The terminology comes from the Information Centre of Natural Resources (CIREN) in Chile, which elaborated and adapted a national version of the Soil Survey Manual (USDA, 1993, cited in CNR and INGENDESA, 1995).

Conventionally land capability classification uses eight classes (**I - VIII**), each comprising land units that have the same relative degree of hazard or limitation. The constraints become progressively greater from low to higher capability classes. In addition, several subclasses explain the characteristics and further constraints such as, subcategories of irrigation, drainage classes, erosion classes, soil depth, texture according to the USDA soil texture triangle, and simple and complex slopes.

Class I) The soils in Class I present very little limitations constraining the use. They are level or nearly level with deep soils and well drained. The workability, water retention capacity and natural fertility is good. Crop yields are good in comparison with other sites in the area, but it is necessary to conserve the natural fertility and productivity by using simple methods of management.

Class II) The soils in Class II present slight limitations, which reduce the choice of crops, or require some moderate conservation practices. They correspond to level soils with slight slopes, deep to moderate deep soils, good permeability and drainage, favourable textures that vary more between clayey and sandy than class I. Common constraints are: slightly sloping and a micro relief slightly profound; less deep soil than in Class I; not favourable structure and texture characteristics; and wet conditions, which can be drained.

Class III) The soils in Class III present moderate constraints reducing the choice of crops. The topography varies between level and moderately sloping which severely constrains irrigation. The soil permeability varies from slow to fast. Common constraints are: topography moderately sloping; less deep soil than in Class II; unfavourable structure and texture; low water holding capacity; and wet soil conditions that impede root development. Moderate conservation practices are necessary.

Class IV) The soils in Class IV present severe constraints, which limit the choice of crops. These soils require careful agricultural practices, conservation measures and are more difficult to use and maintain than Class III. Common constraints are: very shallow soils; dissected and sloping topography; low water holding capacity; and poor drainage.

Class V) The soils in Class V are level and present none or low erosion risks. However, other severe limitations are not practicable to remove such as, excessive wetness, stony and/or rocky, frequent inundations and prolonged salinity. Soils are suited for pasture or forestry.

Class VI) The soils in Class VI are inadequate for cultivation and should be used for pasture and forest. Constraints cannot be eliminated, e.g. too steep, high erodibility, effects from old erosion features, high amounts of stones, shallow soil, excessive wetness, low water holding capacity and salinisation.

Class VII) The soils in Class VII are not adequate for cultivation and should be used for pasture and forestry.

Class VIII) The soils in Class VIII have no value for agriculture, livestock or forest, and should be kept in the natural state for recreation, wild life, or as protection of hydrological sites.

4.4 Complementary land evaluation

Bdliya depicts a complementary land evaluation approach (Table 3) to the widely used AEZ and land capability methods. Suitability and land capability classifications emphasise the most efficient use of a land unit in terms of plant production, often excluding social and cultural constraints. Furthermore, the classification does not generally bear any relation to the fragmented use and variable soil conditions and is irrelevant to practical husbandry. Constraints or potentials can hardly be precisely defined outside a frame of reference, i.e. a land characteristic that is a constraint in one context might be a potential in another (Bdliya, 1991).

Table 3. A comparison of two evaluation approaches to the ground considerations (from: Bdliya, 1991)

Ground considerations	Complementary land evaluation	Capability classification
Questionable homogeneity	Delimitations of production systems	Land units
Dynamic nature of land resources	Analysis of land properties	Environmental factors
Consistency of value/rating	A statement of relationships	Classification
Land use	Implications	Implications
Land already allocated	Scopes and directions of manipulation	Allocation of uses to sites
Inter cropping and multiple-cropping	New enterprises	Specialisation in enterprise
Small-scale holdings	New husbandry techniques	Large-scale operations
Rudimentary technology	New inputs	Replacement

A land evaluation should assess the present production systems rather than land units. Identified, analysed and mapped production systems are more meaningful to analyse than land forms. The latter are generally too broad to be used in settled areas. The current land use should reflect the dynamics of properties, e.g. pH, organic matter content and measures that enhance or degrade the productivity of the soil. Ecological relationships between land properties and production systems, both current and projected, should be specified and analysed. An approach of land evaluation should attempt to show the differences of present land use characteristics and a possible specified development objective. Such information could be presented in "improvability classes", which are properties reflecting current land use and categorised that show characteristics of production systems. As such, they can be used to show the degree of differences of each production system from that of the target system. It would also be an indication of necessary bridging of technology gaps (Bdliya, 1991).

4.5 Computerised land evaluation models

Computerised models can integrate socioeconomic and biophysical factors and would help to: **i)** store, manipulate and appraise large amounts of data; **ii)** fulfil the appraisal within a specific time-frame; and **iii)** distribute insights for future land evaluation appraisals. However, the computerised models may also be expensive, time-consuming and draw needed resources away from other planning activities (FAO, 1996b). The basis of this section comes from Chidley *et al.* (1993), who made an overview of computerised models used in land resources management. For more extensive information about APT, CRIES, AEZ-CCS, Perfect, WOFOST, ALES, and expert systems the reader is referred to Chidley *et al.*, (1993). Section 7 evaluates the computerised models against a set of criteria, which are necessary to integrate in a land evaluation.

APT (Agricultural planning toolkit) gives access to several software packages of use to agricultural planners. Briefly, the toolkit consists of modules treating, the climate, biomass yields, crop modelling, agro-ecological zones, productivity assessment, optimal land use plan, and land evaluation. **CRIES** (Comprehensive resource inventory and evaluation system) consists of several software modules and an integrated spatial GIS. Modules treat water balance calculations, yield estimates, enterprise analysis, linear programming, input/output analysis, and experimental design (Chidley *et al.*, 1993).

The **AEZ - CCS** (Agro-ecological zones country case study) software was developed for the country case study of Kenya (FAO, 1993, Fischer and Antoine, 1994) and has been used in various countries, e.g. Bangladesh, China, Nigeria and Thailand. The software developed for the Kenyan country case study may be used as an analysis tool and a learning tool. It enables the resource assessment for planning agricultural development at a sub-regional level within a national context (Chidley *et al.*, 1993).

Perfect (Productivity, erosion and runoff function to evaluate conservation techniques) simulates the plant-soil-water-management dynamics in an agricultural system. The aim is to predict runoff, soil loss, soil water, drainage, crop growth and yield. Perfect is used for research purposes since it is highly site-specific and models a single soil profile in a single field. Potentially Perfect could be used as a decision support system at farm management level. The **WOFOST** (World food study) is a model that simulates crop performance taking into account the effects of major land qualities, day length, temperature regimes and moisture availability on the annual crop physiology behaviour. An application of this model can be a good place to start an evaluation using the AEZ methodology. WOFOST does not treat erosion risks, economic analysis and soil resource sustainability (Chidley *et al.*, 1993).

Expert systems is a branch of computer science known as Artificial Intelligence (AI). Expert systems may be defined as a computer programme, which, when asked questions gives the same answer as an expert in the field. Like the human expert the model can explain why it came to that decision and what intermediate decisions it used in coming to that conclusion. Writing an Expert System can either start from scratch or use an "Expert System Shell". The latter provide necessary components, but without any domain knowledge. Programming Expert systems requires two skilled experts since one must have the domain knowledge and the other one to convert the knowledge into a computer programme (Chidley *et al.*, 1993).

ALES (Automated land evaluation system) is an Expert System in which the user supplies the knowledge. The user can compute the physical and economic suitability of land mapping units according to the FAO Framework for Land Evaluation (FAO, 1976). First, a prototype is constructed, and second, the prototype is refined by comparing its output with that derived by other methods. A GIS is built into ALES itself and is named **ALIDRISI**. Data requirements for ALIDRISI are: actual and planned land use; socioeconomic characteristics; changing yields and land qualities; land use requirements; and prices. In addition, soil characteristics such as, soils and terrain include vegetation, land use, hydrology and climate. Evaluation matrices show ratings for: physical suitability subclasses; economic suitability subclasses; predicted gross margins; expected yields of crops or other outputs; ratings for single land qualities; net present value; benefit/cost ratio and internal rates of return (Chidley *et al.*, 1993).

Household modelling is part of the Expert Systems family, but is not specifically used for evaluation. Household modelling is interesting and involves the thinking of complex decision-making processes at farm household levels. Models that mimic decision-making processes are useful for planning purposes in two ways. First, it is possible to pre-screen how a farm household would react to new circumstances, e.g. to new policies, in terms of its social and economic costs and benefits. Second, it is possible to pre-screen the process when introducing new technologies or changes in the physical surroundings, e.g. the climate (Edwards-Jones and McGregor, 1994).

Households or defined groups need to be classified beyond the agro-ecological zones to include social and economic factors, as well. Socioeconomic factors are complex since the subjects cannot be manipulated and controlled. Thus, the data must come from various observations. Also, the important variables are difficult to identify and to quantify since interactions with other household members affect decisions. In addition, each individual's response may vary with situation and further complicate evaluations. Techniques exist for representing social data on a computer, e.g. languages for representing human thinking and decision-making, object-oriented, and frame-based programming. Whole farm household models (WHM) have been used to investigate the feasibility of integrating biological and socioeconomic models, but several factors were grossly simplified. Further analysis and modelling are required (Edwards-Jones and McGregor, 1994).

Hoanh developed **CAILUP** (Computerized Aid to Integrated Land Use Planning) for regional level in irrigated areas of the Mekong delta, Thailand. The model integrates biophysical and socioeconomic data and consists of mathematical sub-models of demography changes, land use weighting, socioeconomic factors at regional and farm level, biophysical factors, land use allocation, productions, environmental impacts, supplement intervention and goal impact analysis. The model defines different key interventions for the different sub-models and involves many estimations. Sub-models concentrate on specific influencing factors in detail, while other factors are superficially treated. Model users need expertise knowledge in every step such as, agronomists, soil scientists, sociologists, animal husbandry and policy makers. Different performance indicators are necessary and should be easy to measure and part of the governmental policy (Hoanh, 1996).

IMGLP (Interactive multiple goal linear programming) is a model that examines consequences of optimising certain goals for land use, intensification levels and degree of exploitation of natural and human resources. The model can contain, in quantitative terms (input-output format), all known relations among and between agricultural activities, and natural and human resources. Therefore, the model requires much data (van Duivenbooden, 1995).

A GIS seldom provides **GIS** and **land resources modelling**, although some basic aspects of land resources appraisal can be incorporated in the simple boolean language and arithmetic of a GIS. Often the user must transfer data from the GIS, model the data and then transfer it back to the GIS software. Linkages between GIS and models have been developed separately, partially (a GIS around or on top of an existing model), or full linkage (a GIS and model in close interaction). FAO has attempted separate and partial linkages between GIS and AEZ. ALIDRIS uses full linkage between GIS and ALES (Chidley *et al.*, 1993).

All the revised land evaluation methods, methodologies and computerised models analyse, to a differing extent, the complexity of a situation. This leads to another issue, i.e. the concept of complexity. The following Section 5 treats basic systems theory, complex systems and what is necessary to manage the analysis of complexity.

5 Systems theory

Fresco and Westphal define a system as a limited part of reality with well-defined boundaries that contains interrelated elements. These elements have strong functional relations with each other and limited, weak or nonexistent relations with elements in other systems. A system can be studied by distinguishing its boundaries and major components (elements) and by characterising the flows and the relations between flows and components. Flows are transformations of energy, materials, money, information, etc. Components are state variables such as, livestock numbers, crop area, human population, etc., which in fact, are often subsystems themselves. Also, Fresco and Westphal define a farming system as a class of similarly structured farmer systems, i.e. a particular combination of farm household, cropping and livestock systems that transform land, capital, and labour into products for consumption or sale (Fresco and Westphal, 1988).

A land unit is an area of land demarcated on a map and possessing specified land characteristics or qualitites and is identical to a land mapping unit. A land use system is the combination of specified land uses practised on a given land unit (FAO, 1976). The system definition implies a land use system to be a complex issue of interactions of different components. To place the concept of complexity into a relevant context, Pretty (1995b) distinguishes three types of agriculture - the industrialised, green revolution, and the diverse and *complex* agriculture. According to Pretty the complex agriculture supports approximately two billion people around the world and that traditional policy making does not appropriately address complex systems. Thus, describing the meaning of complex systems is necessary and how to analyse such a system.

5.1 Complex systems

What is a complex system? Gustafsson *et al.* (1982) explain a complex system to be a system that often fools the observer by its unexpected behaviour. Implemented measures often show bad or insufficient results, or even opposite results than anticipated. Short-term results can be promising, while in the long-term be deleterious. Understanding the behaviour of a complex system is difficult. and, according to Gustafsson *et al.* the reasons for this are: **i**) large systems, which include many disciplines; **ii**) high orders, which include many components and feedback loops; **iii**) time delays; and **iv**) nonlinear characteristics containing stochastic elements.

i) Interdisciplinary interactions make the system hard to understand. One has to describe the interactions as good as possible and those not described is the same as assuming their non importance. The main problem of interdisciplinary systems is that conventional and analytical tools are often useless. In addition, gathering necessary expertise (disciplines) can be difficult for an adequate analysis.

ii) Many variables characterise a high order system, which form a complex web of relations, flows and regulators. Feedback mechanisms, both positive and negative, make the system dynamic. The interactions between different feedback mechanisms are difficult to understand, although understood separately. Interactions determine to a certain point the characteristics of a system.

iii) Dynamics of a system can delay the effects of a measure, e.g. an observer does not see any results of implemented measures and interrupt the process/project.

iv) In nonlinear characteristics such as, economic, social, biological and mixed systems, the outcomes are often surprising. Different interactions and relationships can change depending on the circumstances. Stochastic elements refer to the lack of knowledge of exact information and without possibilities to predict random actions.

Often systems are paradoxical and might be simple. The general belief is that cause and effect relationships are intimately coupled in time and space. However, many variables are correlated in time, but this does not necessarily infer a cause-effect relationship. One danger is where an observer reacts on symptoms and wants to carry out changes without knowing the dynamics and inner structure. Changes may not eradicate the problems but sometimes even worsen the previous situation. The resulting effect of curing symptoms, which in the first place are signals of the malfunction, are aggravated problems. This, because observing the symptoms is no longer possible, which mean lost possibilities for future solutions. Another danger related to implementing measures is the wide range of interacting variables. Measures may not cause the expected results, and due to interactions and time delays the results are not possible to relate to the measures in the first place. Then, the solution is to implement more changes of the same character, which may worsen the situation (Gustafsson *et al.*, 1982).

Gustafsson *et al.* mean that delineating the problem area, i.e. a system with clear boundaries is crucial for the problem solution. Sometimes the problem is very complex and has no clear boundaries. In this paper the assumption is that the most adequate focussing point is at community level (Fig. 4).

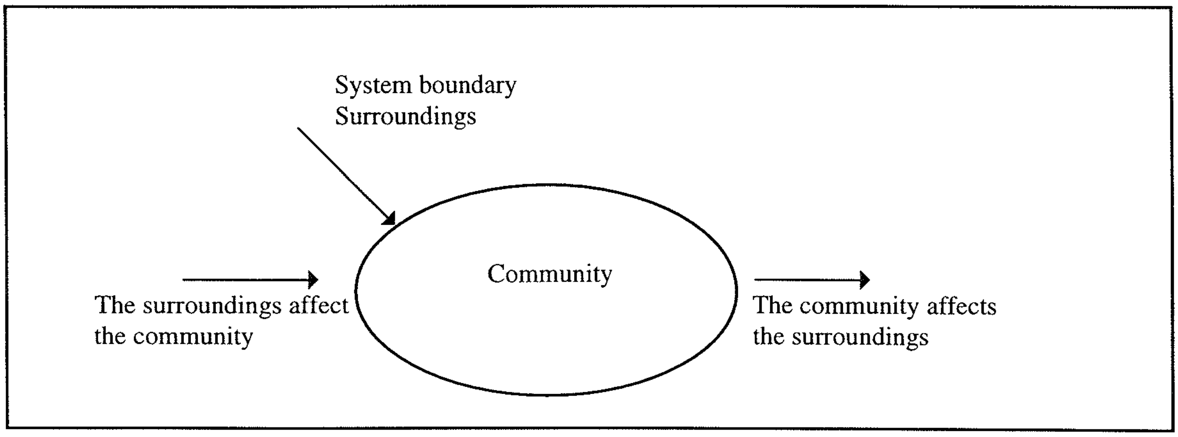

Fig. 4. The community and its boundary, which is both affected from and affects the surroundings (adapted from: Gustafsson *et al.*, 1982).

A few factors are necessary to describe the situation of the community and surroundings:

i) The aim is not to find solutions but the potential for development for decreasing erosion and increasing production. People of the community are the ones who take action, implement, and maintain structures, e.g. new enterprises, soil and water conservation measures and new varieties.

ii) The complex actual situation consists of desertification, overgrazing and weak economic returns. Different actors have invested much work, money and energy in the area, but still the results are not promising. The community boundary is not sharp due to various intervening actors (e.g. the government), migration, remittances from relatives, off-farm work and different survival strategies.

Goals of the community are not clear from the perspective of intervening actors or the individual farmer. Therefore, the stakeholders look upon and analyse the problems differently.

iii) The situation is of a nested character, i.e. the people are part of the community, which is part of a commune, a province, a region and a nation. This means that many interactions between people, biophysical factors, actors, other communities, etc. complicate the analysis and need to be simplified.

5.2 Methodology to use in analysis of complex systems

Biophysical, socioeconomic and political factors create a complex and uncertain environment to evaluate. The question is if an appropriate methodology exists to use addressing complex agricultural systems? Sriskandarajah (1995) treats soft systems approaches in a sustainable rural development context and makes the distinction of holism and reductionism. "Being holistic is to view reality in structured wholes and being reductionistic is to reduce the whole into component parts before trying to understand it (Sriskandarajah, 1995)." Sriskandarajah sees the interrelationships between people and the environment as a whole, which makes it impossible to studying one part and solve complex problems. Definitions are given below according to Sriskandarajah, which describe the ideas of this specific systems approach.

Systems: A collection of parts that are interrelated in such a way that there is some sense in regarding them as a coherent entity.

Systems thinking: An appreciation of the wholeness of a situation and subsequent conceptualisation according to system properties, e.g. boundaries, inputs, transformation and outputs, information networks, control and feedback mechanisms, behaviour, purpose and performance, hierarchical relationships of components, subsystems, systems, supra-systems and environments each with specific properties not apparent at other levels.

Systems practice: Applying methods of description, analysis, synthesis and design, which use systems concepts and properties for improving complex situations.

Systems approach: Integration of systems thinking with systems practice into methodologies, which reflect an underlying process of learning through reflection of experiences.

Holism: A viewpoint that a whole entity or system has properties, which are not revealed through a study of its parts. Therefore, the idea is that the whole is at least different, if not greater, than the sum of its parts.

Systemic (holistic) experiential learning: Incorporation of the notions of systems thinking, both as the learner's worldview and the learner's procedure for learning, through the recursive cycle of divergent, assimilative, convergent and accommodative activities.

Checkland (1989) developed a soft systems methodology (SSM) with the above described notions incorporated. Checkland distinguishes between three major systems: **i**) natural systems - physical systems ranging from subatomic to galactic systems; **ii**) designed systems - man-made systems, i.e. both physical or abstract such as roads and mathematics respectively; and **iii**) human activity systems. The last involves human beings in the activities itself and are different in the eyes of different observers. Sriskandarajah (1995) sees farming as a human activity system. SSM is applied to ill-structured systems with often no clear goals, and where the outcome is ambiguous or uncertain with no clear answers or optimised solutions. In comparison a "hard" methodology is where a system is well structured with clear goals which yield predictable outcomes and optimal solutions (Checkland, 1989).

5.3 Soft systems methodology

The soft systems methodology (SSM) is, broadly speaking, divided into two "worlds", namely the real world and the abstract world. It is a process of inquiry, which is iterative rather than linear. Checkland (1989) gives an overview and shortly describes and illustrates the different stages (Fig. 5). A basic idea is that every problem exists in a context, not with a "problem" as such, but with a "mess" (Stage 1). People perceive the context differently. Thus, the first task is to create a picture of the situation or assemble a representation, which is rich in both quantitative and qualitative information (Stage 2). The analyst tries not to see the situation as a specific "problem type" but to seek for general patterns or aspects (issues). Systemic ways of viewing the situation is necessary by defining relevant systems that constitute of issue-based or primary-task-based systems. The first type examines the problem setting and tries to find out the basic issues in it.

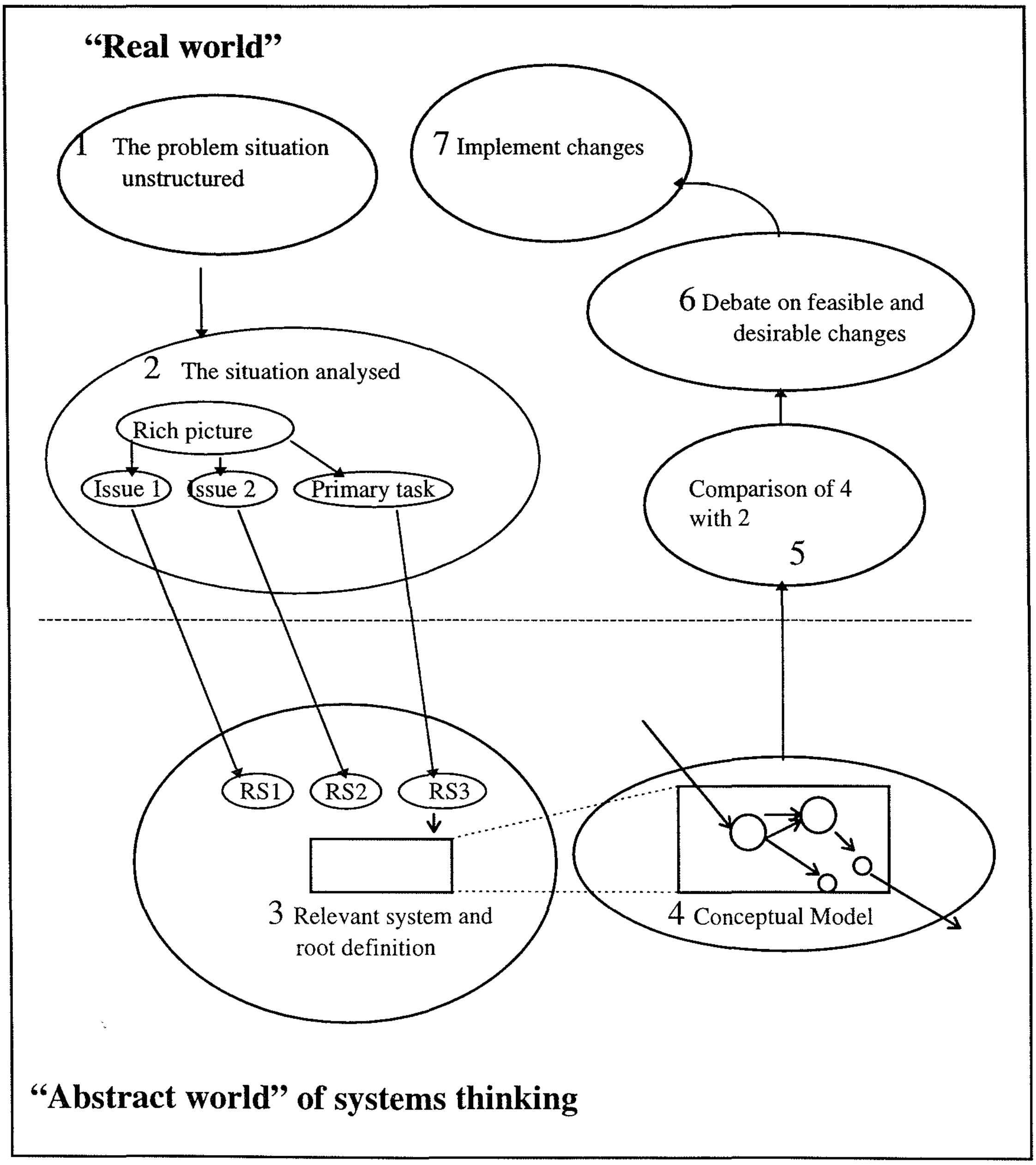

Fig. 5. An overview of the Soft Systems Methodology by Peter Checkland (from: Checkland, 1989).

