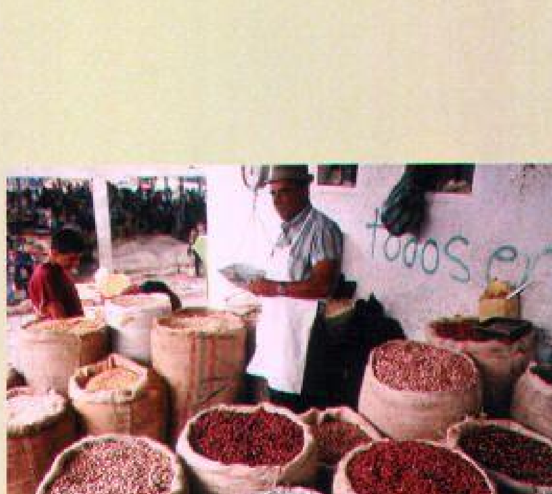
Agricultural marketing systems and sustainability

Study of small scale Andean hillside farms



Jairo Castaño

Propositions (Stellingen)

1. Vertical marketing systems (VMS) are a more appropriate marketing scenario than conventional marketing channels (CMC) when aiming at soil conservation (this thesis).

2. The time horizon of the strategy of the marketing channel leader is a significant factor for farm soil sustainability (this thesis).

3. It is possible to reconcile efforts to increase the profitability and competitiveness of the agricultural sector while improving the management of natural resources (this thesis).

4. Environmental hazards in small-farms in less developed countries are often difficult to control by regulatory approaches only. Marketing mechanisms seem well suited to deal with these hazards because of the economic benefits that help offset investment and effort devoted to land conservation (this thesis).

5. Government intervention aiming at soil conservation in small farms in less developed countries will be better achieved by focusing on the improvement of the marketing environment of small farms (this thesis).

6. A full understanding of the different aspects of soil management is vital for the formulation of appropriate policies towards sustainable farming (this thesis)

7. Increased environmental concerns in consumer markets and growing urbanisation in developing countries imply that markets are increasingly driven by demand rather than by production issues (ISNAR, 1998).

8. Reduction of tariff barriers for forest products could, in the long run, raise stumpage values, which may increase the economic incentives to invest in more efficient wood processing and in better management of production forest in tropical timber producing countries.
   Barbier, E.B. (1996). Trade and environment relating to forest products and services. Paper prepared on behalf of the ITTO for the 3rd. Session of the IPF, Geneva, 9-20 September 1996.
   Nordtröm, H., Vaughan, S. (1999). Trade and environment. WTO's special studies. Geneva.

9. Income growth, while being a necessary condition for allowing countries to shift gear from more immediate economic and social concerns to more long run sustainability issues, is not sufficient to reverse environmental degradation. It must be accompanied by adequate environmental policies.
   Nordtröm, H., Vaughan, S. (1999). Trade and environment. WTO's special studies. Geneva.

10. The factors that have led Colombia to being a major drug exporter are not only economic and geographic factors but also social, political and cultural factors. The Colombia state has been weak and unable to guarantee basic individual rights such as education, health, work, justice, etc. This has driven society towards individualism, where individual well-being prevails over the society well-being.
Thoumi, F.(1999). Lucha antidrogas: en busca del tiempo perdido? http://www.analitica.com/vas/1999.12.4/international/10.htm.

Propositions presented with the doctoral thesis *Agricultural Marketing Systems and Sustainability. Study of Small Scale Andean Hillside Farms* of Jairo Castaño, Wageningen, 24 October 2001.

Agricultural Marketing Systems and Sustainability

Study of Small Scale Andean Hillside Farms

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Agricultural Marketing Systems and Sustainability

Study of Small Scale Andean Hillside Farms

Jairo Castaño

Proefschrift
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in het openbaar te verdedigen
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des namiddags te vier uur in de Aula.

To Nhora, Emmanuel and Christian David

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List of acronyms and abreviations

ALS	Alternating Least Squares
ASAP	Adoption of Sustainable Agricultural Practices
CETEC	Corporación para Estudios interdisciplinarios y asesorías Técnicas
IPRA	Investigación Participarativa para la Agricultura
CIAT	International Center for Tropical Agriculture
CIPASLA	Inter-institutional Consortium for Sustainable Agriculture in Hillsides
CMC	Conventional Marketing Channel
COAPRACAUCA	Cooperativa Agraria de Productores de yuca y Rayanderos del Cauca
COOPERA	Cabuyal Optimal Resource Allocation
CORPOTUNIA	Corporación para el desarrollo de Tunía
CVC	Corporación Valle del Cauca - Cauca Valley Corporation
ECONORCA	Empresa Comercializadora del Norte del Cauca
FAO	Food and Agriculture Organization
FNC	Federación Nacional de Cafeteros -National Federation of Coffee Growers
FUNDAEC	Fundación para la Aplicación y Enseñanza de la Ciencia.
GIS	Geographical Information System
GMO	Genetically Modified Organisms
GPS	Geographical Position System
ICA	Instituto Colombiano Agropecuario - Colombian Agricultural and Livestock Institute
IM	Income Maximising
ISNAR	International Service for National Agricultural Research
LP	Linear Programming
LUT	Land Use Type
MGLP	Multiple Goal Linear Programming
MO	Marketing Opportunity
NTAE	Non Traditional AgroExport
OLS	Ordinary Least Squares
PC	Principal Component
PCA	Principal Component Analysis
RTP	Rates of Time Preference
SC	Soil Conservation
UMATA	Unidad Municipal de Asistencia Técnica Agropecuaria
UNCED	United Nations Center for Economic Development
USLE	Universal Soil Loss Equation
VMS	Vertical Marketing System