When this is done it is time to think of relevant systems, which would bear on it in a beneficial way. The analyst conceives the primary-task systems differentely by looking at the problem trying to identify the nature of the essential tasks that must go on within it. The identification and relevance of the chosen system are crucial in the inquiry process, because it forces the analyst to view the situation in a particular way.

Then, the analyst describes the relevant system precisely in words, a root definition (Stage 3). He or she derives the essential activities that logically the relevant system should do, i.e. a conceptual model (Stage 4). This stage implies an abstract world and the model is a system whose elements are activities. Checkland and Scholes (1991) say "These [world examples] will always be found to be richer and messier than the pure concept." In short, the conceptual model represents a system that nobody is going to try to build in the future.The conceptual model derives from the root definition using rules of deductive logic. It is an attempt to trace (in activity terms) the logical consequences of the system designated as "relevant"(Checkland, 1989). In the following stage (Stage 5) the analyst compares the abstract model with the existing actual problem situation and generates two possible outcomes: a reassessment of the view of the problem situation, or a list (agenda) of possible changes. Local people debate the possibilities (Stage 6), and the changes that survive are thought to be agreed upon and socially and culturally feasible. Of course, the relevant system may not have been relevant and must be revised and redone. That is always a risk. In the final stage the changes are implemented (Stage 7).

To be able to compile a rich picture of the problem situation information has to be gathered. Studying reports and relevant literature may gather much of the information, but also through conducting interviews and participatory techniques. This is the topic of the following Section 6.

6 Information gathering

Conducting interviews is a technique demanding skill and many things to consider, for instance how to conduct the interview? Should it be individually, in groups, structured, unstructured, or questionnaires? Participants themselves may create information by using PRA techniques and a few relevant techniques are explained that intend to collect information relating to the described resources in Section 3.3 (Table2).

6.1 Interviewing technique

Patton (1980) mentions important things to remember conducting interviews. The interviewer should explain five questions and providing this information at the beginning is an obligation. The questions are: What will be asked in the interview? Who is the information for? How will the information be handled? What is the purpose of collecting the information and how will it be used?

Waldenström (1997, pers. comm.) means that different methods have something in common, namely the relation to the respondent and the content. Waldenström asks questions such as: What kind of relation between the interviewer/analyst and the respondent does the method cause? How much time is available? Will there be continuity? Will there be direct or indirect methods? If direct, how many participants will attend? and Will it be individually or in groups? Waldenström says that adjusting individually to a specific case is possible, while groups are more of a social character, sharing experiences and discussion of common problems. Patton (1980) and Narayan (1996) discuss basic interview approaches to collecting qualitative data. The authors have named the approaches differently, but the meaning is approximately the same.

(1) The informal conversational interview (Patton, 1980) or open-ended (Narayan, 1996)

(2) The general interview guide approach (Patton, 1980) or focussed (Narayan, 1996)

(3) The standardised open-ended interview (Patton, 1980) or semi-structured (Narayan, 1996)

(4) A closed quantitative interview (Patton, 1980) or structured (Narayan, 1996)

The approach of (1) needs more skilled interviewers than (2) and (3). In approach (4) there are some guidelines to keep in mind compiling a list of questions. However, this last approach is not used in this paper. Table 4 summarises the four different approaches.

According to Patton (1980), probing questions like "who", "where", "what", "when", and "how" give a complete picture of an activity. Words that correspond to the respondent's own language are likely to be most clear to the respondent.

Both Patton and Waldenström (1997, pers. comm.) mean that "Why" questions are to be used sparingly, because it presumes a cause-effect relationship, an ordered world, rationality and perfect knowledge. A "why" question goes beyond what has happened, what one feels, and presupposes that there is a reason why things occur.

Table 4. Showing the variation of different qualitative interviewing approaches and the quantitative approach (from: Patton, 1980, Narayan, 1996)

Type of interview	Characteristics	Strengths	Weaknesses
Informal/ Open-ended	Topic in mind, free-flowing in a conversational informal manner, questions emerge during conversation	Increases the relevance and salience of questions; built on and emerge from observations; can be matched to individuals and circumstances useful for exploring ideas and hypotheses,	Comparability between different interviews is difficult; less systematic and comprehensive if questions do not arise "naturally"; organisation of data and analysis can be difficult, time-consuming
Guide approach/ Focussed	Topics and issues to be covered are outlined in advance; the interviewer decides the sequence and working of questions in the course of an interview	The comprehensibility of data increased and more systematic; logical data gaps can be anticipated and closed; still fairly conversational	Somewhat difficult to compare different interviews; topics and issues may be inadvertently omitted
Standardised/ Semi-structured	More structured than (2), exact wording of issues and questions are determined in advance, each question is probed in some depth, respondents are asked the same questions	Comparability between respondents' answers; data not omitted; reduces interviewer bias; clear presentation; facilitated data analysis	Low flexibility in relating to individuals and specific circumstances; standardised wording and phrasing may constrain the naturalness in answering the questions
Quantitative/ Structured	Questions and responses are determined in advance; responses are fixed and respondent chooses from among these	Data analysis is simple; many questions can be asked in one time and be easily aggregated	Respondent may perceive the interview as mechanistic, impersonal, and irrelevant; respondents nuances omitted

Answers might be unclear and difficult to analyse, since many responses are possible to a "why" question (Patton, 1980). Waldenström concludes that summarising the interview before changing the subject is a signal to the respondent that one is listening and allows for more clarifications and adjustments.

Interviewing is not the only source of information. The PRA techniques were developed to empower passive respondents into active participants and a few of these techniques are described in the next Section 6.2.

6.2 Participatory rural appraisal

PRA consists of different techniques aimed at engaging local people in search of constraints and solutions of problems. Bonnal and Rossi (1996a,b) describe in a preliminary working draft some PRA tools, which seemed appropriate for the purpose of collecting information.

The **Village Resource Map** collects information about the natural resources and the infrastructure resources. There should be a mixture of men and women, or organise more than one focus group.Ask them to illustrate their community by drawing: houses, soils, land use arable, grazing land, forest, water bodies, location of main crops, forest, shrub land, grazing, water resources and irrigation (for humans and animals), environmental degradation (erosion, deforestation), shops, markets, health clinics, schools, religious sites, entertainment, roads (distances to high-potential areas or nearest, bigger cities, state of the roads, number of vehicles per day), electricity and sewage. Other sources of information are, universities, organisations, institutions and interviews.

Seasonal Calendars is the next PRA technique to collect information about: financial resources, rainfall, agricultural labour, casual labour - household labour, income sources - list and rank, expenditures - list and rank, more costs than incomes, food availability, water resources and availability, migration patterns, yields of crops, animals, and fuelwood. Other factors such as, savings strategy, a livelihood pie diagram by socioeconomic category, mutual aid and savings groups, investments, indebtedness, priorities, process of capital accumulation, process of impoverishment, and amount of income, demand trust and longer time to figure out. Therefore, the seasonal calendars will not explicitly treat these factors. The seasonal calendar is a line representing a year divided into periods according to the participants view; make marks; starting with rainfall patterns is easiest that later correlates other lines and activities; use stones or something similar to show the relative amount of rain, labour, income periods; more stones - higher intensity. Ideally, this should be done with different groups of men and women, young and old, different socioeconomic groups, but the time and interested participants decide. Also, ask for dry year and wet years since this will show differences. Other sources of information are reports and interviews.

Venn Diagrams (Thomas-Slayter *et al.*, 1995) addresses the social resources. Knowing which organisations that have respect and confidence in the community is critical. For instance, social organisations, village/community administrative leaders, traditional leaders, elders, water use associations, traditional groups, cooperatives, youth-, neighbour- and women associations, formal and informal organisations and unions. Social resources also include trust, values, perceptions, conflicts, conflict resolutions, history of participation and collaborative actions. Using circles of different size and colours to represent different institutions, influential persons, or organisations, participants (with the facilitator) create a visualisation of these relationships. Focus groups are divided into, e.g., according to gender and age. The participants decide which relationships to examine. Other sources of information are interviews and reports.

A **Village Social Map** describes the socioeconomic equity resources, i.e. who is going to benefit from the development. The potential differs between men and women, between households, land owners, rich and poor, by gender and power relationships between stakeholders. A focus group of both men and women tries to depict different socioeconomic groups, birth rates, the in-migration, out-migration. Mark all the households, what is poor and rich in their own terms, assessing each household, then continue with probing questions of characteristics of the households. Other sources of information are interviews and reports.

6.3 Further gathering of information

Interviews and reports treat the information on productive resources, i.e. technology, inputs, irrigation (type, the date of construction, crops irrigated, water management), land preparation (ownership of oxen, hired or exchange of oxen), seeds, fertiliser, farm manure, herbicides, insecticides, fungicides, equipment (plough, carts, tractors), post harvest, transport of crops and by-products, input suppliers (public, private) and employment.

Interviews, reports and data from the productive resources treat information on institutional resources, i.e. NGOs, credits - formal and informal, tenure regimes and owner and user rights, laws and justice, political system, government projects (extension, mode of work, cash, food or seed distribution, training), research stations (location and linkages with extension services and farmers), inputs supply (distribution of seeds, fertiliser, machinery), forestry agents, livestock and veterinary services (function and organisation).

Information on human resources comes from interviews and reports treating education, literacy status, knowledge, attitudes and practices. The political resources or governmental policies are analysed through interviews and reports. The linkage resources depend on other "resources", i.e. linkages with high-potential areas and to urban areas, between farmers and between communities. This means roads, policies, processing industry, off-farm income generation, institutions and the capacity of the people.

6.4 Visualising the information

Visualising the information for better understanding is necessary; otherwise the gathered information may be difficult to interpret or perhaps even useless. Using the soft system methodology (SSM) infers drawing pictures of the present situation and of a conceptual model, which is a form of visualising the information. For more formal ways, Richters (1995) mentions relevant methods such as: **i**) superimposed transparent sheets; **ii**) numeric transparent sheets; and **iii**) computational techniques. However, using these techniques does not coincide with the essence of SSM, since especially **i**) and **ii**) analyses components without showing the interactions and wholeness of the situation. Nevertheless, the techniques mentioned by Richters are widely used and explained below (Richters, 1995):

i) Superimposed transparent sheets is a technique often used. Every transparent sheet have three common characteristics such as, the same scale, the same format, and some common features to simplify the superimposition. The technique is simple and its principal function is to show the situation and relations between important components. Disadvantages are that new information makes the transparent sheets obsolete and the number of components possible to analyse is limited.

ii) Numeric transparent sheets might be used to reduce the problem of component limitations. Instead of using, e.g. different colours numbers are used. More information may then be represented on a concluding transparent sheet. Likewise, the same three common characteristics are valid as for the superimposed transparent technique.

iii) Computational techniques vastly increase the amount of components and quantity to be processed. Statistics, extensive data bases, expert systems, satellite image processing and geographical information systems (GIS) are examples of useful tools.

The drawbacks of the first two simple and cheap techniques are not present in a GIS. Different data bases of biophysical and socioeconomic factors, digitised on aerial photo or satellite images, are possible to superimpose on each other. Generating good quality graphic screens or maps is possible, which simplify later discussions. The tendency is to generate too many irrelevant data, which may disturb decision making. Another important note treats the possibility to generate nicely colourful graphic outputs, but if the background data is lacking adequacy and accurateness, what then is achieved (Richters, 1995)?

7 Choice of methods

First, the information gathering consists of undertaking a mixture of informal conversational and semi-structured interviews (Section 6.1) combined with PRA techniques (Section 6.2 and 6.3) and literature reviews.

Second, the indicators provide direction towards important issues and structure the information according to the resources (Section 3.3, Table 2).

Third, the AEZ methodology (Section 4.2) is used due to its worldwide scope and utility. The AEZ mainly analyses "hard" data, i.e. quantitative data in combination with expertise knowledge. The methodology has been computerised and applied in the country case study of Kenya (Kassam *et al.* 1991a,b, Kassam *et al.,* 1992), but is not used in this paper. Thus, the analysis is made manually. In conjunction to AEZ, the land capability classification (Section 4.3) complements the data gathering.

Fourth, the soft system methodology (SSM) (Section 5.2.1) is used to analyse the complexities of socioeconomic and biophysical characteristics. SSM, in this case study, is part of a "soft" land evaluation methodology aiming at finding the potential for development of the case study area. Originally, the SSM aims at people taking action and to change a specific situation at a specific site, but this is not part of the objectives of this paper. Therefore, the SSM is first divided into an information gathering phase, structuring the information and drawing a rich picture of the problem situation. The second phase consists of defining a root definition, a conceptual model and comparison of the real world with the abstract world. The comparison results in an agenda containing issues and highlighted facts that evaluate the potential for development of El Almendro.

Fifth, the results of the case study in Chile from the "hard" AEZ methodology and the "soft" land evaluation approach are compared to evaluate the differences, strengths and complementarities. (Section 11).

7.1 Computerised models

The question of suitable computerised models needs to be evaluated. As previously stated, the various computerised models (Section 4.5) were to be evaluated against a set of criteria consisting of the ability to integrate the complexities of the necessary resources (Section 3.3, Table 2). The reviewed computerised models analyse the principal factors in Table 5.

The resources highlight important factors to consider, which are crucial to analyse to find the potential for development of an area. Of the reviewed computerised models none seems able to integrate the full range of necessary biophysical and socioeconomic characteristics.

Table 5. Reviewed computerised models and analysed principal factors

The name of model/software	Principal Factors Analysed	Other - use, etc.
APT	Biophysical; some social and economic	Land use planning
CRIES	Biophysical; economic	Land use planning
AEZ-CCS	Biophysical; some social and economic	Land use planning
Perfect	Biophysical	Research tool
WOFOST	Biophysical	Crop yield prediction
ALES	Biophysical; economic/financial	Land use planning
Household Modelling	Interactions of biophysical and socioeconomic factors	Policy making; high complexity
CAILUP	Interactions of biophysical and socioeconomic factors	Land use planning; sub-regional level
IMGLP	Interactions of biophysical and socioeconomic factors	Land use planning; state result and then optimise factors

Computerised models do not suit as a sole tool to find the potential for development. Many questions need to be solved, for instance the incorporation of widely differing local characteristics, weighting of characteristics, validation and design of socially and economically feasible solutions.

Models that are not explicitly land evaluation tools, e.g. household modelling, IMGLP and CAILUP integrate biophysical and socioeconomic characteristics to some extent. Explorations of these models have, however, not been possible in this paper due to different reasons. CAILUP, for instance analyses irrigated rice cultivation in Vietnam, whereas the characteristics of the IV Region of Chile depend on a semiarid climate and rainfed farming. The concept of CAILUP is, nevertheless, very interesting and may be used in other climate types and land uses than the original after relevant changes in the programming. As a conclusion, no adequate computerised model exists to use within the context of this paper.

PART II CASE STUDY RESULTS AND DISCUSSIONS

8 Structuring the information

This section presents: a list of interviewed stakeholders; comments on interviewing and PRA; and compilation and structuring of the information.

8.1 Interviews

Different stakeholders were interviewed, e.g. the **farmers of El Almendro**, the Regional Office of **FAO** in Latin America and The Caribbean, **GIA** (Agrarian Investigation Group), **Department of Geography** of the University of Chile, **CEZA** (Centre of Arid Zones Studies) of the University of Chile, **MIDEPLAN** (The Ministry of Planning and Cooperation), **ACA** (The Association of Agricultural Communities), **JUNDEP** (The Private Corporation of Social Development), **INDAP** (The National Institute for Agricultural Development) and **PRODECOP** (Development and Cooperation Project of Poor Rural Communities).

As can be seen interviews involved stakeholders from local to high levels. In all cases a phenomenological/ semi-structured interview procedure was used, i.e. the questioning followed up interesting facts, but simultaneously covering specific issues. Interviews were not exhaustive but depended on the assumption that several persons could add facts and opinions to complete the picture of the research area of interest.

Conducting interviews involves a basic thing, i.e. to inform the interviewee of the purpose of collecting information. Asking questions that correspond to the interviewee and by using common sense give valuable responses. The reliability of answers is difficult to crosscheck, but should at least be tried. One way to crosscheck is to interview single persons and ask about the same things. Another way is to check reports and follow up the interview a second time, i.e. to have continuity.

Interviewing a group and/or individually is both recommendable. In a group the analyst may observe group processes and reveal interesting facts. Interviewing one person is also necessary, since the group easily disguises views and opinions. Group members often agree with each other, especially if dominant persons are present. During a group meeting a person said that there were no problems lacking health centres, transport facilities, dentists, etc. in the community. However, in an individual interview a woman mentioned problems of not having access to basic infrastructures and services. Obviously persons define problems accordingly to their situations, which show the importance of covering different socioeconomic groups.

8.2 PRA techniques

The "Village Resource Map" (Fig. 6) shows basic resources in the community of El Almendro. The community area consists of 600 hectares of land, ten (main) houses aligned along the main gully of which three are abandoned. Each house has water, either a well or spring water mostly shared with other persons. At the abandoned houses the well/ spring water has desiccated. Various unregulated tributary gullies cross the road at the Southern side of the community. Every house has its private and irrigated field. The Northern side receives many sun hours and the land users fence and cultivate the rainfed land.The common land is the largest area and the farmers use the land for goat grazing and extraction of fuelwood.

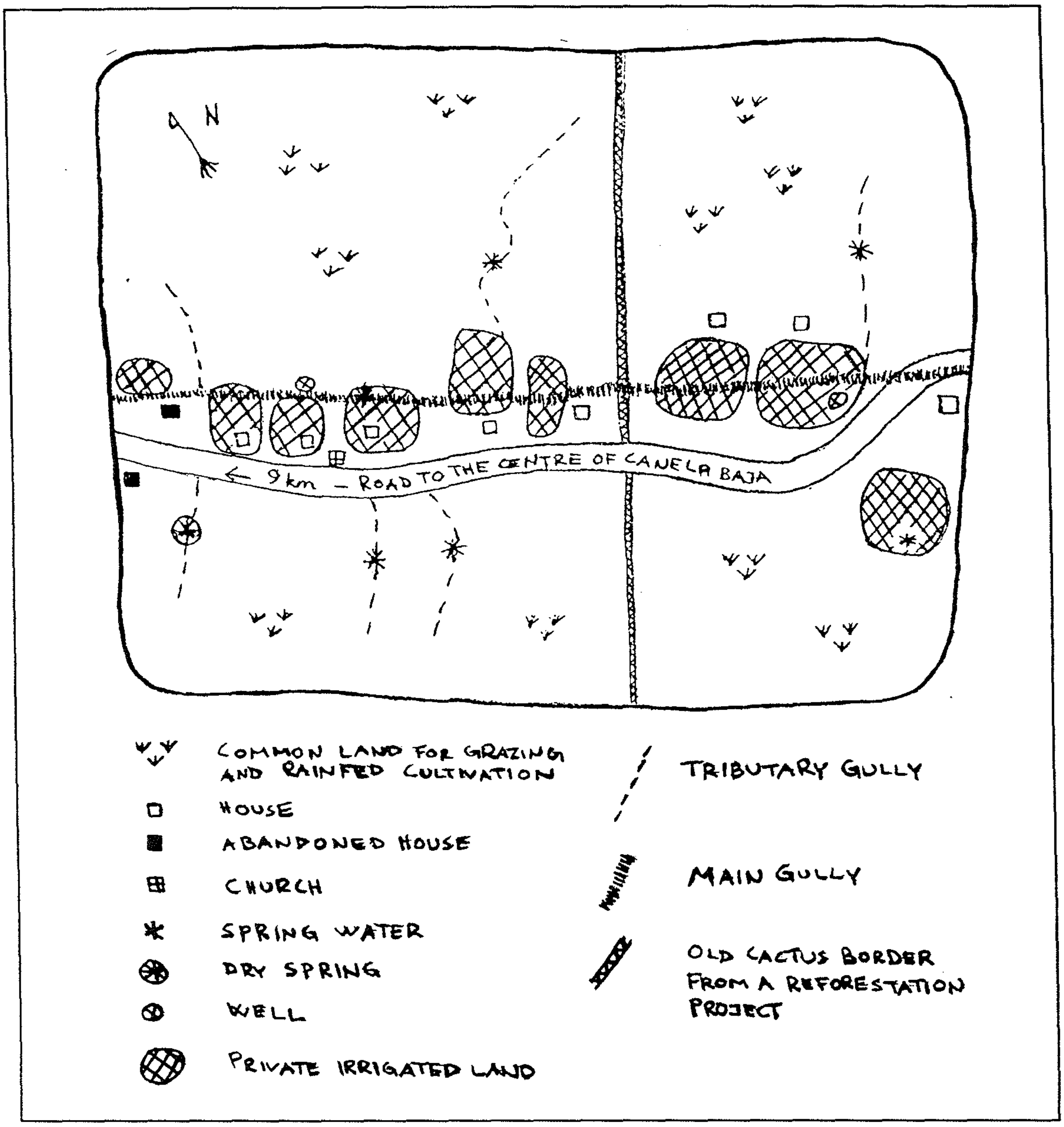

Fig. 6. The Village Resource Map as schematically drawn by farmers of El Almendro, 1997.