Abstract

The study examines the contribution of vertical marketing systems (VMS) over conventional marketing channels (CMC) in stimulating small-farms towards the adoption of sustainable agricultural practices (ASAP). An analytical framework is developed involving a method for measuring ASAP, an econometric model for testing the influence of marketing and other factors on ASAP, and a multiple-goal LP model to evaluate the impact of CMC and VMS on soil sustainability. The Cabuyal watershed, a tropical hillside area in Colombia, is selected as a case study.

The study leads to the conclusion that VMS are a more appropriate marketing scenario than CMC when soil conservation is the objective. VMS channels pose lower risks and are more long-term oriented, crucial factors for farm soil sustainability. The conclusion points to a need of policies oriented at improving small farmers' access to markets and institutions, while supporting the establishment of processing plants, cooperatives and other VMS institutions.

Acknowledgements

I am indebted to a great deal of people who have, in one way or another, contributed to the accomplishment of this study. First of all, I have been privileged to be supervised by Thieu Meulenberg, Aad van Tilburg and Willem Janssen. The development and write-up of this study benefited greatly from their constructive criticisms. I appreciate their support, the opportunity they gave for distance write-up and the time freed for interaction. I deeply thank Willem for introducing me to the Marketing Department. I have been moved by his enthusiasm and continued confidence. I thank Aad for helping me to keep on the right track over most of the research period. I am especially indebted to Prof. Meulenberg for the time that he devoted in my work and his challenging insights that have been beneficial for the quality improvement of the final product.

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1 INTRODUCTION AND AIM OF THE RESEARCH

1.1 Introduction

Farm production results in an impact on the natural environment as it is associated with the use of resources such as land, water and air. The deterioration of the natural environment as a result of farming is particularly acute in less developed countries as, in most cases, their development policies are heavily focused on the agricultural sector (Peattie, 1995). This deterioration has been more severe in marginal and environmentally fragile lands such as tropical hillsides (Reining, 1992; Ruthenberg, 1980). Market distortions are at the core of several of the causes of unsustainable farming. Market distortions, such as limited access to market services, inadequate and distorted information on demand and supply changes, limited access to working capital and excessive transaction costs are likely to mislead farmers into adopting unsound decisions on resource management. This research explores the relevance of marketing mechanisms in correcting market distortions while, at the same time, promoting the adoption of sustainable small-farm production systems. In particular, the research centres on improvements to the marketing channel that would enable the delivery of signals that lead resource-users towards sustainable farming. The central hypothesis is that vertical coordination in marketing channels makes marketing systems better equipped to contribute to the adoption of sustainable farm production systems.

The area used for this study is the Cabuyal watershed, an Andean small-farm peasant community in southern Colombia. The site is a CIAT[1] pilot study area selected to examine adequate solutions to unsustainable agriculture in the tropical America hillside regions. The watershed is a marginal area with poor infrastructure composed of semi-commercial small farms that average 3 ha. Soil erosion is the most critical environmental concern. Major crops are coffee (intercropped with plantain), cassava (for starch production), beans, maize and sisal, in that order. Crops are rain-fed (biannual precipitation) and irrigation is uncommon. Farm produce is traditionally commercialised in local markets through middlemen while contracts with wholesalers and cooperatives are less frequent.

The impact of economic and marketing activities on the natural environment has been an issue of growing importance over the last half of the last century. In the post-war period between 1945 and 1970, food consumption increased dramatically in the world. The main causes are related to population growth in the developing world and increased wealth in the developed world. Western consumers, in particular, enjoyed the increasing wealth without reservation. Consequently, demand for agricultural products from developing countries increased substantially. For developing countries as a whole, the annual expansion rate of agriculture during 1980-90 was 3.1 percent (FAO, 2000). This growth in production was due largely to increasing amount of land put to the plough (use of marginal land and irrigated areas, and forest clearing) and improvements in productivity (increasing use of new varieties and high-energy inputs). Output growth in the agricultural sector brought about resource degradation, pollution and health effects caused by inappropriate farming practices and the overproduction of food and export crops (FAO, 1991b; Odelman, 1991; Lutz & Young, 1993). Aiming at the expansion of production, to cope with the growing food (and foreign exchange) needs of rapidly growing populations, the pace of modernisation of the agricultural sector seemed to be linked to increases in adverse environmental effects.

Concerns for the sustainability of production systems and marketing tasks emerged first in the

[1] The International Centre for Tropical Agriculture (CIAT) is one of the Consultative Group on International Agricultural Research (CGIAR) centres with headquarters in Colombia.

1960s and they have been growing since then (Kotler, 1997; Henion, 1976; Earth Summit, 1992; Meulenberg and Schifferstein, 1993; Peattie, 1995). They have evolved from concerns on the polluting externalities of economic and marketing activities on the natural environment to concerns over impacts on human health, people's welfare and animals' rights. New trends point out that marketing not only must efficiently serve consumer material needs, but it must also consider the environmental costs of serving these needs and wants. Marketing has contributed to the current environmental crisis, because of its central role as a driving force behind the unsustainable growth of (over)consumption (Peattie, 1995). But, as it is part of the problem, marketing is also part of the solution towards sustainable development.

Moved by social concerns, several countries started updating their policy frameworks to consider environmental regulations. Marketers started to recognise the validity of respecting the environment by introducing environmental criteria. Although some industries resented environmental regulations in the beginning, new marketing strategies turned out to be the answer to the challenge of environmentally minded consumers. These new strategies are directed at optimising production methods (e.g. ecological produce, less waste, less artificial processing), marketing activities (e.g. biodegradable packing, recycling), or/and in developing sales and promotion strategies ('cleaner' food, environmental labelling). Examples are found in timber from sustainably-managed forests; organic food from sustainable farming systems; in the energy industry where low or no-lead gasoline and solar powered devices have appeared; and in other industry sectors where low-phosphate detergents, alternative aerosol propellents, low-litter packaging and emission control systems have been introduced. As costs may be passed to the consumer, marketers have also optimised production and distribution costs to keep their products competitive. They have looked for better distribution alternatives by opting for more efficient and low cost transportation and allocation schemes. The interactions between marketing and sustainability could be broadly grouped into six aspects:

- making marketing activities more friendly for the environment
- developing marketing strategies and marketing systems for ecological produce
- responding to the demands of environmentally conscious consumer groups, by changing product range, by changing production and processing approaches, and by innovative public relations campaigns
- stimulating individual consumers, environmentally conscious or not, to purchasing environmentally produced/processed food
- using environmental considerations as a unique marketing attribute for certain products
- using marketing systems to influence production behaviour

In the agriculture sector, the influence of environmental concerns is observed in several examples: organic food production (e.g. in vegetables and other staples); food processed products promoted for their low or non-chemical content (colorant free), healthier food (low-fat) and food with taste (natural flavour or with designation of origin). Other examples are the 'go green' policy reforms in the agrochemical business (see the case of the German Schering Group in Peattie, 1995). Marketing systems have also been developed for the delivery of ecological produce and marketing strategies have been established to promote their consumption. These examples illustrate how marketing mechanisms stimulate marketers to adopt sustainable production/processing systems and encourage consumers to demand ecological produced/processed products. Success in these cases depends on the clarity of the transmitted market signals and marketing support. Market signals, such as market news, market risks, quality request and market services, influence the opportunities to perform channel functions effectively. In the case of high-quality food, producers perceive that health, taste or resource concerned consumers are willing to reward chemical free food (i.e. quality) with premium prices. If, in contrast, the market is sending signals of aesthetic perfection requirements, producers might be compelled to practice intensive chemical use to meet stringent visual quality demands. Similarly, if producers confront market uncertainties as a result of distortions and lack of transparency in the market system (e.g. outrageous interest rates, diffuse information or unknown demand), environmentally adverse resource-use may occur. Under these conditions, producers cannot take rational decisions and may adopt cropping patterns inimical to farm sustainability.

Thereby, although the incorporation of environmental criteria in commercial agricultural production is on-going, progress has been less apparent in the small-farm sector in developing countries. The reason for this is that adopting sustainable production is more complex in small-farm agriculture in these countries. Small households are constrained by underdeveloped infrastructures (e.g., communication, banking, legal and education) and lack of organisation in marketing channels, on one hand, and by scarce factors of production (especially capital and land) on the other. The former limits their market access and the latter troubles their needs for daily sustenance. In this context, the proposition of sustainable agriculture becomes particularly difficult.

Nonetheless, there have been cases where market-based strategies such as price stabilisation schemes, opening of market niches, development of marketing channels, creation of new market opportunities and improvement of the return of a factor of production facilitated the adoption of sustainable agricultural technology. Market-based strategies were successfully used as economic incentives to encourage soil conservation practices. In one case, soil conservation practices were adopted in vegetable production when market access and marketing infrastructures were improved in rural neighbourhoods of Quito, Ecuador (Nimlos et al., 1991; White et al., 1991). A conservation program accompanied these infrastructure developments. Similar examples were seen with maize in Honduras, maize and millet in Nepal, and vegetables in Kenya (Buckles et al., 1992; Carter et al., 1989; Tiffen et al, 1992; Laing et al., 1992; Smith, 1995). By contrast, literature also cites cases where adoption failed due to marketing considerations. Farmers in Southern Ecuador, Zambia and Eastern Africa did not adopt resource conservation when promoted without any market incentive (Budelman et al, 1992; de Graaf, 1992; Laing et al., 1992). Farmers were reluctant to adopt labour-intensive conservation practices without market incentives that allowed them to offset increased costs. Interventions were costly and had reduced impact because of their isolated focus on problems and lack of consideration of marketing aspects. Market incentives are therefore vital as small-farms fully depend on agriculture for a livelihood. Sustainable production demands resources of labour, land, sometimes capital, and energy. Such resources are often scarce, and as consequence, implementing improved land management may appear unattractive to the land users.