PRA is an interesting method to use and even for inexperienced analysts it may render valuable results. Of the various PRA techniques described (Section 6.2), only the "Village Resource Map" was thoroughly used. One woman and two men, between forty and sixty years of ages, participated. One man was quite dominant and did all the drawing. The other two persons agreed all the time and involving them as much as the dominant person was difficult.

While doing the village resource map a modified SWOT technique seemed appropriate to use. SWOT stands for Strength, Weakness, Opportunity, Threats and is a technique to visualise the strong and weak points to take action (Thomas-Slayter *et al.*, 1995). The same dominant person stated that: harmony between neighbours in the community was a strong point; emigration and lack of governmental help during drought cycles were a weak point; electricity was an opportunity; and the lack of "real " governmental help was a threat. The other two did not say anything and the dominant person hampered the participatory process.

A major reason for using the technique of Village Resource Map was the ease to follow up questions about the community and important issues. The starting of the process of "drawing-a-picture" with grown-up people is very interesting. At first they hesitate, but after a while they begin to explain themselves without the analyst asking questions or taking notes. Initiating the process of a dialogue, between the farmers and the analyst, is probably much more important than drawing an exact and correct map of the village resources.

During one meeting the analyst tried to use the PRA technique of Seasonal Calendars to find out the different activities in a year. One farmer did not fully understand the purpose of Seasonal Calendars and became reluctant to answer any further questions. This highlighted the ease to hide intentions behind techniques when, in fact, it is more important to be clear to the respondent of what kind of information one wants to have. Usually researching without intentions is difficult, even if it is "a participatory approach". Doing research without intentions of starting a project probably facilitated the question of meeting as equals. Both land users and the analyst could meet and discuss the community, problems, solutions, ordinary life etc.

These PRA experiences indicate that participatory approaches might be difficult to use "naturally", at least by an inexperienced analyst. The participatory approach did not automatically lead to clear understandings of the analyst's intentions and caused suspicions. The key issue is to create trust between the analyst and participants by using common sense and act normally. To share experiences, laugh, show empathy and discuss are qualities that help to find information about unknown realities and perceptions. Dominant persons hamper the usefulness of PRA techniques and the analyst must try to involve other participants, as well.

Structuring and compiling the information from interviews, PRA techniques and literature is the next topic.

8.3 Resources

As previously mentioned, the resources (Section 3.3, Table 2) direct and structure the information into: natural resources; financial resources; productive resources; infrastructure resources; institutional resources; human resources; social resources; political resources; socioeconomic equity resources; and linkage resources. Only the summaries are given.

Natural resources: Soils are generally rather shallow, gravelly, and inherently with low fertility (Alcayaga and Narbona, 1977). The major part of the land slopes between 30 and 50 percent and has degraded features (Alcayaga and narbona, 1977). According to research the continuing desertification is a serious problem (Etienne *et al.*, 1986, Romero and Tessman, 1989, Torrico, 1994), but specific rates and extension are not found for the community of El Almendro. Analysis of the precipitation patterns shows recurrent cycles of sixty years of which thirty is more rainy and thirty more dry. At the moment the trend is towards more precipiation, but the inter- and intra annual variations are quite profound (FIDA, 1993).

Water wells and spring water are found within the community, but the quantity and quality of the water have not been investigated. The water is sufficient to maintain small-scale irrigation of vegetables and fodder, and sometimes for domestic use; otherwise the governmental drought commision supplies water to the household. The land use reflects water availability and the Military Geography Institute (IGM, 1988) states that between 1935 and 1986 only slight land changes were made compared with other provinces in the IV Region. IGM explains this irregularity by lack of regulated rivers and investments in irrigation structures. No mining activities or fishing resources exist in the community but the people have to move, if they want to make a living on these resources. Although the vegetation is sparse, many different species thrive in the semiarid climate (ARCHILI, 1994). These are mainly used for grazing and collecting fuelwood. Being a semiarid climate and due to use the vegetation has difficulties in regenerating itself (Torrico, 1994). Human activities degrade the land both during the rainy winter and the dry summer period.

Financial resources: Financial resources involve sensitive information, which is difficult to ask the people directly. Often useful information must be deduced. Households have a safeguarding strategy (flexible strategy, according to the classification by Sands, 1986) to manage difficult periods, i.e. by using various survival strategies. For example, subsistence production, artisan cheese production, marketing of various products and remittances from emigrated husbands and children support the families in the community. The actual situation would benefit with a higher amount of financial capital to invest, but lack of credits imposes severe constraints. The IV Region has received above the national average of investments per capita (MIDEPLAN, 1995). During the following years both private and public companies will invest in mining, industry (MIDEPLAN, 1995) and irrigation works (Lagos, Minister of Public Works, cited in Mercurio, 27/4/1997). The importance of these investments for El Almendro is difficult to deduce.

Productive resources: Productive resources are very diverse in the community and differ from farm to farm. A more thorough analysis of possibilities of improvements and constraints must be done if project designing. The main point at this stage is, that the production situation is changing regarding the goat keeping. Investments in new improved technology changed the fodder production and livestock keeping. Serious constraints are the quantity, quality, storage, transport, organisation and marketing of milk and cheese (Lucic, 1986, Nuñez *et al.*, 1986, CRGC, 1996). No jobs are found in the community, except agro-pastoralism. Therefore, people have to migrate to other places. Investments in nearby irrigation works will increase the future demand for temporary migration, especially to the table grape vineyards, but the meaning for the community of El Almendro is difficult to deduce.

Infrastructure resources: Severe deficiencies regarding the infrastructure of living standards and services (Castro *et al.*, 1977), have hardly been improved the last twenty years. The market structure in El Almendro and the nearby and bigger Canela Baja is deficient without developed industry or marketing possibilities. The school in El Almendro/Canela Baja is well appreciated and helps parents to dedicate time to other activities. An increasing pool of agricultural knowledge in the vicinities of the community, mainly by agricultural schools and experiment plots, is promising. The installation of electricity 1998 in the community will improve the situation, but telling the importance of the investment is difficult. The regulation of rivers, or other water harvesting construction works are insufficient (CNR and INGENDESA, 1995) and contribute to severe water constraints in El Almendro. This is a common phenomenon in other communities, as well. The only road in El Almendro is not particularly well maintained and during the winter rains, unregulated tributary gullies damage the road. The alignment of the houses along the road, with the small areal size of the community, gives a concentrated village structure.

Institutional resources: Many problems exist in the Commune of Canela, in which the agricultural community of El Almendro resides. The lists of problems and solutions depicted by the Ministry of Planning and Cooperation (MIDEPLAN, 1996a,b,c, 1997) and the Private Corporation of Social Development (JUNDEP, 1995, 1996) show complexity and awareness of the situation. Problems relate to degradation and desertification processes, but Torrico (1994) means that local people regard the issues of contamination of water and soil more urgent. Governmental institutions and NGOs have undertaken various projects through the years, which have not essentially benefited small-scale farmers (Apey, 1995). Results indicate that it is necessary to improve the capacity in diagnosing and designing projects. In other words, the difficulties are to address "real" problems, design feasible and acceptable solutions.

The Centre for Arid Zone studies (CEZA, 1997) undertakes important research of improving fodder species, breeding goats and spreading of hygienic cheese making procedures. CEZA and the National Institute for Agricultural Development (INDAP) have undertaken capacitation courses to teach efficient goat herding. The mode of working of the most efficient state instrument INDAP, is changing, e.g. restructuring to a more participatory approach. The Project of Development and Cooperation for Poor Rural Communities (PRODECOP, 1996) attempts to find new ways of credit-giving systems, though, it is too early to evaluate the results.

The Association of Agricultural Communities (ACA), an NGO, concentrates on productive activities, e.g. reforestation of *Atriplex numularia*. Other studies of the IV Region have been undertaken by the Agricultural Investigation Group (Bahamondes, pers. comm., 1997) and the University of Chile (MOP and University of Chile, 1994).

Fig. 7 shows the typical administration structure of an agricultural community. Tasks are divided between the General Assembly and the Directory (Ministerio de Bienes Nacionales, 1993), but often the control of number of sheep, grazing, etc. lags behind. The General Assembly has not undertaken preventive actions regarding protective soil and water conservation practices. The inheritance law stipulate one-child-inheritance of the community land and is a constraint to prevent drainage of young people (JUNDEP, 1995).

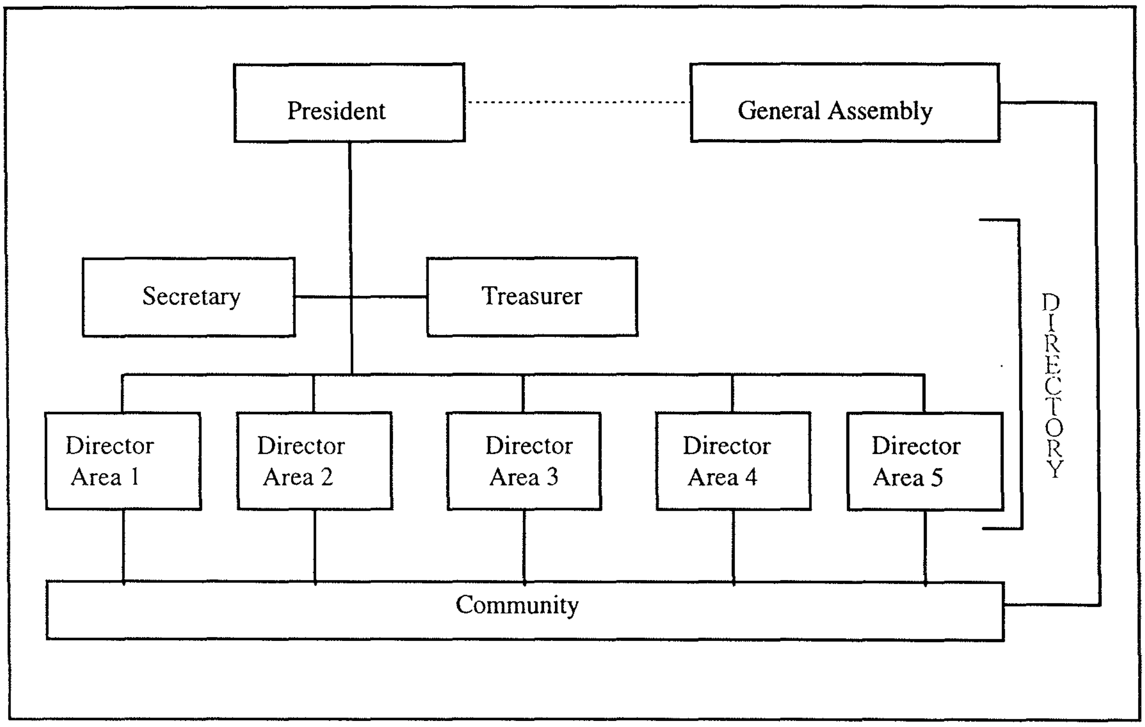

Fig. 7. A typical adiministration structure of an agricultural community in the IV Region of Chile (adapted from: Ianuzzi and Salinas, 1986).

The General Assembly consists of community members with land user rights ("comuneros"). The Assembly meets at least once a year and is the authority of the community. The Assembly elects the Directory, and approves the distribution and utilisation of rainfed and common land. Theoretically, the Assembly should protect the soil, water, forest and be responsible for the economy in the community. The Directory consists of a president, a secretary, and a treasurer. The Directory should, for instance administrate the community; control the number of livestock grazing the common land and contract necessary work for the well being of the community.

State laws legalise how many land users that have rights to community land. The unique tenure regime consists of a mixture of private (irrigated and rainfed "lluvia") and common property (rainfed land) (Fig. 8).

Human resources: The knowledge base of El Almendro is increasing and the drought triggered changes in livestock activities. For example, governmental support and capacitation courses stimulated land users to more efficient goat herding. Extension agents, migrated children and discussions between land users are important sources of information spreading. Often the land users think the extension agents lack knowledge and are not interested in visiting fields. Usually, the interviewed farmers seemed willing to learn more and welcome productive projects. Actual practices, e.g. a minimum of soil and water conservation measures and uncontrolled goat grazing, reflect to a certain extent attitudes towards and knowledge of soil degradation. Seemingly, the land users need more information about degradation processes and how they affect daily life.

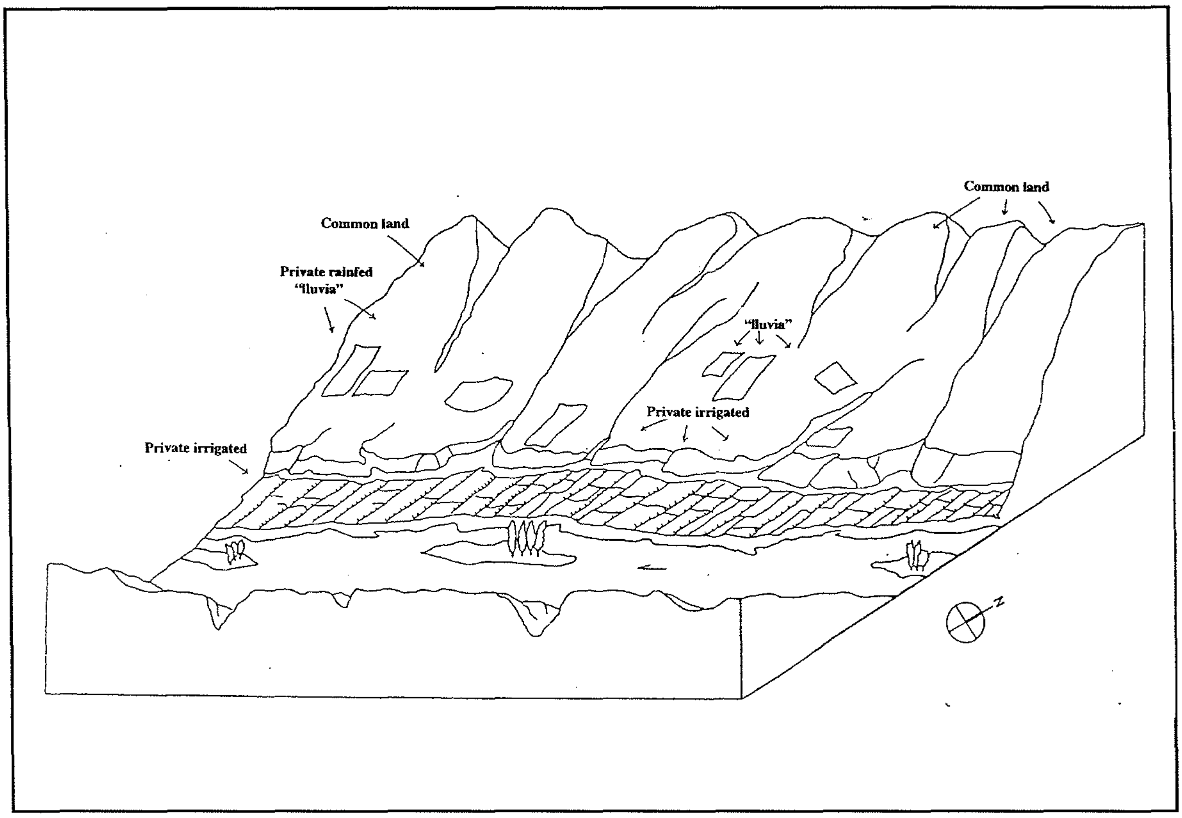

Fig. 8. A typical distribution of land use: rainfed common land; private rainfed cultivated land on steep slopes ("lluvia"); and private irrigated, less sloping land along the main gully (adapted from: Ianuzzi and Salinas, 1986).

Social resources: The historical inheritance (Castro and Bahamondes, 1986, Gastó *et al.*, 1990, Cruz, 1993, cited in Apey, 1995) regarding the natural resources and socio-political conditions, presents an understanding of the actual situation. According to literature the incapacity to counteracting the degradation processes depends on cultural characteristics (MIDEPLAN, 1994). Land users often rely on external help from the government and the poverty situation aggravates the process of marginalisation (Montt and Toloza, 1994, cited in MIDEPLAN, 1994). Different activities, e.g. a woman group, sports, a neighbour and parent associations within and across community borders strengthen the information spreading and bondage between people and communities. This facilitates collaborative actions in reciprocal forms since the people understand the benefits of doing something together.

The migration pattern is a complex issue (Pouget *et al.*, 1996) and the depopulation of El Almendro (Castro *et al.*, 1977, INE, 1992) presumably decreases the potential for development. The different religion in neighbouring community sometimes imposes obstacles to undertake collaborative actions, but usually they are surmountable. Perceptions of problems, solutions and needs vary largely between intervening actors and between the land users themselves. Regarding the community as a whole, the needs are income generating activities that prevent drainage of young forces and abandoning of households. The land users are always willing to try new solutions and participate in projects. Interviewed farmers can exemplify this, for example one farmer said "...there is alway the chance of income generating activities and there might be lasting positive results."

Political resources: The concept of rural poverty is complex and no general agreement exists of how to deal with the issue (Apey, 1995). A national policy of action is necessary to give "real" help to the poor agricultural communities of the IV Region. In fact, the actual governmental policy stimulates people to migrate to high-potential areas. Also, the issue of land degradation is not dealt with either, although a law dictates legal actions if degrading activities continue without any adoption of soil and water conservation techniques. Governmental control or programme does not exist for soil and water conservation and degrading activities continue (Torrico, 1994).

Socioeconomic equity resources: National differences originating from governmental policy are extremely difficult to affect and cannot be expected to change in the shorter run. At the regional level considerable economic development has taken place. Results show big differences between communes and people and many live in poverty (Apey, 1995). According to Torrico (1994) the government should concentrate on the socioeconomic inequities; otherwise, the degradation will continue and make the situation unbearable. Although, there seems not to be serious socioeconomic differences in El Almendro the issue should be addressed to avoid creating new problems. Gender roles in the community are diverse and differ between households. For example, one woman does everything from taking care of the children to investing in the goat rearing, whereas another household shares the work as much as possible. These differences need to be considered, for instance to implement a labourious solution will evidently be impossible for the female headed household.

Linkage resources: Analysing linkages, according to Bonnal and Rossi (1996b), between the farmers and various stakeholders reveals interesting issues. Farmers are aware of the services offered by the linkages to, e.g. input suppliers, traders, etc., but improving the relations is difficult. However, improvements can be made regarding linkages to CEZA, other intervening actors, extension workers and markets. In principal, the control and timeliness of these linkages are without reach for the farmers.

The farmer to farmer linkage is crucial since farmers share the same predicament. This is an effective and exploitable link to use more efficiently. The farmer to other community linkage shows the contacts and potential of possible collaborative actions. Another important, but unknown actor, is the linkage to future investments in the Region. For example, what do the investments in irrigation, mining, fishing, tourism, etc. imply for the migration pattern and development of El Almendro?

All the information has now been compiled and structured into resources. Thus, the paper continues to analyse the case study by extracting relevant resources. For this purpose the AEZ methodology represents a "hard" land evaluation methodology. Here , the word "hard" signifies a methodology that uses physical and quantitative data that specify a goal of sustainable land use management. In comparison, a "soft" methodology uses both hard and soft data, i.e. quantitative data complemented with perceptions, knowledge, thoughts and often a vaguely formulated goal.

9 "Hard" land evaluation approach

The widely promoted AEZ (agro-ecological zoning) methodology (FAO, 1981) and its ability to incorporate important biophysical and socioeconomic characteristics is tested in the case study in Chile. Data from the land capability classification fill information gaps. The AEZ methodology follows specific steps presented as definitions of land utilisation types, thermal zone matching, soil requirements matching and suitability classification. Lastly, the results are summarised and commented upon (Section 9.5).

9.1 Land use and land utilisation types

There are several land uses distinguished and estimated (Table 6). Major "lluvia" (rainfed) crops are wheat and barley for subsistence production. Grain is for flour and the straw is for fodder and building material. The "lluvia" is also cultivated with aniseed and cumin, which the land users sell at the market. These crops demand more nutrients and cannot be grown very often. The rainfed cultivation is estimated to occupy less than 2 percent of the community area, i.e. 10 hectares of a total of 596 hectares. The major part of the land, approximately 95%, is common land used for grazing and collection of fuelwood. These figures are not exact, but give a perspective of the distribution of different land uses. A drought governing since 1992 has severely diminished the agricultural activities of the rainfed area.

Table 6. Rough estimates of relevant land uses in the community of El Almendro, 1997

Description	Area (ha)	%
Total area	596	100
A. Arable farming ("lluvia")	10	1.7
A.1 Dryland annual crops	0	0.0
A.1.1 Wheat	-	0.0
A.1.2 Barley	-	0.0
A.1.3 Aniseed	-	0.0
A.1.4 Cumin seed	-	0.0
A.1.5 Fallow	10	1.7
B. Private land	16	2.7
B.1 Irrigated crops	3	0.5
B.1.1 Vegetables, potatoes	1	0.2
B.1.2 Alfalfa + barley	2	0.3
B.2 Fallow	3	0.5
B.3 Fruit trees, cactuses	1	0.2
B.4 Recreation, houses, areas of trees	3	0.5
B.5 Not specified	6	1.0
C. Common land, pasture-grazing land	570	95.6
C.1 Moderate state, coverage >50%	?	?
C.2 Bad state, coverage <50%	?	?

-: Drought since 1992 and the rainfed land is sparsely cultivated
?: Not possible to estimate

Relevant land utilisation types (LUTs) were selected in the community for rainfed production, pasture and goats (Tables 7, 8 and 9, respectively). These LUTs are relevant for the interviewed farmers of El Almendro. The most important features of rainfed annual crops (Table 7) are the cultivation on steep slopes of wheat and barley.