It seems, thus, that a key element of successful adoption of sustainable farming is the incentive appeal of market signals. As noted, market signals influence the performance of marketing functions within a marketing channel. Marketing functions, in turn, vary with the organisational structure of the marketing channel (i.e., the coordination or not of marketing functions) and with the level of development of the physical, legal and financial infrastructure available. If marketing channels perform functions inefficiently, market signals are distorted, farmers are misled and farm resources are sub-optimally employed. Even more, distorted market signals may deter investments addressed to control current resource problems. Therefore, depending on their structure, marketing channels may differ in their purpose of encouraging (or discouraging) sustainable production systems. If such a difference holds true, it is essential to discern what marketing patterns are more appropriate in promoting environmentally friendly production methods.

The role of marketing as an alternative or a complement to typical interventions of the public sector must be further examined. There is a need to explore whether improvements in the marketing channels equally improve the type of signals being received by resource-users resulting in both high-expected profitability and higher sensitivity to long-term sustainability concerns.

Exploring alternative approaches to promote sustainable production systems in small-farm systems in less developed countries is vital as resource degradation is reaching alarming levels, especially in the tropics.

Over the last decade, there has been increased awareness that market failure is among the base causes of hazards to farm sustainability (FAO, 1991b; Earth Summit, 1992; ISNAR, 1998). This highlights the potential role of marketing strategies to help overcome environmental problems. A great number of studies have been made about socially responsible and environmentally friendly food production. These studies are often concerned with specific issues such as adoption of resource conservation technology and state intervention as the inducing force. But little attention has been given to the question of how marketing can be used as an instrument for promoting the adoption of environmentally friendly agricultural production systems. This study is a step in that direction.

1.2 Formulation of the problem

Over the past decades, some of the growth of the agricultural sector in the third world has caused long-term resource degradation. Resource degradation has been even more severe in environmentally fragile lands as tropical hillsides (Reining, 1992; Ruthenberg, 1980). Small-scale farmers in these countries did not make an appropriate use of the land and other resources due to multiple reasons. Market imperfections were at the core of many of these reasons (Pritchard, 1969; Ellis, 1988; Abbot, 1993; Abbot and Makeham, 1979; Harrison, 1975; Kindra, 1984; Kinsey, 1988; Budelman et al., 1992; van de Graaf, 1992). In some cases, farmers overexploited farm resources with cultivated cash crops in order to pay for their daily needs and, perhaps, high interests on loans. In other cases, small-scale farmers limited their output for the market, either because of the low prices received, or because demand was uncertain. Market imperfections have also resulted in higher input and lower output prices such that farmers' choices are sub-optimal with respect to resource use allocation and use (e.g., soil mining, chemical pollution).

Market imperfections result in the distorted use of resources because market signals, such as demand (reflected by prices) and market risks, transmitted via the marketing channel and received by resource-users (i.e. farmers), do not fully reflect the market panorama (FAO, 1991b; Kohls and Uhl, 1998; Earth Summit, 1992). Market imperfections likely mislead farmers towards inappropriate farm decisions with respect to resource allocation and use, cropping mix and long-term sustainability. Identifying a strategy that addresses and corrects market imperfections and guides adequately farm-resource decisions is therefore fundamental for the long-term continuance of small-farm systems in the developing world.

Farm environmental problems may take the form of on-site effects, such as soil erosion that directly affect the quality and capacity of the farm's natural production factors, and off-site effects (i.e. externalities), such as downstream water contamination, which have a substantial impact on society as a whole and cannot be traced to a specific farm. State intervention (e.g. regulations, taxes and subsidies) is often a good mechanism to control externalities, especially when environmental impacts are large and complex in extension (Peattie, 1995; Perman et al., 1996). Regulatory strategies to control small-farm on-site environmental problems in developing countries, however, are extremely difficult to implement and of reduced impact (Lutz & Young, 1993; Barkin, 1994; Laing et al., 1992; ISNAR, 1998). Marketing strategies, conversely, may be more appropriate to deal with farm on-site environmental problems. Farm in situ environmental problems such as soil erosion and groundwater exhaustion can directly affect farmers because of the consequences on crop yields (lower profit), input needs (production costs) and long term productivity (economic instability).

The attention of the literature to the interactions of marketing and agricultural sustainability has been growing in the last decade. Citations embrace the impact of poverty and uneven market access on agricultural sustainability; the lack of a more proactive role of marketing in targeting sustainable agriculture; the need of a market-based agricultural policies for environmental issues; and the enhancement of marketing channels (in terms of infrastructure, organisation and coordination of functions) to target environmentally sound agricultural production systems. The potential contribution of marketing to agricultural sustainability needs to be further explored to find alternative answers to resource degradation and poverty problems in environmentally fragile lands as tropical hillsides.

1.3 Aim of the study

The need for sustainable agricultural production is generally accepted, and it is increasingly investigated. There is, however, a need for assessments of agricultural sustainability from the perspective of the marketing channel. What is the optimal match between the marketing channel and sustainability in agriculture? This study is an attempt to consider the question of sustainability of agricultural systems from a marketing channel perspective, examining the contribution of arrangements in the marketing channel as economic incentives for farm investments to maintain the productive resources. The particular interest of this study is in the environmental 'friendliness' of the production system, focused, principally, on soil conservation as an environmentally 'friendly' production method. The object of analysis are small farms of tropical countries where agriculture is the main form of livelihood and where environmental resource problems are particularly important since small-scale farms are often confined to marginal, hilly and more environmentally fragile areas.

As different marketing systems arising in the marketing channel may vary in their effects on the sustainability of small-farm systems, the study pursues the following research questions. To what extent are alternative marketing channels or arrangements better equipped to contribute to the adoption of sustainable farm production systems? What is the added contribution of other factors, such as physical, institutional, economic and personal factors, to affect farmer's decision to use sustainable production systems? What is the impact of greater levels of sustainable production systems on farm income? The responses to these questions are intended to identify policy recommendations that elucidate the role of marketing in stimulating sustainable farm production through economic incentives.

The study develops a research framework based on marketing channel theory that attempts to discern the theoretical interactions between marketing systems (i.e. conventional and vertical marketing systems) and the sustainability of agricultural production systems. The interactions between marketing system and sustainable production will be analysed in a tropical hillside area by the application of relevant appraisal methodologies. More specifically, the analysis aims to provide an insight into:

- the extent of the contribution of marketing factors to farm sustainability as compared to other farm affecting factors
- the relevance of coordinated and function-integrated marketing systems in influencing environmentally 'friendlier' farm production systems
- the economic costs and the agro-ecological benefits that market system modifications would bring in the farm context
- policy implications and recommendations to avert negative impacts on tropical agriculture

1.4 Outline of the study

Figures 1.1 shows the structure of the study. The study consists of two parts. The first part, which comprises Chapters 2 to 4, involves the theoretical discussion that will identify the main interactions of agricultural marketing and farm sustainability. The second part, which comprises Chapters 5 to 10, refers to the empirical analysis of the interactions identified in earlier chapters.

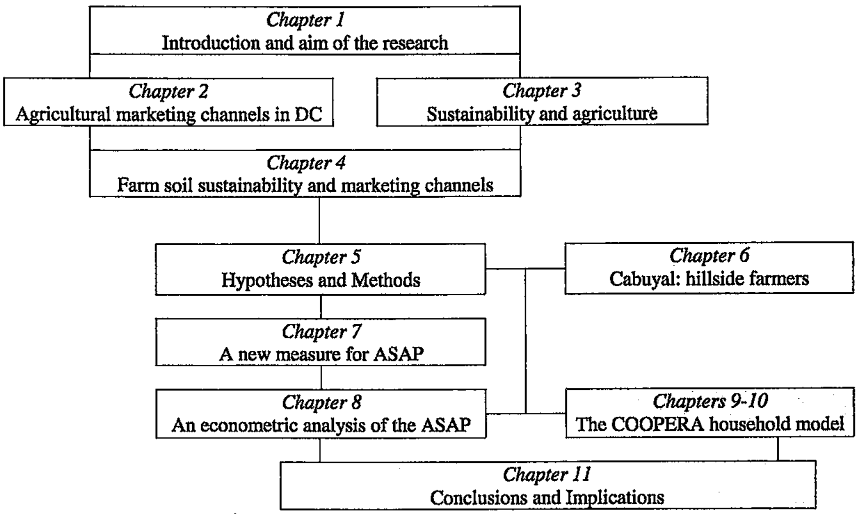

Figure 1.1 Structure of the study

The theoretical discussion is organised as follows. Chapter 2 offers a review of the structures adopted by the2 marketing channels to deliver products from producers to consumers and the basic functions that distinguish these structures. The discussion uses marketing channel theory as the conceptual framework. This chapter compares conventional marketing channels (CMC) and vertical marketing channels (VMS) and highlights their strengths and weaknesses. The chapter then describes small-scale farm marketing channels in developing countries recognising that these channels are predominantly conventional and leave room for improvement.

Chapter 3 provides the basis for an operative definition of sustainability and draws attention to critical issues of sustainability in the third world. It starts by reviewing the evolution of environmental concerns in society and offers an overview of the status of sustainability in the third world, which highlights soil degradation as the most serious sustainability problem in the third world. Environmental impact of farm activities are classified as on-site and off-site (externalities) impacts and it is theorised that, while the government is entitled to intervene by regulating externalities, marketing has a potential role in addressing farm on-site impacts. The chapter proceeds with the definition of the concept of sustainability in terms of farm on-site soil sustainability. Finally, a review of empirical studies of the diverse factors affecting adoption of sustainability is carried out.

Chapter 4 aims at discerning the synergies between marketing channels and farm sustainability. To this end, the chapter begins by reviewing the studies that have identified interactions between marketing and agricultural sustainability. Following, the impact of agro-food activities on the physical environment is discussed noting that this impact is particularly pervasive at farm level. The chapter then describes the strategies that agricultural marketing has adopted to promote adoption of environmental issues and emphasises the role of marketing approaches in correcting the market distortions that misguide farmers and affect sustainable farm management. In particular, a VMS is identified as a strategy capable to offer clearer stimuli and promote long-horizon planning and care for the soil resource base in the long run.