Table 7. Attributes of rainfed annual crops (extensive system) (adapted from: FAO, 1993)

Attribute	Low input level
Produce and production	Rainfed agriculture of wheat and barley; 1 ton per hectare a good year; one annual crop, grown on steep slopes, low fertility erodible soils; straw for fodder and adobe
Market orientation	Subsistence production
Capital intensity	Low
Labour intensity	High in: April-May (land preparation), December-January (harvesting), and threshing; including uncosted family labour
Labour division	Husband undertakes the land preparation; wife, children and neighbours help during other activities
Power sources	Land preparation with mules otherwise with manual labour
Technology employed	No improved crops; no fertilisers bu only from goats when grazing; no chemical pest or disease control; some weed control during land preparation; the know-how is low regarding land degradation problems; no conservation measures are applied; the soil is used till weeds and nutrient shortage become a problem
Infrastructure	Market accessibility not necessary; lack of advisory service
Landholding	Small and fragmented
Land tenure	Fenced common land in private use ("lluvia")
Income levels	Low
Institutions	No institutions for credits, markets, cooperatives; deficient extension services

The production is subsistence oriented and the yield depends on the amount of rainfall. A good year yields about 1ton of grain per hectare. Knowledge of how to conserve soil and water is quite low and no incentives exist for the farmer to adopt conservation measures. Farmers have good knowledge judging whether it will be a wet or a dry year. Farmers do not apply improved crops or fertilisers.

The most important LUT in terms of extended area, rainfed pasture and fodder, occupies more than 95 percent of the total area (Table 8). It plays an important role feeding the goats and production of fuelwood, but no incentives exist to improve or protect the land from being over utilised. Inputs are low and maintenance of the common land is nonexistent.

Table 8. Attributes of rainfed pasture and fodder (adapted from: FAO, 1993)

Attribute	Low input level
Primary resource	Natural vegetation and stubble from cereals
Water	Rainfed
Land use and feeding system	Traditional; very extended area and permanent grazing; no fodder is collected, except the stubble
Fertilisation	None, except for grazing animals
Labour intensity	Low, uncosted family labour
Labour division	Family
Technology employed	No fire control; no improved pasture; no legumes, or improved fallow; no fodder production for the dry season; lack of know-how to improve the pasture and fodder; no conservation measures; no organised herding - the animals eat what they find
Land tenure	Common land
Institutions	Deficiency of extension agents and no credits to invest

During winter rains the pasture grows vigorously, but desiccates during the summer period. Goats graze freely and seek fodder wherever possible and sometimes farmers leave the goats within the "lluvia" to graze the stubble. Farmers have an intensified irrigated fodder production to keep up the production of milk and cheese, which are important income sources. The LUT of irrigated fodder was not evaluated, because in this case study the AEZ only considered a land evaluation for rainfed cultivation. Livestock that graze the rainfed pasture and common area (Table 9) have a low input level and faces serious constraints.

Table 9. Attributes of the non pastoral land utilisation type - livestock (adapted from: FAO, 1993)

Attribute	Low input level
Produce and production	Goats dominate; milk and cheese production; very few sheep for meat and wool
Nutrition	Traditional
Market orientation	Both subsistence and commercial purposes; goat milk is processed to cheese and sold at the market; poor storage and transport facilities; poor processing; including hides and skins
Capital intensity	Low
Labour intensity	High; milking twice a day during peak lactating period Aug.-Dec.; cheese making
Labour division	Husband and women responsible for the herd, milking and cheese making
Technology employed	Some control of diseases and parasites; some improved breeding, sometimes selection of unrelated males of good conformity, and sometimes small male goats are not taken away from the herd; the extensive system have made the breeding heterogeneous; the animals are kept inside a fence at nights; no facilities to improving the hygiene standard of cheese/meat production
Land tenure	Common land
Income levels	Low; the cheese and manure most important income resources
Institutions	Lack of: extension agents; credits to improve the processing of milk and cheese

No credits to invest in hygienic milking, cheese making, shortage of storage and transports, are factors that decrease the quality of cheese.

9.2 Thermal zone matching

Next step is to match the crops to thermal zones, which is an indication of crops that could be considered from a temperature, growth and phenology viewpoint.

9.2.1 Climate

An arid subtropical climate dominates the climate in the region, with strong influences of the South Pacific anticyclone that impede precipitation during 9 -10 months. The sky is seldom clouded in the dry period and lot of solar radiation passes to the earth surface. This creates climatic gradients with hot interior areas without extreme variations in temperature, and coastal areas heavily influenced by the cold Humboldt stream. The hot interior areas have in the spring and summer period almost an arid hydrology regime. The agro-climatic zone for El Almendro corresponds to valleys and coastal hills with marine influences. The area is situated at 200 to 600 metres above sea level and it is an intermediate zone with rather high marine influence, which creates not so cold winters or warm summers (CNR and INGENDESA, 1995).

Agro-climatic characteristics are from climate stations in Canela Alta and Canela Baja and are assumed to represent El Almendro (Table 10).

The winter period is between June and August with average temperatures around 10° C. Simultaneously the precipitation is at the highest resulting in a hydrological surplus in July. During the rest of the year the potential evapotranspiration exceeds precipitation and results in hydrological deficits. Cold hours are defined as temperatures below 7 ° C and occur between autumn and spring, i.e. April to October. Summer is between December and February with average temperatures around 18 ° C.

Table 10. The agro-climatic characteristics[1] of El Almendro (from: CNR and INGENDESA, 1995)

Parameter	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
Temp.max[2]	25.7	25.5	23.9	21.5	18.8	16.5	15.6	15.6	17.2	19.6	22.3	24.6	20.6
Temp.min	13.0	12.9	11.9	10.2	8.3	6.7	5.8	5.9	6.9	8.6	10.5	12.1	9.4
Temp.average	18.5	18.3	17.1	15.1	12.9	11.1	10.1	10.3	11.5	13.5	15.7	17.5	14.3
Temp.sum	255	250	213	154	95	62	50	52	70	108	171	226	1704
Cold hours[3]	0	0	0	1	26	94	154	137	76	17	0	0	506
Precipitation [4]	1	1	2	6	25	38	58	27	12	5	5	4	183
Effective prec[5]	0	0	0	4	23	35	53	24	11	4	4	3	161
Relative hum.[6]	70	71	73	77	80	82	83	82	80	76	73	71	77
PET[7]	179	170	144	109	75	49	40	44	67	102	139	168	1285
Hydr. deficit[8]	178	169	142	103	50	11	0	17	55	96	134	163	1121
Hydr. surplus[9]	0	0	0	0	0	0	18	0	0	0	0	0	18
HI[10]	0.00	0.00	0.01	0.06	0.33	0.77	1.46	0.61	0.17	0.05	0.03	0.02	0.14

[1] Time period unknown
[2] Temperature (°C)
[3] Cold hours temp (< 7 °C)
[4] Precipitation (mm)
[5] Effective precipitation: amount of water available to roots (mm)
[6] Relative humidity (%)
[7] Potential evapotranspiration (mm)
[8] Hydrological deficit (mm)
[9] Hydrological surplus (mm)
[10] Hydrological index: precipitation divided by PET(-)

A very low precipitation during summer does not reach the roots of the vegetation, i.e. the effective precipitation is zero. The hydrological index (HI), i.e. precipitation divided by PET is low throughout the year except the winter periods.

During the summer period October to March the precipitation is minor (Table 11). The probability of precipitation to exceed average rainfall of 160 - 180 mm per year is 50 percent. In practice it means great intra- and inter annual variations. In certain years the rain falls abundantly, whereas in other periods there are one to three, sometimes up to six consecutive years, of dry spells (Santibañez, 1986, cited in Azócar and Lailhacar, 1990). The yearly amount of precipitation is part of a larger cycle and right now it is an increasing trend of precipitation. This trend is part of a larger cycle of sixty years, i.e. thirty years of decreasing and thirty years of increasing precipitation (FIDA, 1993).

Table 11. Average annual precipitation and probability of amounts of rain based on 1950- 1990 (from: CNR and INGENDESA, 1995)

Average rainfall	Probability to exceed		Probability to exceed Period October - March	
(mm)	(%)	(mm)	(%)	(mm)
160 - 180	5	350	5	40
	20	200-250	20	15
	50	140-160	50	0
	80	80-100		
	95	40		

Frosts are not numerous, but occur a few times yearly (Table 12). No information is available about the time of occurring frosts, though.

Table 12. The number of frosts of varying intensity (from: CNR and INGENDESA, 1995)

Parameter	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Yearly
0 °C	0.0	0.0	0.0	0.0	0.0	0.0	2.0	1.8	0.0	0.0	0.0	0.0	3.9
-2 °C	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.2

9.2.2 Agro-climatic potential

CNR and INGENDESA (1995) evaluated suitable species according to an agro-climatic diagnostic model where they matched species' requirements and climatic variables (Table 13). The most determinant variables were : **i)** the thermal sum which indicates the disposition of ° C to accomplish a whole growth cycle; **ii)** the period free of frosts which influences yield; **iii)** the max. temperature which may lower the quality of the plant through desiccation; and **iv)** the hydrology deficits which depress yields. Results of the agro-climatic evaluation for Canela Alta and Canela Baja, are assumed to be valid for El Almendro.

Table 13. Evaluation of the agro-climatic potential for winter wheat and barley in El Almendro (adapted from: CNR and INGENDESA, 1995)

Species	Temp.sum	Period free of frosts	Temp.max	Cold hours	Hydrology deficit
Winter wheat	1	1	1	(In Spanish)	4
Barley	1	1	1	(In Spanish)	4

1 = no constraints on the species
2 = slight constraints for commercial production
3 = moderate constraints on the species
4 = severe constraints on the production
Ex = this variable excludes the species
(In Spanish) = no data available

The thermal zone matching shows that the hydrological deficit is the most severe constraint. Otherwise, no other specific climatic variable constrain the crop performance. In practice cereals are well adapted to the climate type, but frequent droughts impose constraints from year to year.

9.2.3 Present and potential yields

The drought affects the present yield, which is less than 1 ton of wheat and barley per hectare. Farmers in El Almendro mentioned 1 ton of wheat and barley per hectare as a good year. Cosio *et al.* (1986) mention actual yields of 1 -2-metric ton of wheat per ha, 0.6 - 1 metric ton of barley per ha, and 1 - 3 metric ton of straw per ha. Potential yields in semiarid climates are assumed to be linked to maintained yields every year, dry as wet. No crop growth model was available, therefore, the assumed potential yield is 1 metric ton of cereals per hectare and year.

9.2.4 Length of growing period

The length of growing period (LGP) is approximately between 25th of May and 16th of August plus extra days for soil moisture in the ground, assumed to be 50 mm and ~3 mm PET/day = ~16 days. In total, the LGP equals to 100 days in an average "good" year. An LGP is normally used for calculating the constraint free yield and subtracted by the constraints affecting the yield. However, this is not done in this paper, since the potential yield in El Almendro is said to be a "good" year, i.e. 1 ton of cereals per hectare and year.

9.3 Soil requirements matching

Next step of the evaluation is to match the characteristics of the soil with the requirements of the crops.

9.3.1 Soils

Soils of El Almendro have not been classified and the only information available is results from a soil survey presented at scale 1:250 000 (Alcayaga and Narbona, 1977). Generally soils are shallow, approximately 40 cm deep and the parent material is diorite and acid schists. Soils lay above a substratum of stones, gravel, clayey material, and/or rocks. They are fine textured through the profile with sub-angular blocks to 28 cm and then prismatic to the substratum. Roots are abundant in the first 14 cm and few down to 49 cm where the substratum begins. In the substratum roots penetrate only 5-8 cm and then vanish. The soil fertility is inherently low.

0 - 14 cm	(10YR 3/3 to 7.5YR 3/2); dense clay; moderate sub-angular blocky structure; friable whendry, plastic and sticky when wet; abundant roots, smooth horizontal boundary.
14 - 28 cm	(7.5YR 3.5/2), with small sectors of dark reddish colour (5YR 3/2 - 3/3), dense clay, medium to big sub-angular blocky structure; hard when dry, plastic and sticky when wet; few roots; clear horizontal boundary.
28 - 49 cm	Dark (7.5 YR 4/2 - 4/4) with reddish colour (5 YR 4/4); dense clay with abundant gravel; fine to medium prismatic structure; very hard when dry, plastic and sticky when wet; few roots; abrupt horizontal boundary.
>49 cm	Stones, gravel, and/or rocks

According to Alcayaga and Narbona the most common variation from the typical soil profile constitutes of superficial strata of different colour (10YR 2/2) and with moderately fine texture, e.g. sandy clay loam.

9.3.2 Land capability classification

To complement the information of soil types and characteristics, the land capability classification by the National Forest Corporation (CONAF, 1980/82) was consulted (Fig. 9). Along the main gully

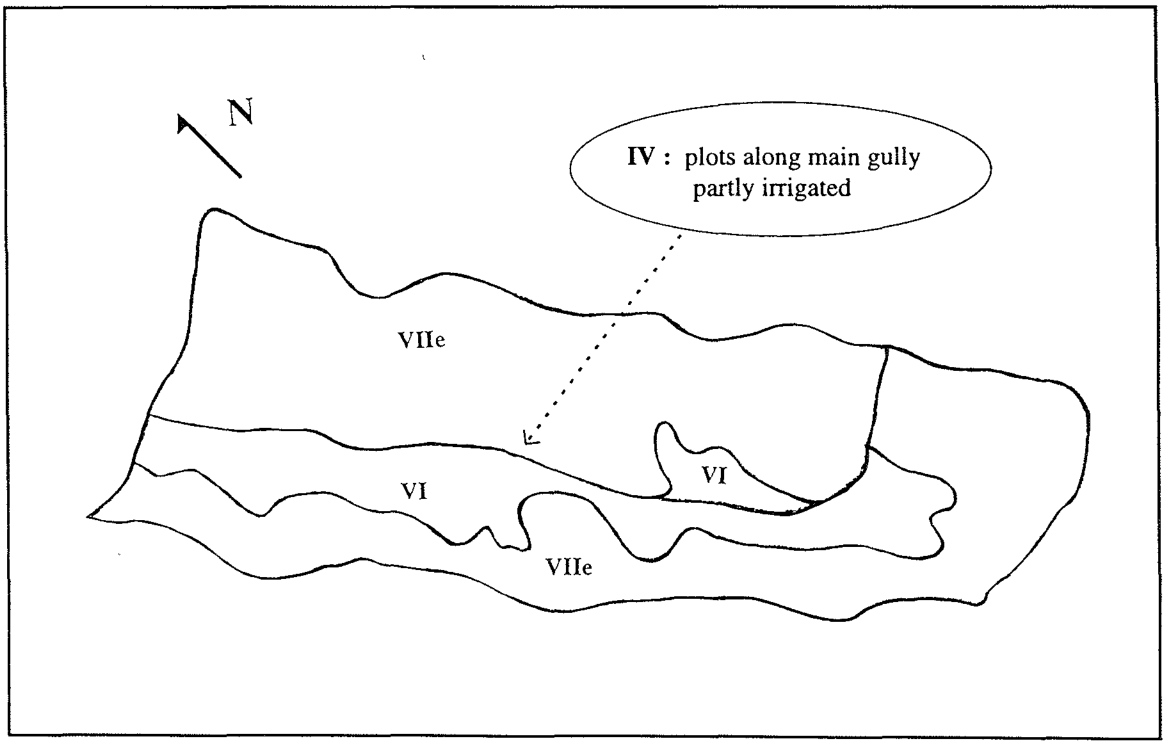

Fig. 9. Land capability classification of the agricultural community of El Almendro (adapted from: CONAF, 1980/82, not in scale).

are small, almost flat to gently sloping, irrigated and fertilised plots. These plots belong to Class IV soils and consist of rainfed land for cereals, a mixture of irrigated alfalfa and barley, and vegetables. The irrigated part is estimated to be three hectares and the rainfed cereal part to six hectares. The dominant type of capability class is VI and VIIe, which impose severe restrictions to agriculture. Class IV soils require careful practices and conservation measures, while Class VI and VII are suited for pasture, shrubs and forest. The extensions of the different classes are depicted in Table 14.

Table 14. Land Capability classification of the soil in El Almendro (from: CONAF, 1980/82)

Land capability classification (class)	Area (hectares)	Remark
IV	8.58	Plots along main gully, three hectares irrigated
VI	120.88	
VIIe	466.54	e= erosion
Σ	596.0	

Alcayaga and Narbona (1977) and CNR and INGENDESA (1995) give more details about the soils, i.e. drainage, aptitude for irrigation, fruit trees and agriculture (Table 15).

Table 15. Qualities of the land in El Almendro (from: Alcayaga and Narbona, 1977, CNR and INGENDESA, 1995)

Quality/characteristic	Remark
Drainage class	Well drained - in general intermediate textures
Irrigation aptitude	Soils not apt to irrigation (only soils of class VIIe considered)
Fruit tree aptitude	Severe limitations due to climatic, physical, and economic constraints
Agricultural aptitude	Soils of Class IV, possible to use under careful management; fruit (micro irrigation); pasture (alfalfa)
Slope	Soils of Class VII, for pasture, shrubs, forest, 30 - 50% slope

The drainage is generally considered good, irrigation is possible on Class IV land; otherwise qualities and characteristics limit possibilities to undertake an efficient production. Table 16 summarises the information of the physical constraints of the soils.

Table 16. The physical constraints of the land in El Almendro

Factor	Remark
Root depth	Moderate constraint, rather shallow, around 40 -50 cm
Erosion risk	Severe constraint
Temp	No constraint
Frost	No constraint
Available soil moisture	Severe constraint
Soil fertility	Moderate - to severe constraint
Drainage	No constraint
Regeneration of natural vegetation	Severely constrained

No quantifiable data is available; nevertheless, the different factors indicate severe restrictions on the agricultural and livestock production.

9.4 Suitability classification

On the basis of the factors in Sections 9.1 to 9.3 a suitability classification (actual and potential) is made.

9.4.1 Actual suitability classification

According to CONAF (1980/82) 8.6 ha or 1% of the community area may be used for agricultural purposes. Three hectares of these are used for irrigation purposes on almost flat to gently sloping land. The specific evaluation of the irrigated land is not done in this paper. Following the AEZ methodology, the actual land use of 5.6 ha along the main gully is set to "marginally suitable" for cultivation of cereals, cumin and aniseed (Fig. 10).

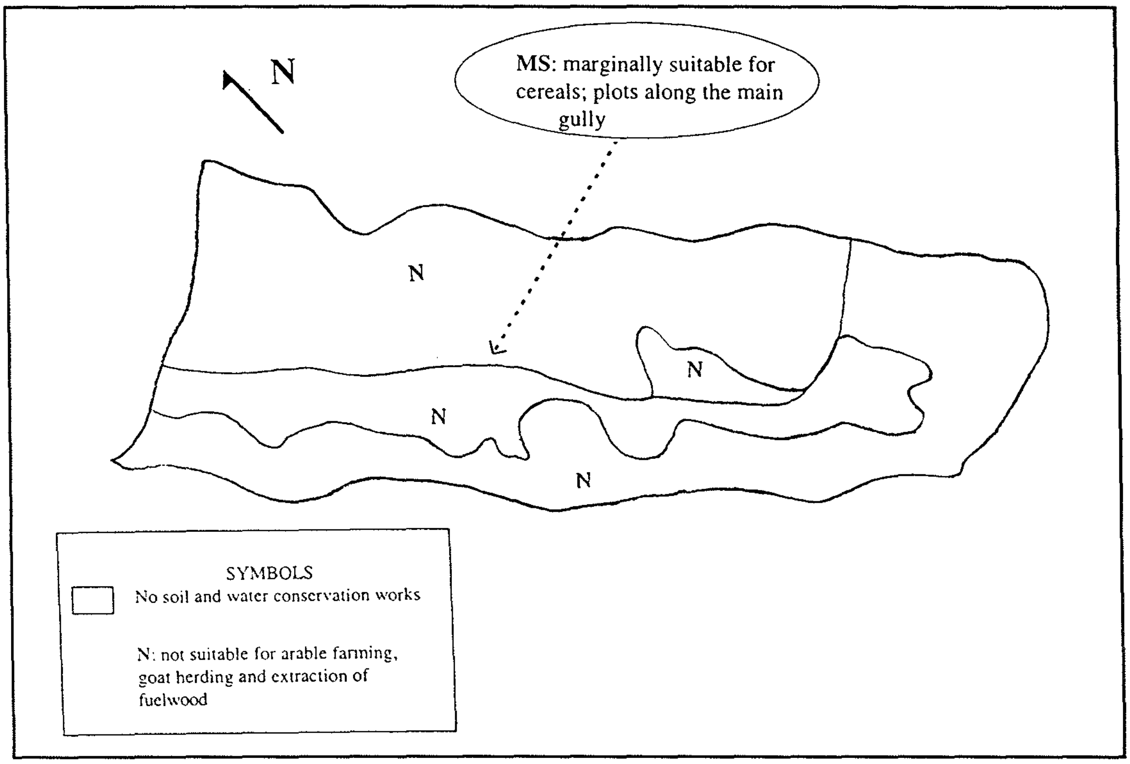

Fig. 10. A suitability map of actual land use in El Almendro.

The "lluvia" and common land are together of 587 hectares. Of these, only ten hectares (Table 6) are cultivated with wheat and barley on steep slopes having a high potential erosion risk. Therefore, the suitability classification is set to "not suitable" for cultivation of cereals. Unrestricted goat grazing and fuelwood extraction occupy the remaining 577 hectares of the land. In combination with the high erosion risk the suitability classification is set to "not suitable" for goat grazing and extraction of fuelwood. Thus, the major part of the actual land use in the community of El Almendro, in fact more than 95 percent, is "not suitable" for cultivation of cereals, goat grazing and extraction of fuelwood .

9.4.2 Potential suitability classification

Potential land uses are, e.g. pasture, shrubs, forest, and/or cereal production in combination with soil and water conservation measures. To assess these options new evaluations of the different AEZ steps must be considered, e.g. interactions between livestock and pasture/fodder production, and also, fuelwood production and extraction.

Shortages of data restrict the planning of potential land uses to a strictly hypothetical situation (Fig. 11). Therefore, quantification of the expected results is not possible to do.