As a result of the theoretical discussion in Chapters 1 to 4, Chapter 5 introduces few general hypotheses in relation to the contribution of marketing systems to farm sustainability. This chapter also reviews the most common methods employed in the appraisal of sustainability. The chapter ends proposing two different methods, an econometric and a linear programming model, to assess and validate the hypotheses. The former model integrates approaches from several disciplines (e.g. from the psychology, socio-economy and geo-physical disciplines) to test the actual influence of a number of hypothesised variables on the adoption of soil sustainable practices. The linear programming (LP) model incorporates a multiple objective specification intended to provide insight into the likely consequences of market interventions on the economics and sustainability of the farm. While the econometric model aims at measuring and testing the actual effect of a number of explanatory variables (including marketing) on soil sustainability, the LP model aims at evaluating the possible impact of a number of 'what if' market scenarios on soil sustainability, income and other variables.

Chapter 6 presents a case study in Cabuyal, an Andean hillside region in southern Colombia. The region is a watershed inhabited by small farms linked to the market predominantly by conventional channels. Agricultural patterns, soil fertility management, physical infrastructure and prevailing marketing channels are described throughout the chapter. The sampling method is presented and the appraisals made to collect information on farm management and marketing issues are discussed at the end of the chapter.

The empirical analysis of the study begins in Chapter 7 with the measurement of farm soil sustainability in Cabuyal. After a literature review, the chapter proposes a method for the measurement of soil sustainability that both evaluates the degree of sustainability adopted and is straightforward to apply on field-to-field basis. This proposal is complemented by an empirical procedure that attains metrical behaviour to the sustainability variable in order to facilitate the application of quantitative analysis methods. This methodology used is believed to improve substantially the empirical approaches of previous works to appraise soil sustainability. The chapter ends undertaking a preliminary characterisation of soil sustainability, which is complemented by a cluster analysis, attempted to identify soil management typologies in Cabuyal.

In Chapter 8, the conceptual econometric model introduced in Chapter 5 is developed and applied to the case study data. The model attempts to explain adoption of soil sustainability methods in the Cabuyal watershed on the basis of marketing factors as well as other aspects such as personal, sociological, physical and economic factors. The model tests the hypothesis that marketing factors have a direct relationship to the adoption of sustainable practices (ASAP). To pursue this assessment, model variables are quantified by means of an innovative and straightforward methodology. The methodology addresses weaknesses of previous works and comes out with a theoretically comprehensive econometric model.

Complementarily, in Chapter 9, the normative model introduced in Chapter 5 is further developed to pursue sustainability, and other objectives such as profitability, risk avoidance, and temporal income distribution. Concurrently, selected market scenarios are defined to resemble CMC and VMS in order to compare changes in factor allocation and to appreciate the associated impacts on soil sustainability and farm income. This comparison attempts to provide insight into the economic costs and in the agro-ecological benefits that certain modifications to the farmer's market environment would bring. The resulting allocation of land, labour and capital and the estimated impact on soil erosion in each market scenario is presented and discussed in Chapter 9.

Finally, Chapter 11 makes a summary of the study embracing both theoretical discussions of initial chapters and the empirical analyses of later chapters. Main conclusions are then drawn and policy implications are highlighted at the end of the chapter.

2 AGRICULTURAL MARKETING CHANNELS IN DEVELOPING COUNTRIES

The purpose of this chapter is to review the structures adopted by the marketing channels to deliver products from producers to consumers, and the basic functions that distinguish these configurations. Section one focuses the discussion of marketing channels because of their influence on farm household decisions, production systems and farm sustainability. Section two defines the marketing channels and the functions held by channel members, and identifies conventional marketing channels (CMC) and vertical marketing systems (VMS) as organisations that emerge as a result of the coordination (or not) of the exchange, physical and facilitating channel functions. The section finalises comparing CMC and VMS in terms of functions and highlights their strengths and weaknesses.

Section three describes small-farm marketing channels in developing countries in terms of marketing functions and argues that product prices vary not only with supply and demand changes, storage, transport and processing costs but also with the complexities that poor infrastructure and institutional weakness bring about. Section four discusses the relationship between small-scale farmers and their marketing channels in terms of various elements of the marketing mix. The discussion attempts to highlight the comparative advantages of CMC and VMS. The last section of this chapter makes some final remarks on the marketing channels for small-farm products in the developing world. It concludes that those channels are predominantly conventional leaving room for improvement.

2.1 Basic characteristics of marketing channels

The marketing channel is the trade or distribution channel and it is defined by Stern et al. (1996) as sets of interdependent organisations involved in the process of making a product or service available for use or consumption. The channel follows a vertical structure where products flow from producer to the ultimate consumer and in which actors meet each other at markets. Producers, wholesalers and retailers as well as other channel actors exist in channel arrangements to perform marketing functions (business activities) that contribute to the product flow. Actors stood between producers and final users are known as intermediaries. Figure 2.1 shows a hypothetical food marketing channel. The coordination of marketing functions by channel actors, which give rise to marketing systems, are further discussed later in this chapter.

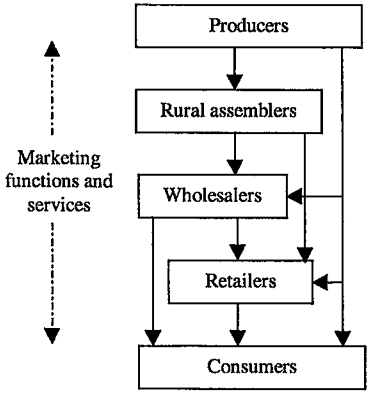

Figure 2.1 A view of a fresh-food marketing channel

This study draws particular attention to marketing channels because they enable farmers to interact with the rest of the world in their economic realisations and the provision of consumer needs. Most importantly, marketing channels have a great impact on the farm household decisions. They play a significant role as a major source of rural income and in facilitating social interaction, general communication and information about the market and technology. The development of the marketing channels is, consequently, of paramount importance in agriculture and affects farms in regard to several issues, namely:

- crop mix: market conditions inform farmers on the products in demand and prompt him to decide what, when and how much to produce
- farm income: agriculture, as the farm's chief economic activity, is the main source of income for the farm
- food security: production of agricultural products for consumption and for the market affects farm food availability and household consumption and nutrition
- farm resource allocation: market channel news have, inevitably, impact on changes in use of the farm factors of production land, labour and capital
- farm sustainability: marketing channels have ultimately effects on the use of the farm natural resources, and, hence, on sustainability.

The focal point of this study lies on the latter topic, that is, the impact of the marketing channel on farm sustainability. The marketing channel, which starts with the farmer and his production system and ends with the consumer and his consumption habits, is a two-way flow of market signals. The nature and means of farm production have a major determining effect on the organisation and operation of the marketing channel. At the same time, the dynamics of the marketing process itself has a direct influence on agricultural production. For example, as shifts in demand in consumer markets and other market developments are common in the marketing channel, marketing channel actors influence farmers' decision making by giving market signals (Figure 2.2).

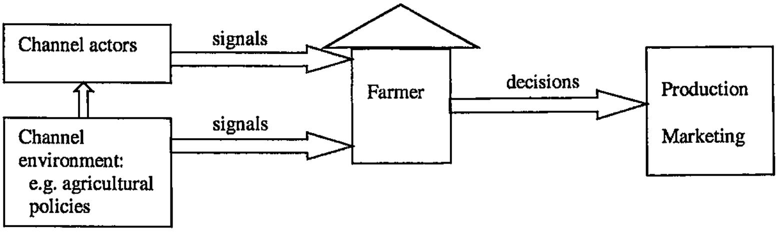

Figure 2.2 Farmer's decision making on the basis of signals from the actors and the environment of the marketing channel

Farmers will make appropriate decisions on resource allocation and on other management matters depending on the extent to which correct market channel signals are sent, clearly received and not distorted by market imperfections. However, this is commonly not the case in developing countries. Resource users in those countries no always get correct or clear market signals from the marketing channel, which have unforeseen effects on the sustainability of the farm system. Two central issues can be identified as major causes of the distortion of market signals in the marketing channel:

- the structure of the channel does not allow actors to carry out marketing functions as efficient and economic as possible
- marketing channels are underdeveloped by obstacles such as lack of reliable communications, inadequate transport facilities, financial constraints and ambiguous law systems.

Both issues are major obstacles for market transparency and farmer's optimal decision-making processes. The former falls within the marketing domain and is related to the structural characteristics of the marketing channel. As discussed in forthcoming sections, channel structures arise from the coordination (or not) of marketing functions and the arrangements that intermediaries make to enable the delivery of goods to industry/consumers more efficiently. The latter issue falls within the national domain and is the result of the prevailing political environment in which the marketing channel works. National policies determine the development of legislation, the banking system, physical infrastructures and many other matters. Marketing is more entitled to address the former issue. The relevance of certain marketing channel structures in providing the signals required to adequately guide farm resource users towards sustainable farming are discussed in the sections ahead.

2.2 Coordination in marketing channels

The functions held within the marketing channel cover exchange functions (e.g. buying and selling), physical functions (e.g. storage, transporting and processing) and facilitating functions (e.g. grading, financing, risk bearing and market intelligence) (Stern et al., 1996; Kohls and Uhl, 1998). From the producer to the ultimate consumer, the marketing channel follows a vertical structure in which stakeholders interact with each other at markets.

The structure of the marketing channel varies to the extent to which marketing channel intermediaries specialise on particular channel functions, respectively coordinate their efforts to make the delivery of goods and services to customers or final users possible or more efficient.

The coordination of marketing functions may be related to one or to a group of functions (e.g. processing, transporting and selling) and can be achieved by backward (e.g., contract farming, big retailers assuming middlemen functions) or/and forward coordination (e.g., farmer cooperatives, big dairy cooperatives marketing farm-made cheese directly to consumers). Among the reasons for the emergence of marketing channel structures, Stern et al. (1996) highlight economic reasons as the most important determinants. Economic determinants include the need for exchange and exchange efficiency, minimisation of assortment discrepancies, routinisation of selling practices and the facilitation of the search for customers by buyers and sellers. Stern et al. distinguish as well macro-environmental determinants of marketing channel structures including demographic (e.g., population concentration, urbanism), physical (e.g. topography, climate), economic (income, finance), technological (e.g., communication infrastructure), political/legal (e.g., law frameworks), and social/cultural (e.g., people's beliefs, values and norms)[2].