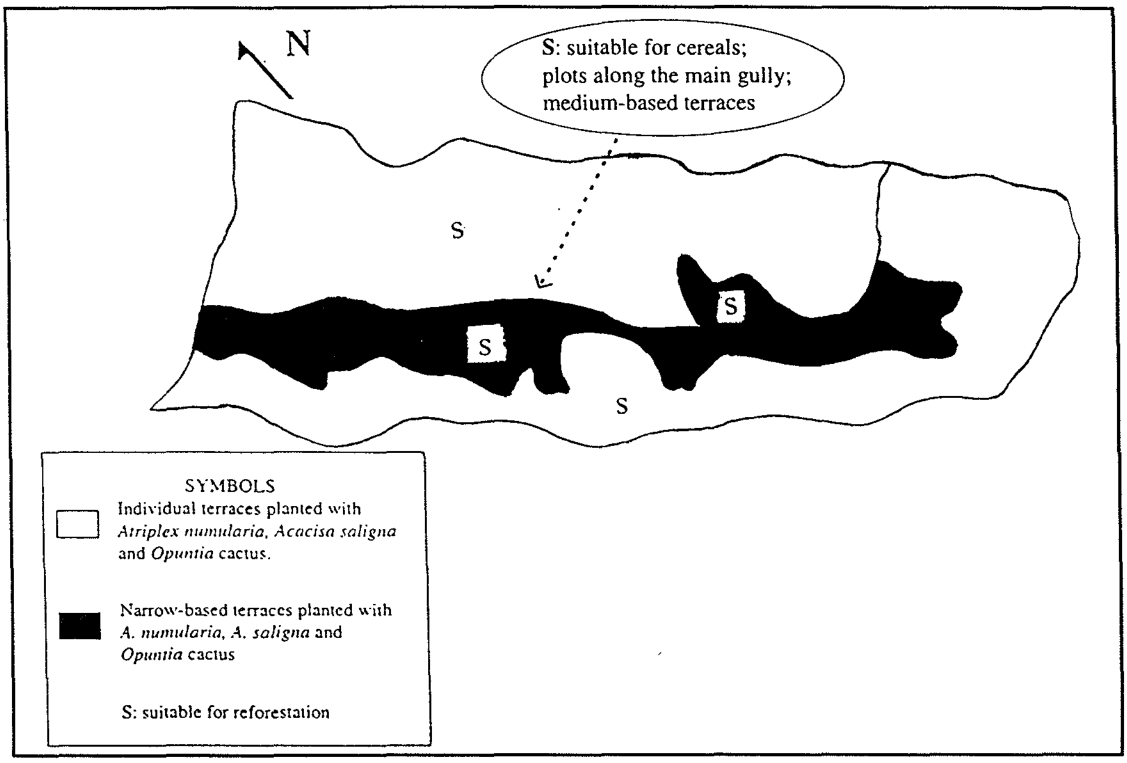

Fig. 11. A potential situation of suitable land use in El Almendro.

Class IV area sloping approx. 8 - 15 percent (Klingebiel and Montgomery, 1961, cited in Bohlin and Messing, 1981) can be used for cereal production, if medium-based terraces (Bragagnolo, 1995) are constructed. The area is reclassified as "suitable" for cereals. The aim is to produce at least 1 metric ton of cereals per hectare every year. Another solution can be an agroforestry system consisting of, e.g. *Opuntia* cactus, *Acacia spp.* and cereals. The area would similarly be reclassified as "suitable" for agroforestry.

Class VI area sloping approximately 15 - 30 percent can equally be forested with the same species as for Class VIIe. Having a regulated goat grazing is necessary to let the vegetation regenerate. Terraces with a narrow base (Bragagnolo, 1995) are necessary, both to prevent erosion and to collect water. The area is reclassified as "suitable" for reforestation.

Class VIIe area is most suited to pasture, shrubs, and/or forest. According to Jorquera (1992) the *Atriplex numularia* is adapted to the climatic and edaphic conditions of the Chilean semiarid and could be used to reforest the area. A goat management plan is necessary to restrict the free grazing (Demanet, 1985). The slope is between 30 - 50 percent and small individual terraces (Bragagnolo, 1995) could be constructed to accumulate water. Seedlings must be irrigated because of frequent droughts. Another solution could be to leave the land idle and let the regeneration of vegetation take its time. Either way, the area is reclassified as "suitable" for reforestation, if also, having a goat management plan.

Earth moving could extend the irrigated land to create flat to almost flat land. A number of vegetables and fruits can potentially be cultivated. No documentation is available on the quantity or quality of water, therefore, estimating potential land use for irrigation is difficult.

9.5 Summary and comments

The AEZ methodology makes rather crude estimations of the biomass-mass production for local level, therefore, the yield of a good year was used as a potential yield. Shortages of data, but with the help of the land capability classification and other investigations, made it possible to classify the suitability of actual and potential land use. The major part of the actual land use (95 percent) is not sustainable and is designated as "not suitable" for cereal production, goat grazing and extraction of fuelwood. Remaining land (5 percent) is designated as "marginally suitable" for cereal, cumin and aniseed production.

Potential land use consists of reforestation of the land (95 percent) with additional soil and water conservation measuressuch as, individual and narrow-based terraces. Terraces slow down the water speed and increase the infiltration capacity. Preferably a goat management plan should be compiled, as well. The land is reclassified as "suitable" for forest and shrub species. Remaining land (5 percent) needs medium-based terraces and the land is reclassified as "suitable" for cereal production. In this paper no calculation of construction and maintenance costs have been made; nor has the community itself been consulted. Thus, the economic and social feasibility is not known, nor the expected decrease of erosion or agricultural and livestock production.

Land utilisation types, climatic inventory, actual and potential crop yields, physical constraints were considered in the AEZ methodology. These considerations resulted in a potential solution of pasture, shrubs, forest in combination with soil and water conservation measures. It is intended to be a sustainable option for land use management mainly considered from a biophysical point of view.

Conventionally (as in this paper) the AEZ methodology has been used omitting other important factors that decide land use such as, survival strategies, traditions, farmers' views, different households and so on. Although the Framework for land evaluation (FAO, 1976) stresses the importance to involve farmers as an important stakeholder and to consider social aspects. Consequently, many potential solutions fail to implement soil and water conservation measures, because land users do not readily accept changes or improved techniques. According to Smyth *et al.* (1993) the Framework by FAO is still commonly applied in various forms using procedures that take account of economic and other rapidly changing factors. Further, Dent (1993, cited in van Duivenbooden, 1995) means it is difficult to translate the suitability classes into practice due to a rather qualitative classification and the absence of formalised procedures for selecting land use systems.

The AEZ methodology was developed for making a global inventory of land resources and has both strong and weak points. The strong points are its simplicity, global applicability, and estimations of potential and actual yields. However, the accuracy is low and insufficient for larger scale planning, e.g. district or local level. "The accuracy of the generated land suitability indications would improve considerably if the AEZ methodology were (made) fully land-use-system-specific and dynamic" (Driessen and Konijn, 1992). The AEZ methodology does not consider the temporal variability of land-use requirements and land qualities. There is a reliance on (claimed) expertise knowledge, but would gain in correctness if well-documented relations of, e.g. biological, physical, and chemical laws, could be used. The data gathered would increase considerably, but also demand good basic information (Driessen and Konijn, 1992).

Relevant data of the resources (Section 3.3, Table 2) corresponding to the needs of the AEZ methodology was used. Likewise, different relevant resources are processed within the "soft" land evaluation approach based on the soft system methodology (SSM). "Soft" implies vaguely formulated goals to analyse, therefore, involving aspects of human activities is necessary such as, knowledge and perceptions, etc.

10 "Soft" land evaluation approach

The basis of this approach is the soft system methodology (Section 5.2.1). It consists of a Rich Picture of the Problem Situation (Stage 1 and 2), a Problem Situation elaborated with a Relevant System and Root Definition (Stage 3), and a Conceptual Model (Stage 4). The comparison between the Conceptual Model and the Real World of the Problem Situation (Stage 5) forms the basis to evaluating the potential for development of El Almendro.

10.1 Rich picture and problem situation

Stage 1 and 2: The aim is to represent the community as a whole, which serves to illuminate the problem situation and consequently a possible way to evaluate the development potential. Fig. 12 shows the unstructured Problem Situation. The assumption is that the community delimits the system border.

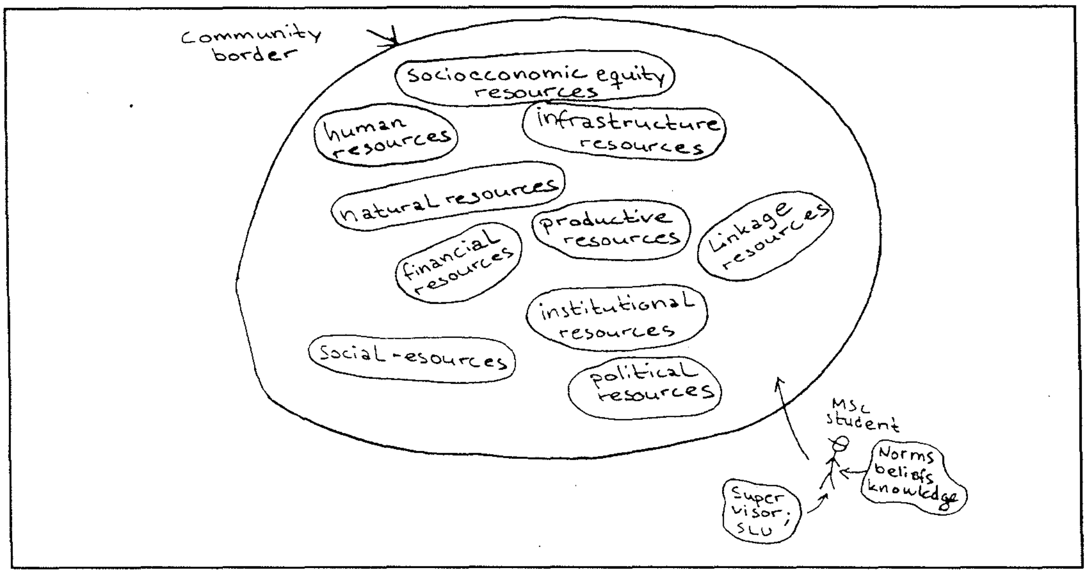

Fig. 12. Unstructured Rich Picture of Problem Situation.

This representation does not help very much in understanding the messy situation but a more elaborated version of the Problem Situation is shown in the Rich Picture (Fig. 13). The rich picture has some general aspects, i.e. structural characteristics, processes, atmosphere, facts and queries. These are briefly explained to make sense of the problem situation. Numbers refer to Fig. 13, and structural characteristics (1, 2, 8) affect and are affected outside the community. Likewise, (12) has implications outside the community.

Structural characteristics: The structure of the problem situation contains the main actors of land users and intervening institutions, organisations, etc. Structural characteristics change relatively slowly and these are:

(**1**) Historical context - the history affects: present land use, community administration, and actors acting on the behalf of the government.

(**3**) The community consists of the households, community administration and tenure regime; there are ten "comunero" (land user) rights; state laws depict how to manage the community, but the "comuneros" have the authority to decide and control their own lives.

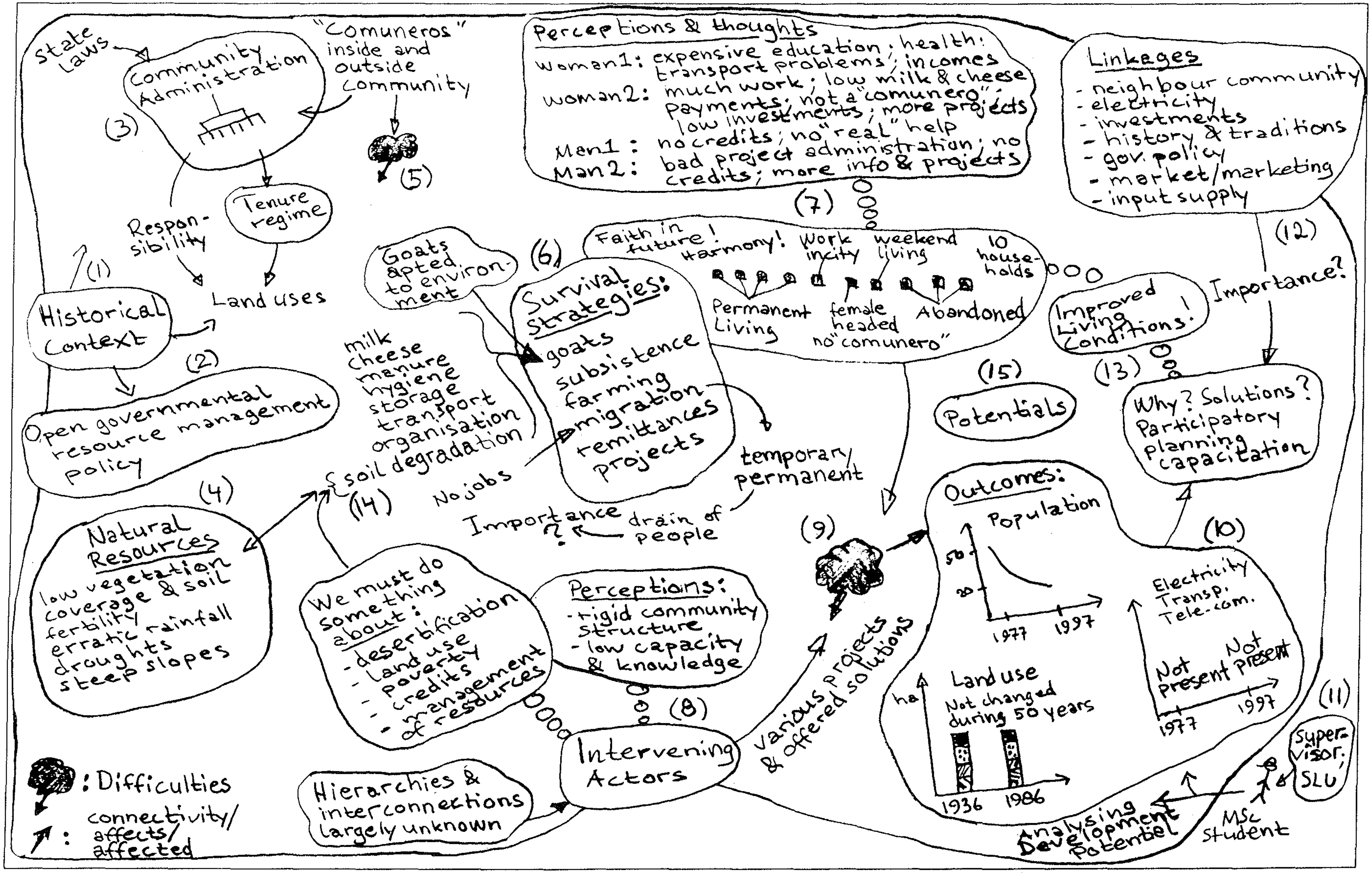

Fig. 13. Rich Picture of the Problem Situation of the Community of El Almendro in the IV Region of Coquimbo. The numbers refer to the text.

(4) Natural resources.

(6) Survival strategies - a mixture of: goat production, subsistence farming, migration, remittances from migrated relatives, projects by intervening actors.

(8) Various different intervening actors with perceptions of problems and solutions - hierarchical organisations but the extent is unknown; interconnections between actors are largely unknown.

(11) The MSc student is part of the situation brought in by the supervisor and sponsored by the Swedish University of Agricultural Sciences (SLU).

Processes: (14) Processes within the problem situation are numerous and unclear to the analyst. What importance have the interactions and to what extent do they occur between: "comuneros" and community administration; survival strategies and natural resources; intervening actors and survival strategies? The goat herding can illustrate the last example of interactions. What does it mean? Is it part of the community structure or is it a process? The goat herding is part of the survival strategy and, as such, part of the community structure, but simultaneously it is part of the process of land degradation.

The goat herding example shows how a structure problem turns into a process issue. Clearly, the difficulty lies in how to address the issue since solving the problem implies different actions from intervening actors and community. Reasoning like this transforms the degradation process to a structure issue and should be addressed accordingly. Paying the land users to reforest the common land and and believe they will take care of the management because "it is for their own good" is not sufficient. The risk is that the land users look upon the project as another short-term survival strategy. Without a proper management plan, acceptance by the community administration and capacitation, the reforestation project probably is a failure.

Atmosphere: The atmosphere of the problem situation reveals interesting aspects of the community and other actors.

(5) There are "comuneros"(land users) that live permanently in El Almendro and others that live in other places. This may create difficulties since the "comuneros" have different opinions and perceptions.

(7) Not lasting improvements and difficulties to achieve a prosperous community development affect the land users' perceptions of intervening agencies. Land users are quite accustomed to participate in projects and to try to achieve anticipated objectives. Perceptions of the projects are, however, that the project administrations are bad and withdraw too early, no credits are given to fulfil project objectives, and inadequately trained and sometimes even uninterested personnel are hired.

Needs differ depending on whom is asked. Woman One complained about personal health, transport problems, education costs of children and low incomes. Woman Two mentioned much work, inability to invest in the house, the husband far away, low incomes and not being a "comunero", i.e. not having rights to the land. Man One mentioned that the government did not give them "real" help and lastly, Man Two mentioned the need for more information, projects, and better prices on milk and cheese. The interviewed "comuneros" seemed to have faith in future and mentioned "harmony" as a strength of the community.

(9) Difficulties arise between intervening actors and land users to have a constructive dialogue and negotiations. Projects and solutions are offered and the land users try to fulfil the objectives.

(12) The importance of future linkages is difficult to evaluate. For instance, the changing political climate and investments in the vicinity affect the structural characteristics. What do the market, trader, input suppliers, other community, electricity, history and traditions mean? What importance has a decentralised decision-making and participatory planning? Especially the installation of electricity in El Almendro gives hopes of a better and comfortable future. Still, the project is not accomplished.The linkage to neighbouring community may be hindered since there is another religious belief. According to farmers there have been troubles with parents not letting their children participate in certain activities, or organise a feast to raise money for installation of electric wires. However, the future was important enough to promote collaborative actions and the fund raising went well.

(13) Attempts to improve the living conditions continue. Questions are asked about why projects failed and what are the possible solutions for the future? Intervening actors are optimistic that they will achieve solutions and development. New projects normally mean years of work and new chances of getting more experiences. Also, institutions and organisations know that they are trying to implement ideas and objectives not really supported by an official governmental policy. Land users wait till next project and have expectations of better projects in the future. Next project "will be better", which means new hopes, new commodities, or perhaps a subsidy to build a better house or invest in irrigation.

Facts: (10) Facts are available of outcomes from past years of interventions, both from the region as a whole and specific data about El Almendro. Outcomes for the agricultural community of El Almendro show a negative development in the sense of: losing community members, not having a basic infrastructure development, irregular land use development, and after all, a high regional investment per capita in comparison to the national average.

Queries: (15) Nobody seems to know the potentials of the land users and intervening actors to improve the present living conditions in El Almendro.

Before continuing, the perspective is necessary to resume and choose what to analyse in the successive stages of the soft systems methodology.

10.2 Choosing the perspective of the problem situation

The problem situation suggests many challenging issues to take action, but what is the main problem necessary to consider? What are the needs of the land users? Is it possible to decentralise decisions and capacitate people as prerequisites to developing the community? Nobody seems to know if living conditions can be improved. Likewise, the potentials of improving living conditions are unknown.

Without being too puzzled of the many intriguing issues, the basis for further analysis relies on the analyst's perspective of intervening actors and land users. Barrow (1993) mentions poor management of livestock as one of the major human activities and reasons that lead to land degradation. This seems to coincide with the problem situation of El Almendro. Therefore, to illustrate the successive stages of the soft system methodology the following pages concentrate on the goat herding, which is a survival strategy of the community of El Almendro. The objective is to analyse the potential for development and what can be done to improve the present situation. The assumptions, comments and reasons for choosing the goat herding are given below:

i) Activities seem to: lack a clear and coordinative strategy among and between intervening actors; and have a low people participation in planning and designing of projects intended to improve actual living conditions. Analysing the goat herding gives possibilities to analyse these issues.

ii) Goat herding is a survival strategy from historical times, affected by and affecting the natural resources. Historical economic aspects in conjunction with a semiarid climate demanded certain ways of livelihoods. It showed, however, to be unsustainable and people overused the land. The extraction of fuelwood, rainfed cultivation on steep slopes and pasturing created the actual situation, where the goats are the only animals capable of survival and production of milk and cheese.

CONAF and CEZA (1988) mention that goats are capable of moving easily and fast. Goats can feed on different forms of vegetation during the year and adapt to degraded areas with scarce forage resources. From this aspect the goats are seen as a potential due to the ability to adapt to harsh biophysical constraints. But this is a controversial view and Azócar *et al.* (1984) mean that the literature about goat herding is abundant with accusations of the damages it causes. According to Azócar *et al.* the damages on the vegetation and the soil depends on exceeding the carrying capacity, lack of knowledge to plan the goat management and free grazing. In addition, the goat herding links to the intervening actors and how they analyse the degradation issue. Simultaneously the issue links to the farmers management of meeting the nutritional requirements of the goats in relation to conserving the natural resources. From this angle addressing the issue of soil degradation as a simple process remedied with a "reforestation project"is difficult.

iii) Pouget *et al.* (1996) mean that results from the Province of Limarí (IV Region) indicate that agriculture is not, or seems to never have been, the sole survival strategy. The authors refer to the economic development, which have not improved over the years, even if investments are directed towards agricultural activities. Pouget *et al.* mean that communities concentrate on social reproduction, i.e. based on a complex migration strategy and not just agricultural activities. Thus, projects should address other sectors as wellsuch as, roads to simplify temporal migration, social organisations and so on. The results by Pouget *et al.* verify, as described in the problem situation, that land users have different survival strategies. Concentrating on goats, as the issue to analyse further in this paper, depends on land users mentioning milk and cheese production as one of the most important economic activities.

iv) Nitsch (1994) states that the conventional idea among development workers has been to define what is good for the target group. This approach has shown not to work in agricultural extension and advisory work. Consequently technical solutions do not "diffuse" to other farmers and desired development will not happen. Other reasons for difficulties are that the target group (land users) is seen as an object for advice and persuasion; thus, neglecting situational important factors. Nitsch means that needs assessment is a tricky enterprise, because farming represents a complex system of many interacting factors, for instance, economic, ecological, changing climate, social, cultural, technical, and institutional factors. Clearly, farm management, i.e. "*the ability to coordinate complexity under uncertainty*" embeds many possibilities and deficiencies and often cannot be separated and described as well-defined needs (Nitsch, 1994, italics in original). Therefore, the assumption is that the outcomes of the projects partly depend on the inability to define the needs and capacity of the target group, which makes it necessary to include the land users as early as possible in evaluation and planning processes. By analysing the goat herding it is believed, that the soft system approach can involve the land users.

Before proceeding, it should be noted that land users mentioned the need of repairing their houses, but in the further analysis it is assumed that the basic needs of food, housing and clothing are satisfied. Having explained and clarified the assumptions and reasons for analysing the goat herding, the next stages continue elaborating the issue.

10.3 Relevant system and root definition

Stage 3: At this stage the analysis enters the "abstract world", which intends to scrutinise and get new perspectives on the problem situation. A primary task states a task that is central to the problem setting of the actual situation. As previously explained the primary task to consider is sustainable land use relating to goat herding with additional activities. The root definition translates and elaborates the primary task into a relevant system. This means to write down verbally the essence of the processes inferred by the relevant system. The soft system methodology relies on experiences, which show that the CATWOE checklist sharpens up the meaning of the root definition (Table 17).

Table 17. The CATWOE checklist to sharpen up the meaning of the root definition

CATWOE	Remark
Customers	The customers are the farmers and the households
Actors	The main types of actors are the farmers, governmental institutions, NGOs, and experimental agricultural stations
Transformation	People participation, investments, knowledge, support, advices, technology dissemination ----> sustainable land use
Weltanschauung	The world view behind this system is that institutions, organisations and local people should take responsibility of the present situation and deliberately work for mutual understandings, transparent decision-makings on a long-term perspective, and view the goat herding as a potential not as a problem
Owner	The financiers of the project have sufficient power to cause the system to cease to exist
Environment	The constraints the system takes as given are: a governmental policy not defining sustainable land use or appropriate strategy; lack of ongoing decentralisation process of decision-making; lack of availability of professionals, appropriate techniques, financial resources and time; willingness to collaborate within and between intervening actors; willingness of general assembly to improve practices; marketing possibilities

The CATWOE criteria resulted in the following relevant system and root definition:

"A system in which intervening institutions and organisations promote people participation, capacitation and credits to achieve financial profitability at household level stimulating farmers to adopt or adapt disseminated technology to herd goats sustainably with a satisfactory quantity and quality of milk and cheese."

This is but one example of a relevant system and root definition. More views and relevant systems can be suggested, for instance: **i**) a system that forbids goat grazing of the common land and where the intervening actors capacitate and support goat/ milk/ cheese production; **ii**) a system that forbids people and goats in the community letting the vegetation regenerate; or **iii**) a system where the farmers are left alone without any support from intervening actors. None of these suggested relevant systems were elaborated nor used in the continuing stages of the soft system methodology. This is not equal to dismissing the importance of these views but it is expected that one example will show the strength and ability of the continuing theoretical/ practical reasoning.

10.4 Conceptual model

Stage 4: The conceptual model is an abstract reality derived from the root definition and represented by the front-line activity terms of: **i**) promote; **ii**) stimulate; **iii**) disseminate; **iv**) adopt/adapt; **v**) goat herding; **vi**) credit-giving; **vii**) marketing; and **viii**) monitoring (Fig. 14).

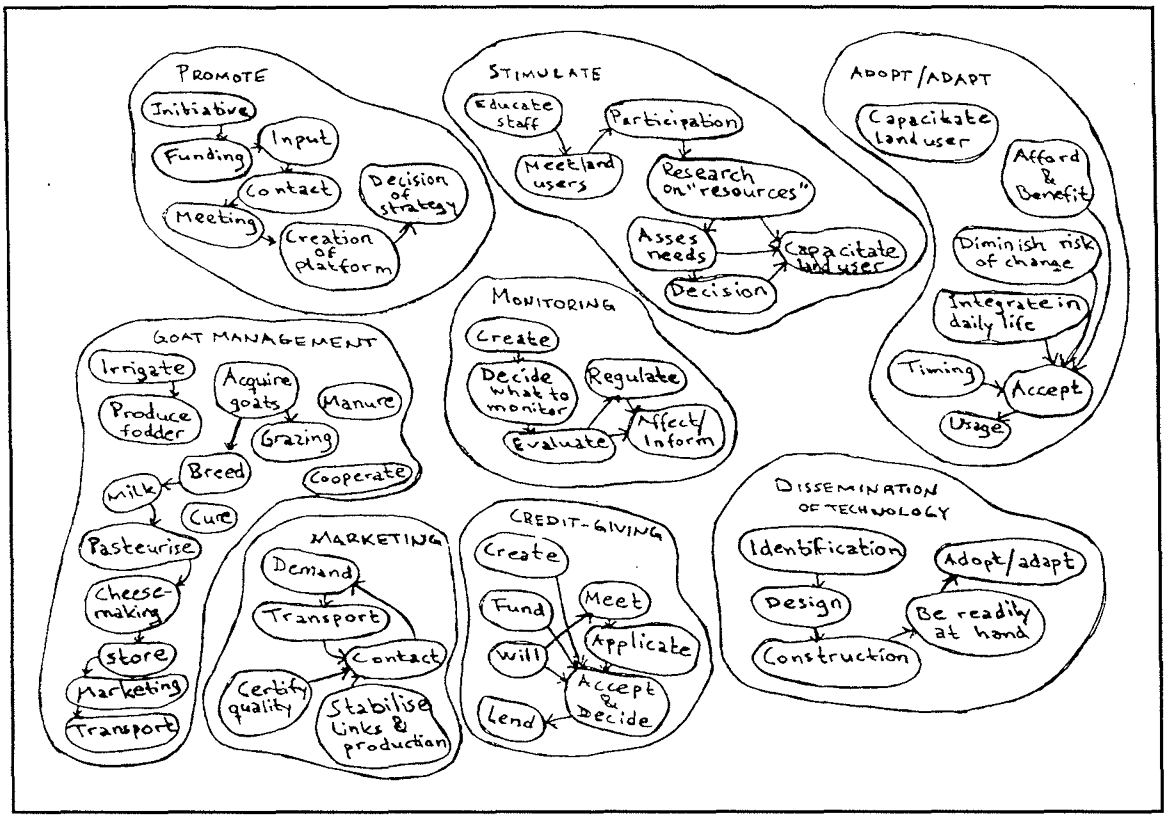

Fig. 14. Front-line activities (capital letters) and identified back up activities. The interconnections between front-line activities are not shown.

Every verb (front-line activity) inferred certain subsidiary back up activities to take place, e.g. **i)** promote inferred initiative taking, funding of projects, inputs of knowledge, expertise and time, contacts with stakeholders, meeting of stakeholders, creation of a platform for decision-making. This procedure of listing and ordering front-line activities with subsidiary back-up activities was undertaken for every verb. Thus, the list of verbs (**i** - **viii**) consisting of subsidiary activities are subsystems within the whole model. Just as the CATWOE criteria refined the root definition, a formal system (Fig. 15) was used to scrutinise the conceptual model.

The formal system is essentially a compilation of features that experience suggests having to be present if a set of activities is to comprise a system capable of purposeful activity. Simultaneously, the formal system explains the connectivity between the subsystems (Checkland, 1989). The refinement of the front-line activities by using the formal system resulted in a developed and conceptual model of sustainable goat herding in the community of El Almendro (Fig. 16). Some subsystems had functional points in common. For example, activities involving "creating" were grouped into a creation subsystem, the activities of "meeting" were grouped into a meeting place subsystem and so on. Explanations and changes are briefly mentioned beginning from the left in the model. "Initiative" and "funding" supposedly come from outside the system, i.e. outside the community of El Almendro. Names of departments or entities are not named, because the process of model building is to be a purely logical one (Checkland, 1989).

The "environment"consists of, e.g. the decentralisation process and governmental sustainability policy outside the community. A "platform" for discussions and decisions between stakeholders is necessary to create. The same platform elaborates and decides "monitoring indicators" to evaluate, spread information and take regulatory actions. A "credit-giving institution" needs to be created to fund techniques and stimulate adoption rates.

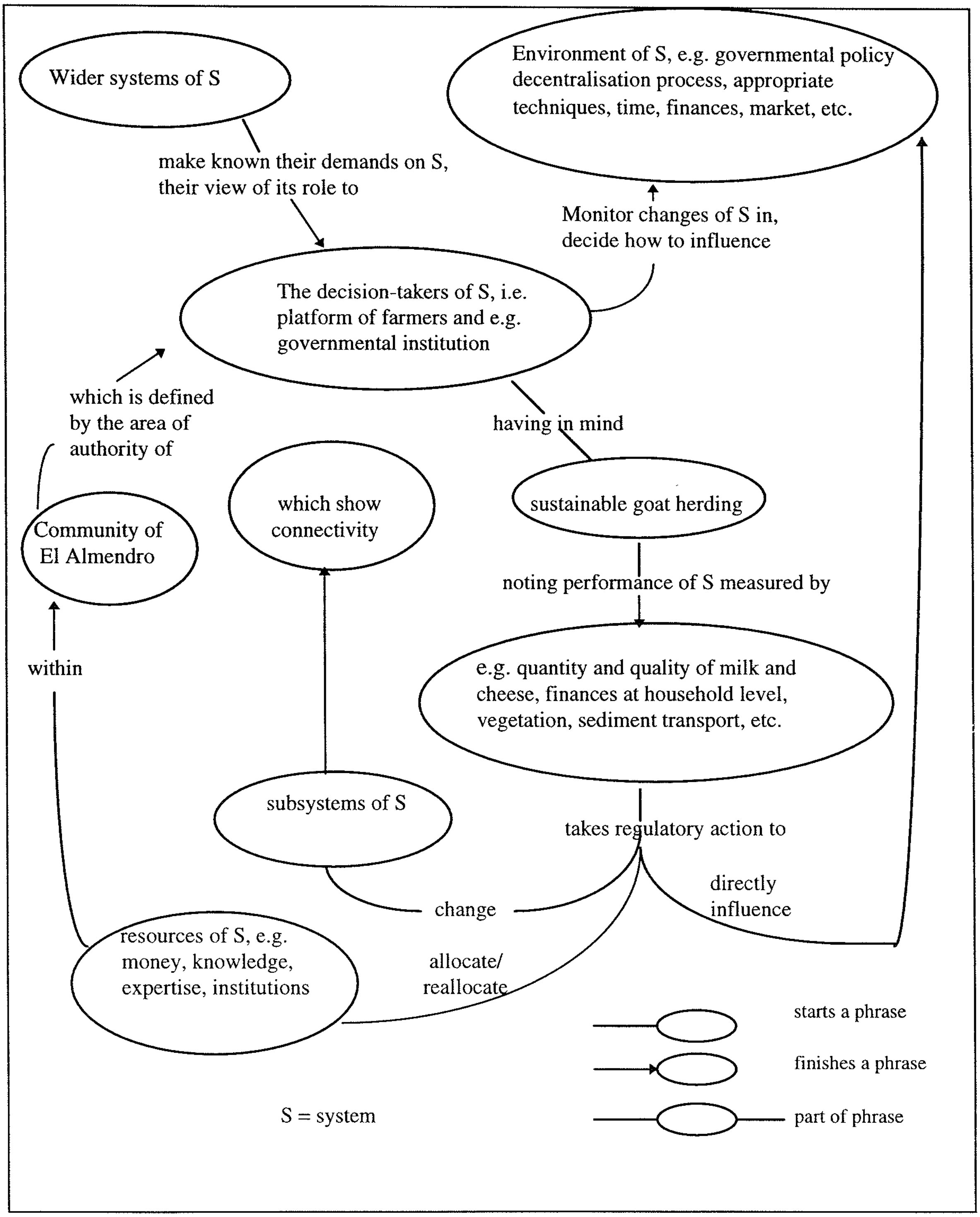

Fig. 15. The formal system to scrutinise the depicted conceptual model (adapted from: Checkland, 1981, reprinted in Checkland, 1989).

An "education and capacitation" programme needs to be available. Staff of institutions and organisations are taught participatory techniques and how to involve land users. The "stimulation"subsystem consists of involving the land users in the research process, to assess needs and necessary capacitation courses. "Marketing" is an important subsystem to involve, because the production of milk and cheese depends on the market structure and demand. In addition, transport

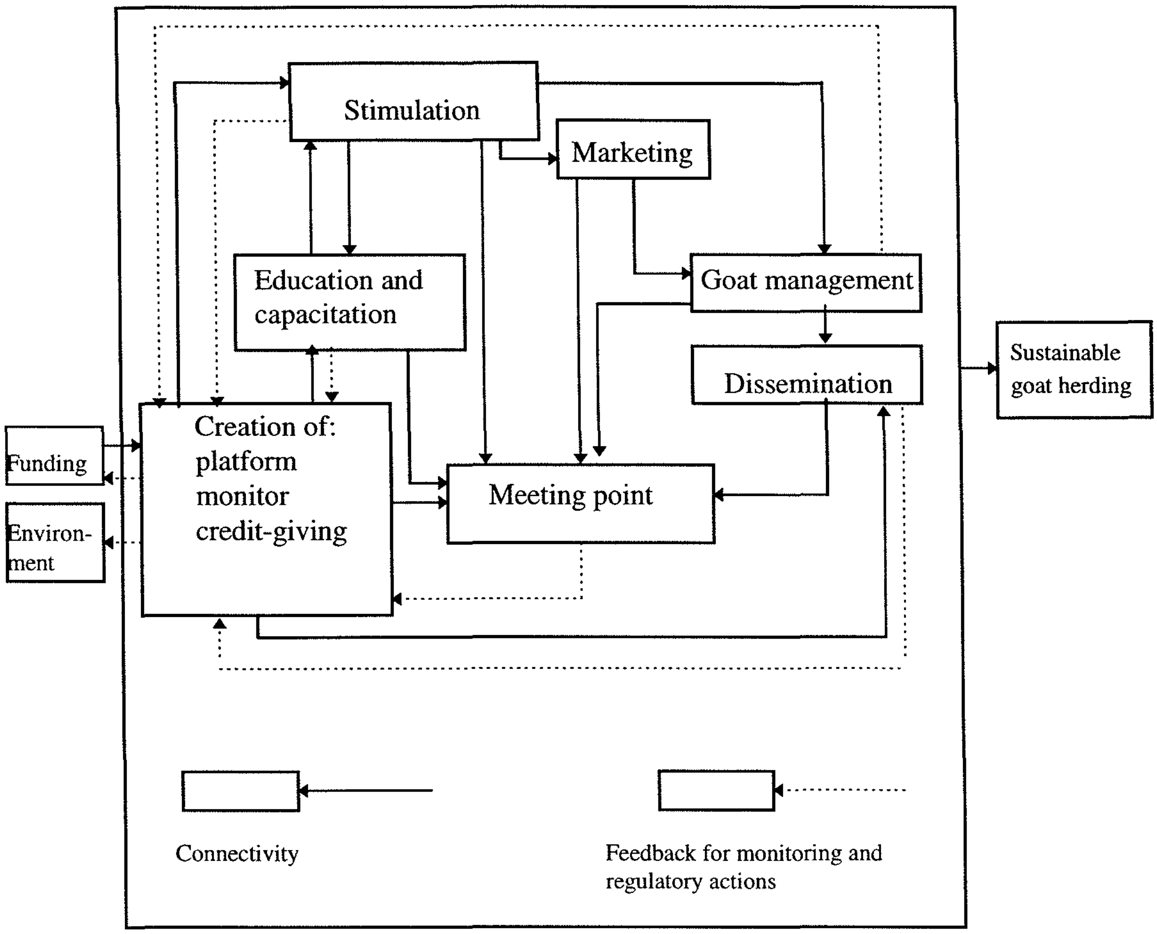

Fig. 16. The conceptual model of a proposal for sustainable goat herding in the community of El Almendro. The relevant system, root definition, logic activity terms and formal system shaped the construction.

and quality factors are crucial to reach many customers. "Goat management" involves many issues and one relates to irrigation possibilities for fodder production. Thus, the research of the "resources" in the stimulation subsystem is very important. The subsystem of "dissemination" of technology has been clustered with the subsystem of "adopt/adapt". Identification of technology, capacitation of land users, short-term benefits, integration of techniques into daily life and timing are issues increasing the acceptance. To afford the improved techniques the credit-giving institution is an important link.

As noted, the "meeting point" seems to play an important role of the model's functionality. It should be a common place, well-known to everybody, easy to reach where land users can discuss informally, receive information, ask questions and so on. An extensionist should regularly attend and may coordinate formal meetings and link to other stakeholders. It will be one of the most important subsystems within the whole system since regular contacts, feelings, etc. give opinions of the performance. Consequently, this creates possibilities monitoring changes and proceedings and to take necessary actions. The resulting process of the conceptual model assumes to be sustainable goat herding.

10.5 Comparing the conceptual model with the real world

Stage 5: The objective of comparing the conceptual model with real world is to create an agenda and to highlight missing activities, peculiar settings and other issues (Table 18). The agenda is a base for

Table 18. The resulting agenda of the comparison between the conceptual model (CM) and the real world (RW)

Activity in CM	Present in RW	Comments
Creation of a decision making platform	No	Seems to be top-down approaches and weak incentives for collaboration
Creation of a credit-giving institution	No	No will to accept credits to insecure and low net-return projects
Monitoring	Yes	Partly done by the National Institute of Statistics (INE) as agricultural census, broad coverage
Education and capacitation programme	No	Capacitation of experts, staff, and farmers. INDAP has given courses for El Almendro before
Stimulation to have a participatory research	No	Experts and extensionists seem to not have time or sufficient knowledge
Marketing	No	Seem not to know the demand of pasteurised cheese and cooperatives
Goat management	No	A great need to implement in conjunction with, for example reforestation projects
Dissemination of appropriate technology	No	CEZA and INDAP have undertaken improved technology courses, but there is a great need for more
Create a meeting point	No	There is a house used for neighbour meetings. It is not regularly used for information, feedback to projects, etc.

discussions with the target group(s) to come up with, what are both, systemic desirability and cultural feasibility (Checkland, 1989). Systemic desirability means that any change to be implemented must make sense in system terms, i.e. it must not contradict the system thinking that has formulated the root definition and the construction of the conceptual model. Cultural feasibility simply means that the target groups are the responsible ones to implement changes that emerge (Checkland, 1989).

The comparison shows many differences and highlights missing activities that should have been present, if it were to be a functioning sustainable goat herding system. Stage 5 was the last stage of this paper's use of the soft system methodology. Debate with land users regarding missing activities and feasible action takings is not included due to the time limits set to this study. Thus, the following discussions treat Table 18 and evaluate the possibilities to improve the present real world situation within a short-term perspective of presumably five years.

10.6 Evaluation of the potential for development

Following discussions treat the relative importance of the components of the conceptual model and potentials to improve the real world's activities. It implies two evaluation ranges: **i**) one comprising the relative importance of components within the conceptual model; and **ii**) the other comprising classes that show the real world's potentials to improve the present activities towards the conceptual model.

i) Ranking the relative importance of components within the conceptual model can create a narrow-minded view and focus energy on wrong items. For instance, on one hand creating a negotiation platform could very well be assessed as the most important component of the conceptual model. If this activity is absent in the real world, it would be evaluated as a severe constraint. On the other hand, the conceptual model is an abstract system not very likely to be implemented in reality. This means that the weights of the different components may be irrelevant. For example, the education and capacitation programme of extension agents and participatory methods could be of more practical importance in the real world, than creating a platform. It results to be complicated to weight the importance and implications of missing or existing components.

ii) Ranking the potentials of the real world to improve the present activities results to be difficult, but possible. The real world situation has characteristics that potentially can be improved. Comparing the real world with the conceptual model serves the purpose to illustrate the missing or existing activities, and constraints or potentials, respectively. According to Bdliya (1991), such characteristics could be presented in "improvability classes" which mean to categorise properties reflecting current characteristics of the present system (See Section 4.4 and the complementary land evaluation). The wording of "improvability class" is not easy to interpret since it reminds of "suitability class", which is the nomenclature of Framework for land evaluation (FAO, 1976). Therefore, to avoid fuzzy interpretations the "improvability class" is renamed as "potential class".

The highlighted activities (Table 18) are analysed and scrutinised for information that reveals current characteristics. Remember that the evaluation does not render a blueprint of the probability to implement the conceptual model by a top-down or a participatory approach. Ideas and knowledge originating from the evaluation are to be discussed with involved actors, which in turn increase the probability of achieving wanted objectives and aim. Within the context of this paper the potential for development is the same as the potentials or possibilities to improve the present activities. Thus, the potential for development is evaluated according to "potential classes" where: 0= very low; 1= low; 2= medium; and 3= high. As much as possible the classification is done for both higher level (intervening actors, e.g. governmental institutions) and local level (land users and intervening actors, e.g. NGOs).

10.6.1 Creation of a decision-making platform

The discussion treats views from **i**) higher and **ii**) local levels.

i) The most effective state instrument, INDAP (National Institute of Agricultural Development), addressing small-scale farmers is in a restructuring phase. Previously INDAP contracted consultants to work with the farmers, but inadequate results and low attendance of poor small-scale farmers required changed working procedures. INDAP now intends to have more control of the projects and attend farmers directly. Farmers should be able to come to INDAP and discuss possible solutions to problems. INDAP is going to be more transparent than before and produce information and transmit radio messages to inform about the new working procedures. Even if it is going to take considerable time before senders (e.g. INDAP) and receivers (e.g. land users) will meet, the process has started. A serious drawback, as mentioned in an interview, is the hierarchical and bureaucratic structure of INDAP, which may impede quick results.

Another drawback is the rigid and strong centralised decision-making structure. This means that the regional government of the IV Region may very well decide what to do in cooperation with agricultural communities, but must fund the specific actions via MIDEPLAN (Ministry of Planning and Cooperation) in the capital of Santiago. This creates bureaucracy and slows down the speed. The centralised decision-making legacy from the 1970s and 80s is not easy to rupture and plays a certain role. In addition, lack of knowledge at MIDEPLAN may sometimes result in rejection of creative initiatives. The probable decentralisation pilot project in the IV Region, financed by the European Union (1998), will promote a more effective decision-making process in the future. The lack of a clear governmental policy, regarding the development of the agricultural communities and the use of natural resources, is a drawback.

PRODECOP (Development and Cooperation Project of Poor Rural Communities) started 1996 and lasts eight years. The Chilean government and the International Fund for Agricultural Development (IFAD) finance the project. PRODECOP is quite promising, though, with some initial problems of responsibility issues and capacity to duplicate results. As one official said "It was like throwing a handful of fertilisers in a wheat field. It grew vigorously where it fell, but the rest..." This has lead to a reorientation of the project and PRODECOP now concentrates on a community that has ample water resources to facilitate good results. The project includes difficult but necessary components of farmer participation and credit-giving institutions. PRODECOP has potential and a long project time, but is not operating in the community of El Almendro, yet.

In the Southern Chile, an FAO project treats the strategy and methodology to collect information about agricultural land and water for a sustainable agricultural development. Future results aim to be a tool for the government, regional government, local people and other organisations to improve the potential for development at micro-catchment level.

To conclude, the higher level is in progress towards better working procedures, but still much is left to do before there is a chance to create a common platform where the experts, officials, and farmers may participate on equal terms. It is a slow process; nevertheless, the main thing is the awareness and will to implement changes in poverty stricken and degraded areas. Changed working methodology, e.g. INDAP, towards more farmer contacts and PRODECOP with farmer participation are promising features. At the moment there are no activities in the community of El Almendro, but results will be used as a tool by INDAP to attend farmers and their problem situations efficiently. Constraints on the present system characteristics have a medium potential to be improved.

ii) Equally, the local level shows constraints to involve people in a common decision-making platform. The variety of "comuneros", most of them live and work in other places, makes it difficult to gather views beneath a common goal. Involving everybody is important, which could be represented by a trusted person living in and labouring the land of the community. This trusted person does not only represent the people but also the actual conditions of the natural resources, survival strategies and the ongoing deterioration processes. The trustee could, for instance be the secretary of the community administration. At the moment preparing this paper, the present secretary had contacts with PRODECOP and seemed to be trusted and knowledgeable. Viewpoints of "comuneros" living in other places are largely unknown and can be illustrated by a person that participated in drawing the village resource map (Section 8.3.). This person is well respected, has availability to health centres, services and, consequently, has different views of problems of the community.

The association of neighbours (El Almendro, upper part of the catchment; Canela Baja, lower part of the catchment) is a positive fact, since the people share many of the same predicaments and the negotiating weight may increase. The different religions in the communities may be an obstacle to a unified development and should be observed. Nevertheless, people know the meaning of collaborative actions to obtain beneficial goals.

NGOs, e.g. JUNDEP (The Private Corporation of Social Development) and ACA (The Association of Agricultural Communities), are valuable assets to involve creating a decision-making platform. JUNDEP has knowledge, experience and trust among the farmers and could initially function as an intermediary. If governmental institutions would accept that, is not known. ACA could be part of the platform, since it has connections to INDAP regarding reforestation activities. Both NGOs support farmer contacts, but seem to fail following up the projects. Consequently, land users feel abandoned and have problems fulfilling project objectives.

To conclude, local people with NGOs have knowledge and practical experiences to participate on a common decision-making platform. Difficulties exist, e.g., wide perceptions of the problem situation by different people. A common viewpoint is necessary and could be represented by a trusted person living in the community. This would create a higher weight to the opinions of the community. Farmers appreciate a higher degree of participation and the possible fact of having interested extension agents visiting the fields. Land users have the will, but need to be better organised to be able to cooperate with projects that support participatory strategies and decentralised decision-making. NGOs have an important role to play, but their capacity is not known. Constraints on the present system characteristics have low to medium potential to be improved.

10.6.2 Creation of a credit giving institution

Credit-giving institutions are not willing to risk money. Thus, the farmers have difficulties in investing in improved technology. Farmers depend on remittances from migrated relatives or what they earn from other income generating activities. PRODECOP in a nearby community, tries to find solutions of credits and may in the end be important for El Almendro, but it is too early to interpret the results.

To conclude, remittances from migrated relatives play an important role in the ability of investing in new improved technology. Right now the ability is quite limited, though. In addition, PRODECOP in a nearby community tries to find ways of organising credits and duplicate the results. Constraints on the present system characteristics have low potential to be improved at high level. At local level the potential seems to be very low to low.

10.6.3 Monitoring

The monitoring system needs to have relevant indicators and these should be discussed at the decision-making platform. Monitoring indicators are important and should directly influence the constraints, take regulatory actions to change other subsystems, or allocate/ reallocate resources. Possible indicators are depicted concerning a hypothetical project with one of the objectives to raise the productivity of goats (Table 19). The compilation of monitoring and performance indicators relies on ideas suggested by Mosse and Sontheimer (1996) (Section 3.2). Note that Table 19 is to be read vertically, since horizontal reading does not show direct linkages.

Suggestions of indicators are quantity and quality of milk and cheese, household finances, vegetation in common land as an indication of erosion, credits given, adopted techniques, etc. At the moment no control- and monitoring system exist in El Almendro. The community administration of El Almendro can probably increase their responsibilities as a control organ. Important to monitor and control is the number of goats and where they graze. In addition, penalties could be given if land users violate the rules. The National Institute of Statistics (INE) has thorough knowledge of gathering information and recently conducted an agricultural census. The scope of the census does not specifically cover depicted indicators or time periods as in Table 19 but shows that governmental institutions have sources of knowledge of how to monitor indicators. Interviews reveal that at least one NGO does not monitor or evaluate proceedings.

To conclude, the capability to organise a control system is not known. More information of the meaning and elaboration of indicators is necessary. The increasing interest for participatory approaches increases the chances to involve stakeholders to formulate relevant indicators and control functions. Constraints on the present system characteristics, at both high and local levels, have low potential to be improved.

10.6.4 Education and capacitation programme

This means education of both experts, staff and farmers. Views are given from both **i)** higher and **ii)** local levels.

i) Education of experts and staff involves professional knowledge and ability to use participatory

Table 19. Proposed hypothetical performance and monitoring indicators of a community project. The table is to be understood vertically since horizontal reading does not show direct relations (adapted from: Mosse and Sontheimer, 1996)

Objectives	Inputs (resources provided for project activities)	Outputs (goods and services produced by the project)	Risks and critical assumptions (the outcome is dependant on...)	Outcomes and impacts of project activities
Raise the productivity of animals Raise the farmers net-income Improve the farmers' management of the resources to be environmentally sustainable Empower both women and men	5 years which cost X Chilean pesos Expert knowledge from University of Chile, INDAP, JUNDEP, ACA, pedagogic and didactic skills	X quantity of milk X quality improvement of cheese X increased percentage of vegetation cover X farm visits to pilot farm Training programmes and a manual for goat management Farmer groups in community Women group in community	Climate - sufficient rainfall Governmental support and incentives to start a new decision-making system Regional authorities and institutions capability and willingness to participate and support an improved farming- and income generating system Interest and capability of the community general assembly to participate in the project Quality/lack of an infrastructure, under developed market-structure Interest and participation by women and men in the new farming system Acceptability of proposed measures The art of listening and learning by the intervening agency	X farmers learn and adopt the new pastoral system X new extension agents, which are learning and working with university, teaching and advising farmers (Y days with researchers-university, Z farmers visited etc.) Farmers meet and discuss experiences Women part of the discussion groups or form new groups - interest in the development, create other projects X % of the farmers have improved the yield of products, and net-income compared to previous period The farmer community has increased the net-income, i.e. economic growth Less soil degradation and erosion caused by poor farmers, less sediment transport, improved soil moisture storage, improved soil organic matter content Less migration

methods such as, PRA techniques. Judging from farmer interviews both these abilities seem not to be thoroughly addressed. Availability of knowledge and willingness to learn more about these issues by professionals are not known. Ongoing projects, e.g. PRODECOP and the restructuring of INDAP indicates progress, especially regarding the participatory approach.

Capacitation courses for farmers happen, INDAP, for instance arranged with CEZA how to feed goats efficiently. The course was successful and the farmers of El Almendro could adopt the disseminated technology. Needs of the farmers were satisfied. More capacitation courses are, however, needed in relation to the management of goats and marketing. The knowledge and capability of needs assessment must be improved at higher level. Also, addressing socioeconomic differences of female headed and male headed households is necessary. A full-time working woman with children, goats and agricultural activities, needs knowledge corresponding to her situation. In comparison a male farmer with grown up and migrated children needs support corresponding to his situation.

To conclude, institutions seeminly lack knowledge or possibilities to improve the situation. To some extent PRODECOP addresses these issues, but it is too early to interpret. The ability of organising capacitation courses for farmers in the community has been proven by the success of teaching effective ways of feeding goats. Constraints on the present system characteristics have medium potential to be improved.

ii) Capacitation needs within the community differ. One farmer may have knowledge of the importance of having a restricted number of goats and trying soil and water conservation practices. Another farmer understands that one has to save the "vitamins" of the soil, but not knowing how. After interviewing farmers the need of knowledge and the will to learn more was noted. If the courses are adequate, i.e. relating to the needs of the farmers, the responses will probably be impressive. One example, if soil and water conservation measures somehow could be linked to increased production of milk and cheese, the practices would be adopted. It should be possible, without compromising the financial revenues of the farmer, to improve the sustainability by capacitation and adequate technologies.

Not just technical issues must be addressed and Solís de Ovando *et al.* (1989) mention another important aspect. Many decisions made by the community administration are made verbally and seldom written down. The decisions are respected, but in practice traditions rule more than written norms. Also, there are very few communities that fix certain numbers of livestock, undertake soil protection measures, or effectively use the common land. Why is this the case? Ovando *et al.*mean that the community members do not have enough knowledge of agricultural community laws and, at the same time, the members forget their responsibility of being their own legislators forming their own lives. Ovando *et al.* state that revising the community norms are necessary and, consequently, preserve the culture of the community to avoid future conflicts.

NGOs need to be capacitated, as well, as the institutions at higher level. Further education of the art of conducting participatory methods and professional knowledge is necessary. No information is available of the actual proceedings. However, incorporating capacitation ideas should not be difficult since, by definition, NGOs work closely to farmers.

To conclude, the knowledge and capacity to assimilate capacitation differs. The will among the interviewed farmers seemed high and probably it would not be difficult if needs are met. NGOs need to be capacitated with the governmental institutions and organisations. Constraints on the present system characteristics have medium potential to be improved.

10.6.5 Stimulation

This activity connects to the creation of a decision-making platform, because participatory methods are necessary. It also connects to the education and capacitation activities since the staff must be able to undertake participatory methods and conduct research relating to relevant issues. The stimulation subsystem invites both professionals and land users to assess and define needs, with the objective to minimise ill-defined projects addressing presumed needs of land users. Therefore, the results would gain if land users were involved in the whole procedure of diagnosing, describing their own problem situation and being responsible of the solutions.

Available information is scarce, but deducing from other mentioned activities the "stimulation process" has already started. The most prominent example is INDAP, which changes its working procedures towards more participatory and informative oriented approaches. So far these activities have not reached El Almendroyet. From interviews, land users clearly appreciate higher degree of participation and the fact of having interested extension agents visiting the fields. Nevertheless, much is left to do before there is a chance when researchers and land users work side by side complementing each other's knowledge and skills.

Both the "education and capacitation", as mentioned previously, and the identification of appropriate techniques demands thorough analysis of the suggested resources (Section 3.3, Table 2). For example, innovations, expansion of the number of goats, or of other agricultural practices are intimately connected to the amount and quality of water in the community. This has not been researched and two examples illustrate the implications below:

1) The literature describes a serious problem of a precipitation deficit and a very fluctuating inter- and intra annual precipitation regime. The probability of exceeding average rainfall (160-180 mm/year) is in relation 1:2, which means frequent droughts. Consecutive droughts, for at least three years, are called a drought cycle. The drought seldom implies zero rain but the low precipitation does not allow any feasible production of, e.g. wheat or barley. Land users have sufficient water in wells and springs to irrigate alfalfa, barley, and a variety of horticultural products. Water is not sufficient to irrigate the "lluvia" (private rainfed land) and the capacity of the irrigation system differs widely among the land users. Some have availability to several m^3 of water per day, while others have much less. The future potential of the use of the water depends on investigating the availability of ground water, the quality and a sustainable use of the water, i.e. without diminishing a future delivering capacity. The water could either be used for expanding the irrigation on private land or the "lluvia" establishing multipurpose shrubs such as *Atriplex numularia* and herbaceous vegetation. The real potential is to produce enough fodder on the private land, and control the grazing of the common land and "lluvia". Within a time period there might be revegetated hill sides and erosion problems would diminish considerably. Likewise, the inundation risks for lowland farmers would decrease.

2) Preventing the erosion hazard demands quite expensive, much knowledge and labour intensive soil and water conservation measures. Actual use of the common land and "lluvia" needs to change to improve the degrading situation. The potential to do so is intimately coupled to the availability of water either from precipitation, water-harvesting techniques, more efficient use of existent water, or manipulation of the ground water reservoirs. It is, also, coupled to the knowledge and perceptions of land users in how they use the land. Perceptions result from conditions of natural and social resources, which have been shaped during hundreds of years. Thus, the potential of changing the availability of water does not automatically lead to changed land use. Other aspects muct also be considered, e.g. economic and marketing possibilities.

To conclude, the stimulation activities have great importance in involving land users in the research process and assessment of needs. This is not done today, but signals show possibilities of improvements. Constraints on the present system characteristics, at both higher and local levels, have low to medium potential to be improved.

10.6.6 Marketing

The agricultural production evolved through hundreds of years and has not been the only way to support a family. Other economic components have always been part of the survival strategy and the wisdom of such behaviour is not easy to question. However, a few remarks can be said about the present agricultural situation. For example, the production is low, inefficient, degrades the resources and has low quality of refined products. Equally marketing possibilities and knowledge must be improved to ease farmers' dependence on merchants and traders. Farmers' control is low with small chances to improve the situation. For instance, the transport to markets in Santiago or another big city is financially impossible for a farmer to undertake.

Customer demand of cheese is not known in exact figures, but there is a high demand of pasteurised milk and cheese. Ppossibilities to improve the customer - producer relations, cheesemaking procedures and transports must be investigated. The awareness of intervening actors and organisations in relation to marketing is not known.

To conclude, farm management involves more components than just agricultural production. Farmer's goal is not explicitly to minimise or reduce degradation and maximise incomes. Respecting the cultural and practical reasons of how to survive in a semiarid setting, the evaluation is based on the farmer's knowledge and possibilities to market their products effectively. It seems low. Constraints on the present system characteristics, at local level, have very low to low potential to be improved. At higher level the potential is unknown.

10.6.7 Goat management

Soils of El Almendro are not suited for arable activities but for pasture, shrubs and forest purposes. Very recently one NGO wanted to reforest seventy hectares of the community, without having a management plan. Reforestating necessarily infers more than just planting shrubs or trees. For example, a management plan should be elaborated, both for maintaining plants and for goat herding. The agreement on such a plan depends on a few aspects, e.g. knowledge of implementing agency and farmers, incentives for adopting the plan, possibilities to follow up the plans and importance for the agro-pastoralists, whether households are small or big, female or male headed, etc. At the moment the ability to address these issues among intervening actors seems low.

A goat management plan should include all issues related to the activity, e.g. breeding, milking, cheesemaking, storage, veterinary services, manure, fodder production, common land use and so on. Using fodder gates is just but one part of such a plan; still the goats graze the stubble in the "lluvias", or graze freely the common land and impede sustainable goat herding. Included in a goat management plan should be a monitoring institution and a reward/ punishment system to control the activities.

During drought periods the linkage between goat production and irrigated fodder production is clear to the farmers and the numbers of animals reduce. Upon arrival of winter rains the numbers of animals increase due to more vegetation availability in the common land. Consequently, the vegetation does not regenerate.

To conclude, a goat management plan is difficult to design and depends on many issues. At local level implementing actors seem to lack knowledge, farmers do not link soil degradation and grazing animals, the community administration needs to increase the responsibility, lack of a control system, no appropriate incentives and so on. In addition, other activities relating to goat management such as the elaboration of cheese, storage, transport and marketing suffer from severe constraints. Constraints on the present system characteristics at local level have low potential to be improved. At higher level the potential is unknown.

10.6.8 Dissemination of appropriate technology

The introduction of fodder gates illustrates the importance of disseminating (spreading) appropriate technology. Farmers received material to construct fodder gates to fix eight goats simultaneously to control the foraging. According to one farmer, fodder gates in combination with nutritious fodder, consisting of pellets and a ley mixture of alfalfa and barley, increased the milk production by 100 percent. Thus, this specific farmer could decrease the heads of animals and save time. Another farmer even increased the number of goats during the last drought period, which is an illustration of the efficiency.

To a certain extent, the introduction of improved techniques depend on timing. The farmers realised that animals suffered while bringing them to summer pasture up the Andean mountains. Many animals died due to the drought and the exhausting journey resulting in an inefficient goat herding. INDAP and CEZA organised a capacitation course during this critical phase and a few farmers responded quickly, accepted and adopted the ideas. Presumably the land users understood the benefits and could afford the introduction of the improved technology. INDAP and CEZA reduced the risk of introducing new technology by providing back-up activities in form of construction material. Thus, the only thing necessary was to hire a carpenter to assemble the fodder gates. Another decisive factor was that the land users could incorporate the technical innovation into the daily life without changing any practices.

To sum the adoption cycle, it seems that the capacitation course was the most important prerequisite for acceptance of the improved technology. Perceptions of the land users changed and goat herding could be intensified with fewer goats. Note that "a few farmers responded quickly, accepted and adopted the ideas", but why did not everybody adopt the technique? For example, one land user does not live permanently in the community but has economic activities in other places. Does this mean that the land user did not find it beneficial to invest in fodder gates? Unfortunately, the land user was not at home and could not be interviewed.

The governmental Drought Comission supported and subsidised the introduction of improved water-harvesting techniques and plastic tubes for irrigation. Subsidies and technical advices made land users to afford and to improve the irrigation and drinking water. The introduced technical improvements met a great need and was easy to integrate in daily life, therefore, the farmers highly appreciated it. However, not all the land users received equal parts due to rules concerning community and land user ("comunero") rights.

Dissemination of improved technology does not always depend on capacitation and initiatives from governmental institutions or NGOs but also the land users them selves. An example showing the ability to inform each other and collaborate with a neighbouring community, is the intention to invest in electricity wires. What this means for future events of the community is hard to say. What needs are satisfied? What are the visions? Is the electricity going to be used for productive activities? Or is it going to be used for televisions, refrigerators, illumination and so on? The future is fuzzy and is even more complicated to evaluate concerning future regional investments in tourism, fishing, dams and irrigation, mining, etc. Will the availability of jobs change the community structure to land users depending on external salaries tending goats as a spare time activity? From this point of view the degradation problem will possibly solve by itself.

To conclude, the potential to distribute more improved techniques in El Almendro depends on how well the land users are capacitated in combination with short-term benefits, possibilities to invest, low risks and small changes of daily life. A few experiences, e.g. introduction of fodder gates, tubes and small dams show that the land users are willing to accept and adopt new improved technologies. If needs of land users are clear, e.g. the necessity of efficient irrigation practices, introducing improvements fit into daily life and will be accepted. Otherwise, land users do not accept distributed technologies. Capacitation courses may widen the perceptions.

The question is how much "new improved technology" that can be introduced in relation to degradation and low productivity problems? The answer depends on the ability to involve the land users in research of "resources", assessment of needs (stimulation) and identification of an appropriate goat management plan. Future public- and private regional investments are difficult to assess, but will probably have consequences for the community. The present system characteristics have low to medium potential to be improved.

10.6.9 Creation of a meeting point

The common house, constructed by an NGO, of the women group and neighbour association is important for gatherings such as, the collaboration to install electricity. A central meeting point implicates more crucial issues, e.g. information spreading, informal and formal meetings, and a forum for discussions. A meeting point is an informal decision-making institution of the conceptual model and treats daily important issues. The meeting point links to formal decision-takers, financiers, credit-givers and gives feedbacks to the monitoring institution. The meeting point must be strategically situated where land users have easy access.

To conclude, the creation of an informal institution situated where land users have easy access, would serve as a daily meeting point for land users. The intention is to prevent bureaucracy between the formal platform of decision-takers and the real world of activities. Lack of a central meeting point is a severe constraint and there is low potential, at both high and local levels, to improve the present system characteristics.

10.7 Summary and comments on potential classes

Evaluating the potential for development resulted in a tentative classification of potential classes of El Almendro (Table 20). The previous information and discussions are evaluated according to a relative scale of potential classes: 0= very low; 1= low; 2= medium; 3 = high. The "improvable" column shows characteristics that show potentials to be improved in the real world. The classification is subdivided into high and local levels.

In general the potential is low to medium towards an improved situation in comparison with the real world situation. Potential values do not imply any statistic probability, and categorising characteristics into specific ranges of potential classes do not mean shortages of "this and that component" before achieving a perfect system. It means, for El Almendro, that within presumably five years the development process could result in more capacitation programmes, participatory decision-making methods, a goat management plan that land users support, perhaps a credit system, increased production of milk and cheese, better marketing capacity and indicators controlling the progress.

Table 20. Potential classification towards sustainable goat herding in the agricultural community of El Almendro. Relative magnitude of potential classes is: 0 =very low; 1 = low; 2 = medium; 3 = high

Activity in conceptual model	Present in real world	Improvable	Potential class high level	Potential class local level
Creation of a decision-making platform	No	Yes	2	1-2
Creation of a credit giving institution	No	Yes/No	1	0-1
Creation of a monitoring institution	Yes	Yes	1	1
Education and capacitation programme	No	Yes	2	2
Stimulation to have a participatory programme	No	Yes	1-2	1-2
Marketing	No	Yes/No	?	0-1
Goat management	No	Yes	?	1
Dissemination of appropriate technology	No	Yes	1-2	1-2
Create a meeting point	No	Yes	1	1

?: not known

All the interacting factors make it impossible to predict the exact date when there will be sustainable goat management, but this is not the purpose of the potential classifications. The use of potential classes should be considered as a help to address and highlight missing human activities that should take place in a functioning system. As can be seen from Table 20, most of the activities are not present in the real world. What to address in the real world, if there were to be an organised project? What is the activity most necessary to improve? Every activity is part of a whole system and it is not easy to answer the question. Table 20 suggests that the best potential might be the education and capacitation programme. The creation of a common platform for decision-making deserves attention; the stimulation to have a participatory research; and dissemination of appropriate technology seem to have potentials to be improved. Creations of a credit-giving institution, marketing and goat management are difficult activities and have low potentials to be improved.

It is not for the author of this paper to make further conclusions of potentials, necessary changes and planning to improve the human activities of El Almendro. The main point was to show the usefulness of soft system thinking as a base for land evaluation.

11. Comparing the "soft " approach with the "hard" approach

Comparing experiences of the soft approach with the hard approach helps to clarify the use and utility. The soft system thinking represents the former and the AEZ methodology represents the latter. The comparison is divided into, theory, results, complementarities and comments.

Theory: The Framework for land evaluation (FAO, 1976), which is the theoretical base for the AEZ methodology, has been widely used concerning natural resources management. Actual and potential land uses often regard economic issues such as, cost/benefit analysis, more than incorporating social issues. The Framework does not explicitly invite and promote a transparent evaluation and participation by stakeholders from the beginning. Although social characteristics might be incorporated within the Framework, the AEZ methodology has been accused of being a typical top-down approach (Bdliya, 1991).

The theory base of the soft approach evolved by analysing concepts and how to apply the future results (Fig. 16). The reality of human activity impacts, e.g. degradation of natural resources, implied necessary changes and improvements of present activities. Complex and interacting economic, social and biophysical variables stimulated to search for concepts explaining possible ways of addressing the challenge of sustainable land use. Therefore, the assumption was that concepts of sustainability, indicators, resources, complex systems and soft system methodology (SSM) could lead to a manageable methodology suited for analysing the potential of a specific area. The aim was to highlight possibilities of improving present human activities. Results are supposed to be applied as part of a discussion forum, i.e. a common platform for negotiating land resources management.

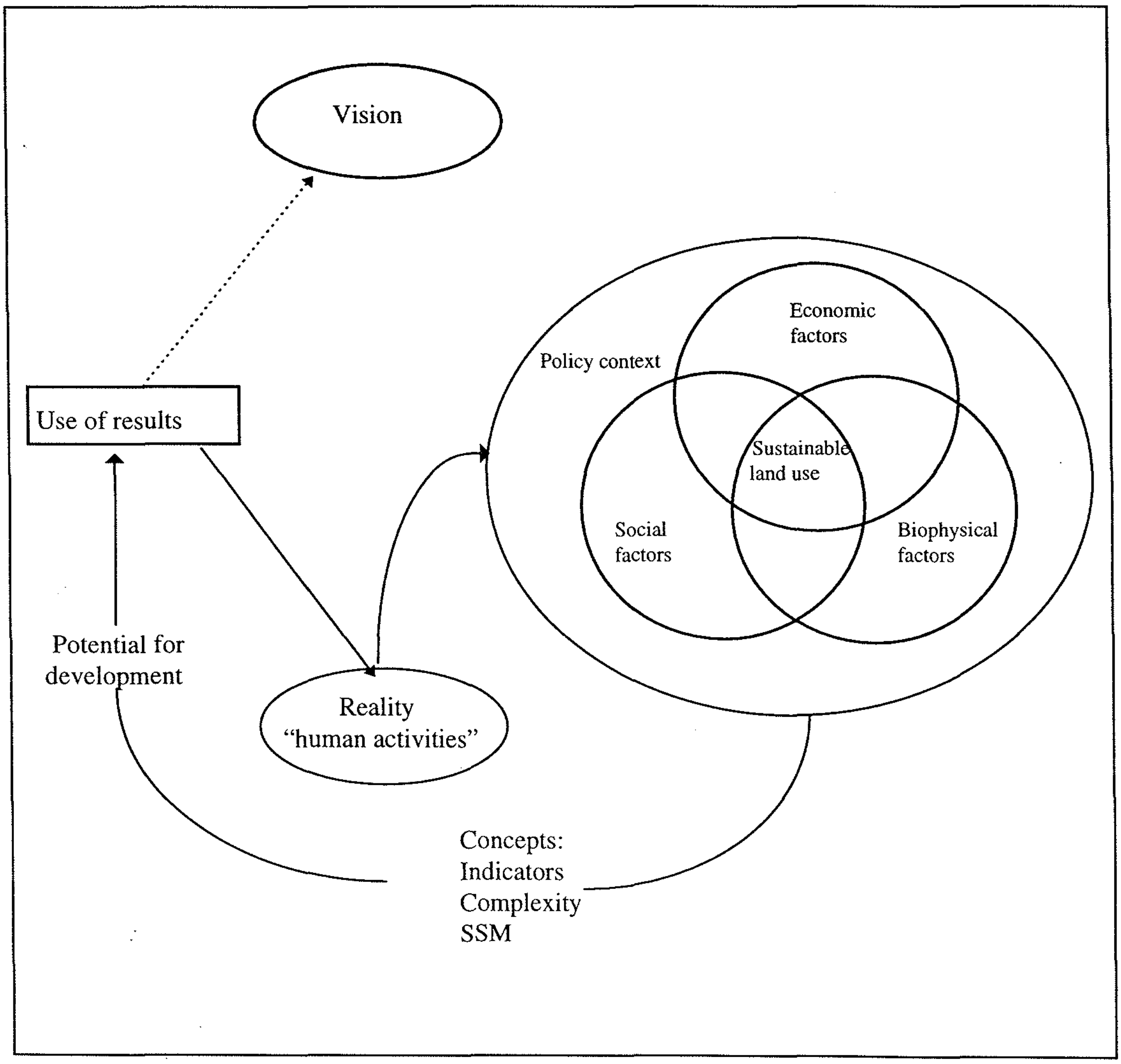

Fig. 16. The theory of the soft land evaluation approach with important intermediate components.

An IFPRI paper ("A 2020 vision for Latin America") may guide the negotiations, in which Garret (1995) says: "...extreme poverty, hunger, and severe malnutrition have been eradicated; where income, wealth, and opportunity are more evenly and fairly distributed; and where all citizens enjoy clean, healthful environments and work together to use and protect the region's natural resources for themselves and for future generations." Using the results implies to revise the reality and analysis of the complex nature of sustainable land use. This is the essence of the theory, i.e. a dynamic structure continuously searching and discussing the changed reality and knowledge to take step after step towards the 2020 vision. The importance of having a specified goal within a common framework is crucial. Otherwise, results from other disciplines have problems to be integrated and it would be very difficult, if not impossible, to understand the current situation of land use systems and to make appropriate land use plans.

One main starting point, as indicated in Fig. 16, is the understanding of reality (the problem situation) and the human activities. The soft systems methodology facilitates this and promotes information gathering from different stakeholders. This is a main difference compared with the Framework and the AEZ methodology, since these do not have a clear entry point of involving stakeholders and qualitative information, e.g. perceptions.

Results: In this paper the analyst applied the AEZ methodology as an extreme top-down approach and did not incorporate the farmer's views or economic considerations. Reasons for this were, shortages of data, but also to show the easiness to produce suitability classifications based on available information. One classification treated the actual state (Section 9.4.1), which was designated as "not suitable" for present goat herding, arable activities and extraction of fuelwood. Another classification treated the potential suitability (Section 9.4.2) for implementing soil and water conservation measures, and a goat management plan.

The problem and difficulty of analysing the case study in Chile resided in analysing biophysical factors without having a larger context of how to implement the changes. Omitted issues were "who will implement", "who will control and maintain the changes". Thus, the suitability classification did not belong to a wider system that illustrated tasks of different stakeholders.

Results of the soft approach depended on a participatory approach in the sense that interviewed stakeholders explained characteristics of the actual situation. The analyst evaluated possibilities to improve the actual situation towards a better land use system aiming at using results for negotiations and debate with stakeholders. Consequently, the analyst did not propose solutions, which made it impossible to estimate expected returns of changed activities. One strong point was that the resulting evaluation resided within a system context, i.e. various interacting activities and components with continuity. Details of biophysical character did not receive much importance, since these could not explain the "whole" of the analysed situation. Stating that both economic and biophysical factors have been analysed, by considering goat herding as one of the most important economic and soil degrading activity, can defend this procedure. Relations between high/ local levels and resulting potential classes have not been investigated. One has to remember that the two potential classes of Table 20 are relative scales within each level and not between high and local levels.

Complementarity: The differing results between the methodologies are interesting to analyse. The AEZ methodology used specific biophysical data, whereas the soft approach incorporated system thinking and involved a wider context. Both approaches aimed at finding a potential solution and to evaluate the possibility to improve the actual unsustainable land husbandry activities. The initial purpose of this paper was not to mix the soft and hard approaches, but considering the different focus points, the AEZ could complement the soft approach in the sense of evaluating details of soils, climate and vegetation. However, AEZ has been criticised of being inappropriate for large scale evaluations. For example, scales of 1:25 000 to 1:5000 render biophysical relations and calculations too inexact (Driessen and Konijn, 1992). To complement the soft approach, more exact models would need to analyse biophysical details.

The other way around give interesting results, i.e. regarding the soil as a system boundary and where the soft approach complements biophysical charactersitics.The appropriateness of translating results between the two approaches due to different proceedings, can be questioned. Anyhow, extracting the subsystem of the "education and capacitation programme" from its system context and translate it to the AEZ nomenclature can be illustrated. The AEZ nomenclature (very suitable, suitable, marginally suitable, not suitable) could tentatively correspond to the potential classes (3= high, 2= medium, 1= low, 0= very low), respectively. The "education and capacitation" subsystem of the soft approach was classified as 2, i.e. a medium potential to improve present activities, which would correspond to "suitable" (Table 21). Likewise, the subsystem of "marketing" would correspond to "marginally suitable" on a potential suitability map.

Table 21. Conversion of potential classification to suitability classification

Factors considered	"Soft approach" potential classification	AEZ suitability classification
Education and capacitation	2	Suitable
Marketing	1	Marginally suitable

Comments: For the AEZ the problem lies in determining what socioeconomic factors are relevant and have a decisive impact on the farm system. Fresco and Westphal (1988) define socioeconomic factors as those properties of system elements situated outside the physical and biological realm. Fresco and Westphal mean that these factors are, nearly without exception, subject to large fluctuations and shifts in trends, within a human life time, so that the scope for changes in farm systems derives mainly from changes in these variables. Unlike the AEZ the soft approach does not *determine* relevant socioeconomic factors to consider, but *finds out* the most important issues during the methodology procedures.

Arguments that both approaches considered in this paper do not manage to integrate quantitative biophysical and socioeconomic information are correct. Stomph *et al.* (1994) say that quantitative information on biophysical and socioeconomic costs and benefits of different land use options, are imperative for decision-making and require quantitative integrations. The objectives of the soft approach were not to incorporate specific quantitative data since the assumption was that all information cannot be quantified. In addition, the soft approach is a land evaluation methodology that analyses different aspects of a specific setting and assembles the various components into a system with continuity. Thus, quantifying every detail would be lost in the whole just as the whole disappears in the details.

One important issue to consider for the future, i.e. that the soft approach may be suitable for the land users themselves to apply in a project. For example, a group of land users together with a facilitator analyse the problem situation, construct a conceptual model and come up with suggestions of how to improve the present situation. Whether this is possible, cannot be said today, probably the methodology has to be modified according to circumstances. As such, the weight of the suggestions from local level would increase and negotiations between the stakeholders would be more constructive. In comparison, the AEZ methodology is a tool for the researchers and policy makers as a basis for their knowledge of the area and contacts with the farmers. A challenge constitutes of, as Table 21 showed, to apply the soft approach within the terminology of AEZ.

PART III CONCLUSIONS AND RECOMMENDATIONS

12. Evaluation of the hypothesis

The case study of El Almendro concentrated on the search for a manageable methodology evaluating the potential for development. From this perspective the evaluation of the hypothesis relies on qualitative reasoning divided into different stages.The hypothesis assumed the necessity of having a holistic strategy of action that provided direction in evaluating complex issues. In addition, it was hypothesised that a single analyst could undertake such a strategy.

Planning and working stages: The concept of sustainability was difficult to translate into a manageable strategy. One approach understanding the sustainability concept consisted of partly overlaid circles or domains of social, economic and biophysical data, assuming the intersecting area to represent sustainable land use (Fig. 3). This was the focussing point, to work within boundaries of socioeconomic and biophysical characteristics, without forgetting that parts of every circle must be included. Further analysis of the sustainability concept proved not meaningful within the context of this paper and other important concepts demanded attention.

The literature frequently mentions the concept of indicators, often in the sense of monitoring and measuring sustainability. Having understood that the concept of sustainability is unclear, the question was how indicators could fit as a component in a manageable land evaluation methodology. Indicators are "pointers" that reveal present stages and regulate actions, allocate and/or reallocate resources. As such, indicators are very valuable, but here as well, the research on indicators proved not to provide a ready-made tool for use. Instead the analyst decided to review literature and compile a list of necessary factors and indicators to include in a land evaluation.

The reviewed literature did not explicitly focus on land evaluation or planning but extracted information from many disciplines. The core was approximately the same, i.e. discussions on project failures, why the world was unfair, visions for the future and so on. From these discussions essential factors or indicators were aggregated into different resources: natural; financial; infrastructure; institutional; human; socioeconomic equity; political; productive; and linkage resources. One could say that these resources, in reality functioned as "pointers", in the meaning of drawing attention to necessary questions and issues. These resources were helpful tools to structure gathered data of reports, participatory methods and interviews.

Addressing land use systems and stakeholders involves much complexity, but what does the concept of complexity really mean? This was an essential part of the thesis and by definition a complex system infers a system that is: large and including many disciplines; of a high order and including many feedback loops; time delayed; and of a nonlinear character containing stochastic elements. Next question to answer was if there were any computerised land evaluation models or non-computerised methods that could incorporate complex socioeconomic and biophysical information.

Computerised assistance would handle and analyse large data bases, but the reviewed models demanded considerable adjustments to suit the conditions of rainfed agriculture in Chile. Neither were there any widely used non-computerised methods that fitted the purpose of this paper. Nevertheless, the decision was taken to use the FAO promoted AEZ methodology (in this thesis called a hard approach) as a reference point of the analysed case study in Chile. In all fairness, it must be stated that the AEZ methodology was applied extremely top-down. The methodology itself did not invite incorporation of stakeholders and "soft"data such as, social realities, perceptions of land users, etc. Another, more practical reason was that shortages of data did not allow to make profound analyses of the case study.

Another interesting approach was to focus on human activity systems, e.g. agricultural activities, and complex relations between components of the system. This form of approaching complex issues relies on soft systems methodology, i.e. a methodology to analyse systems without clear boundaries or goals. The essence is that a human activity system can be analysed holistically and involve soft details such as, perceptions and thoughts in combination with hard data. The soft systems methodology involves formalised procedures to follow in order not to lose track during the analysis. Therefore, the decision was taken that this form of soft approach and methodology could be valuable and of high interest in evaluating the case study in Chile.

So far, nothing has been said of how to gather the necessary information. In fact this is the most important factor to consider since the whole content and results depend on reliable data. How to retrieve the information was not entirely obvious and it was necessary to review interviewing techniques, and adequate participatory methods. Conducting informal interviews with just a few specific questions assumed that information from many respondents could create a picture of the whole. In reality, the results were overwhelming and the respondents shared what they knew about the issues of interest. With land users, it was appropriate to use a participatory technique that concentrated on drawing a picture of the natural resources, infrastructure and institutions. An outsider normally has difficulties entering naturally in a new setting, but the "resource map" was a good entry point. The land users explained, talked and showed important issues and following up questions was easy.

The analyst also tried other participatory techniques in field, but they did not function very well. The main reason was that a set of predetermined participatory techniques was an obstacle to the natural continuity of the interviewer - respondent relation. For example, one land user became reluctant to answer questions since the purpose of "more drawing" was not clear. Thus, participatory methods did not automatically imply good responses and an appropriate strategy to gather information. Without doubt, the most important thing was to explain to the respondent the purpose of the research, why to ask certain questions and how to use the results. Other essential "remember-things" were to be open-minded, share experiences and be observant to the respondent's preferences of interviewing style.

Result stage: The strength of the soft approach consisted of results, which were placed within a whole system of human activities. Results belonged to a certain context, i.e. the analyst could evaluate a whole system and not just a specific activity, e.g. implemented soil and water conservation measures. Subsystems were evaluated according to both high and local levels and resulted in "potential classes". These classes reflected potentials to take action towards a wanted state of presumed sustainable activities on a long-term perspective. This was the essence of this paper, to find a land evaluation methodology able to incorporating complex issues of sustainable land use.

Comments: This paper has, at this stage of developing an improved land evaluation methodology, not considered the deeper philosophy of the soft systems methodology. Therefore, one main point of the soft approach needs to be stated: No plan or design of measures was proposed of how to solve a specific problem. The approach is not a top-down method *per se* but attempts to show the analyst (researcher, development worker) the constraints of undertaking sustainable land use practices. Using the soft systems methodology directs and stimulates the analyst to rigorously assess the possibilities to overcome and improve the detected constraints. As such, the soft systems methodology was applied as a tool to be at hand for the analyst when incorporating views, facts and perceptions from different actors. In other words, the main issue was to diagnose constraints and assess potentials to be later used for negotiating land use planning and/or project implementation.

One weakness experienced by the soft approach was that the biophysical part did not get much attention, at least not in the sense of evaluating the aptitude of the soil to produce crops. Consequently, evaluating the economic returns or make cost and benefit analyses of measures was impossible. Biophysical data was indirectly involved in the soft approach since it recognised unsustainable and deteriorating land uses. Also, the economic issue was partly involved since goat herding is one of the most important economic activities for land users.

Existing information in reports was very important and interviews elaborated the picture of the specific area. The analyst had to be open-minded and pursue data from different disciplines. Often relevant information was difficult to gather and subsequently make fruitful conclusions. During the field work a single analyst has a tough job and can easily lose important information. Working in pairs during the procedures of planning, field work and data processing is probably better.

These results show that a holistic strategy focussing upon human activity systems can be incorporated in a manageable methodology to evaluate the potential for development. Without the holistic approach the analyst would have had bigger problems analysing details and understanding the whole context. Refinements and elaborations are crucial in, e.g. information gathering and data analyses. Therefore, at least one analyst more is needed. Considering the inexperience of the analyst, the hypothesis is regarded to be partly positively confirmed about a "fruitful strategy" and partly negatively confirmed about "a single analyst capable of undertaking this strategy".

13. A "potential for development methodology"

The challenge in this paper consisted of developing a land evaluation methodology that analysed the potential for development, i.e. the capacity of a specific agricultural setting to change and improve the present deteriorating and unsustainable activities. The theory and case study suggest a soft approach of conducting a land evaluation that incorporates stakeholders within a system context. The softapproach is summarised as the concept of a Potential for Development Methodology (PDM). PDM is not a ready-made tool and needs further elaboration. However, it may be useful since the purpose of PDM is to involve stakeholders' views in diagnosing constraints and assessing the potentials for improving the detected constraints. Finally, the findings by applying PDM are to be debated and negotiated with stakeholders. The PDM is explained as:

i) Use of results:To verbalise final use (aim and objectives) and vision is a prerequisite for integrated and reliable results. In this paper the results are supposed to be used for information and negotiation purposes.

ii) Gather information: The use of a combination of report reading, informal/ semi-structured interviews and a participatory approach seems appropriate. It is crucial to promote the analyst to seek interdisciplinary information and let the stakeholders share their thoughts, perceptions and knowledge.

iii) Structure the information: The use of different "resources" directs the attention towards specific issues and helps to structure and process the information.

iv) Processing the information: The basis of PDM relies on human activity systems and soft systems methodology that incorporates a holistic approach and transparent working Thus, promoting an information gathering strategy as explained in **ii**).

v) Analysis of the information: The soft systems methodology contains formalised procedures and highlights missing institutions and/or activities that must exist to achieve a purposeful system with continuity.

vi) Evaluation of the potential for development: The evaluation highlights possibilities of the research area to improve unsustainable human land use activities. These improvable activities are aggregated into potential classes and show issues that need to be addressed at a negotiation platform of stakeholders.

14. Some limitations of the study

Many limitations can be mentioned with respect to the development and results obtained by this research. At the same time regard these limitations as recommendations and guidance for further development of an improved land evaluation methodology. Some limitations are:

- Through the years research has been made about: soft and hard energy; soft and hard thinking; soft and hard modelling; "soft women and hard men", soft-ware and hard-ware, etc. It may be argued that the wording of "soft" and "hard" is somewhat arbitrarily defined in this paper.

- Future research of a manageable land evaluation methodology may concentrate on making the "soft" and "hard" approaches more complementary within the AEZ terminology. This could promote a way for (technical) professionals to incorporate social issues within a recognised land evaluation terminology.

- Soft systems thinking is a great potential since farmers themselves could undertake an analysis of their problem situation and highlight possible solutions. The results can be used at a negotiation platform with other stakeholders. Also, the basis of the soft system methodology relies on changing the present situation and that results should be debated with stakeholders. However, due to different reasons none of these were done in this paper.

- The agricultural community of El Almendro is in the upper part of the catchment. Canela Baja is in the lower part of the catchment, but has not been regarded in the research. Thus, the downstream farmers have not been interviewed, the problems not discussed and so on. Also, some farmers were not encountered or interviewed in El Almendro. Other stakeholders of interest that could not be interviewed were the teachers of the school of El Almendro and Canela Baja, FOSIS (Solidarity and Social Investment Fund) which is a governmental institution and traders.

- A land evaluation can be coupled to an environmental impact assessment (EIA), i.e. to include areas outside the specific research/ project area. EIA is becoming institutionalised by law in many countries and examining the relation between a land evaluation and EIA seems to be important for the future.

- Local details of the community of El Almendro such as, soils, topography, incomes, etc. were not possible to investigate thoroughly. The irrigated area of the community was not evaluated and that is a weakness since the irrigated ley production is very important.

- Interactions and definitions of specific indicators have not been investigated regarding, e.g. the monitoring of sustainability.

- The scale of working has not been discussed, nor the incorporation of GIS.

- Computerised assistance (model) has not been used or extensively discussed.

- Efficient management of data and data bases have not been analysed.

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List of abbreviations

AAD	Agro-ecosystem Analysis and Development
AC	Agricultural Census
ACA	The Association of Agricultural Communities (NGO)
AEZ-CCS	Agro-Ecological Zoning - Country Case Study
APT	Agricultural Planning Toolkit
CAILUP	Computer Aided Land Use Planning
CEZA	The Centre for Arid Zone Studies (University of Chile)
CIREN	Centre for Investigations of Natural Resources
CONAF	National Forest Corporation
CRIES	Comprehensive resource
EIA	Environmental Impact Assessment
FAO	The Food and Agriculture Organisation of the United Nations
FIDA	Intenational Fund for Agricultural Development
FOSIS	Solidarity and Social Investment Fund
FSA	Farming System Analysis
FSR	Farming System Research
FESLM	Framework for Evaluating Sustainable Landuse Management
GA	General Assembly of the Community Administration
GIA	Agrarian Investigation Group
IMGPL	Interactive Multiple Goal Linear Programming
INDAP	National Institute of Agricultural Development
IGM	Geographical Millitary Institute
INE	National Institute of Statistics
ITM	Integrated Transect Method
JUNDEP	The Private Corporation of Social Development (NGO)
LE	Land Evaluation
LEFSA	Land Evaluation and Farming System Analysis
MIDEPLAN	The Ministry of Planning and Cooperation
PDM	Potential Development Methodology
PRODECOP	Development and Cooperation Project of Poor Rural Communities
PRA	Participatory Rural Appraisal
RRA	Rapid Rural Appraisal
SLM	Sustainable Land use Management
WOFOST	World Food Study

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