The way of coordinating marketing functions by channel members defines the organisational configuration of a marketing channel (Kotler, 1997; Stern et al., 1996; Abbot, 1979; Kohls and Uhl, 1998). The degree of coordinating marketing functions in marketing channels has led to the classification conventional marketing channels (CMC, coordination primarily by the price mechanism) and vertical marketing systems (VMS, coordination mechanisms, other than price, are more important) (Kotler, 1997; Abbot, 1979; Kohls and Uhl, 1998). VMS, in turn, give place to a number of institutional patterns ranging from those that materialise the coordination of functions by means of informal agreements (administered systems) or formal agreements (contractual systems) to those that exercise a most complete coordination of functions (corporate systems). Administered systems coordinate successive stages of production and distribution based on informal collaboration on inclusive goals, while contractual systems coordinate tasks based on contractual agreements. In corporate systems, members of different levels are owned or operated by one and the same organisation[3].

CMC are structures where every channel member operates independently in its profit-seeking endeavours, none has formal power over others and price is determined in spot markets (by supply and demand), sometimes by means of bargaining. VMS are more coordinated systems where members aim at common goals in order to achieve efficiency, economies and maximum market impact. When discussing the evolution of marketing channels of food products from CMC to VMS configurations, Meulenberg (1992) calls the first channel the market-driven marketing channel, "whose activities are primarily directed by the market and, to a lesser extent, by relationships between market institutions." Meulenberg calls the second channel the relationship-driven marketing channel, "whose activities are primarily directed by relationships and, to a lesser extent, by market prices" (for a review of the evolution of marketing channel theory, see Meulenberg, 1986, 1992, 1997; Sheth et. al, 1988; Kotler, 1997).

The underlying reasons for channel development from CMC to VMS include effectiveness, efficiency and market power (Alderson, 1967; Stern et al. 1996; Meulenberg, 1986). Vertical integration is achieved in the search for greater efficiency and effectiveness in market functions such as those related to quality and services in marketing high quality products (e.g. fresh meat and dairy products), service delivery (e.g. the speed of fulfilling an order), branding (to improve competence position) and market power (based on credit delivery, being better informed and control of physical facilities).

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[2] These factors include elements such as entry barriers, middleman orientation, customers' characteristics that, in turn, depend primarily on the commodity produced and its final market. For instance, the delivery of perishable produce requires a more direct marketing to assure speed turnover, whereas grains can be marketed over a longer period. The structure of the marketing channel also varies if the final market is for fresh or processed product consumption.

[3] Stern et al. (1996) call corporate systems 'hard' vertical integration, and administered and contractual systems 'soft' vertical integration.

In the case of transparent markets (perfect information) and absence of product differentiation (product homogeneity), coordination by prices in CMC might be a better procedure than coordination by contract in VMS. Examples of this are the marketing of wheat and soybeans in some countries (Khols and Uhl, 1998). The coordination and formation of prices in open markets such as auctions are also examples of efficient CMC markets. But when in addition to price coordination, coordination is required in product specialisation, product services, market information and other elements of the marketing mix, VMS might be more appropriate. The differential characteristics between CMC and VMS are reflected in functional strengths and weaknesses, which are distinguished in Tables 2.1 and 2.2.

Table 2.1 Functional characteristics of CMC

Strengths

- Efficient when the product is homogeneous, there are many small buyers and sellers and there is perfect information
- Efficient if labour costs are low and products flow to the end consumer without delays
- Flexible when markets are geographically dispersed and marketing channels lack infrastructure and market services
- Flexibility and speed of executing transactions between channel actors (important in markets in which there are daily changes in supply and demand)

Weaknesses

- Sub-optimisation of functions may result due to fragmented structures
- Short-sighted objectives and deficient information may confine sales only to nearby markets
- If infrastructure is weak, transaction costs may be high due to an absence of coordination
- Channel proliferation may increase margin costs which result in inequitable retail:farmgate price ratios
- Individuals may have a weaker market position in bargaining
- Poor processing and assembling, and product deterioration may happen for lack of training and feedback
- Lack of coordination, information and other services may render suboptimal use of factors of production

Source: Based on Minot (1993), Kotler (1997), Stern et al. (1996), Kohls et al. (1998), Abbot (1979) and Meulenberg (1992).

CMC is an important channel in homogeneous commodities. As pointed by Meulenberg (1992) "price formation in markets at different stages in the [conventional] marketing channel is directing supply and demand satisfactorily if the commodity in question is well graded and sorted and there are not specific product requirements." CMC, therefore, may certainly be more efficient when demand is diversified and volatile, when the product is homogeneous, producers are small in size, large in number, and relatively scattered geographically, information is not distorted and there are no entry barriers[4]. For example, CMC tend to be efficient in trading basic grains and other staple food crops which are not processed (Minot, 1993)[5]. In developing countries, for example, CMC play an important role in isolated zones with poor market infrastructures where

[4] Perfect market conditions, however, are hardly achieved in in less developed countries where marketing tends to be very complex and incipient (Appendix 2.1) (Kohl et al., 1990; Minot, 1993). Although conventional agricultural producers have long been used as examples of nearly perfectly competitive firms, while there are market failures such as information distortions and credit monopoly, these markets do not come close to the perfectly competitive conditions.

[5] The reason is that there is more economic incentive in forward (rather than backward) integration of marketing functions (e.g. processing operations). If the economies of scale are large for one marketing function, say processing, but small for agricultural production, then integrated production is likely not very efficient either.

producers are financially weak and lack marketing expertise (e.g. in marginal rural areas). While cost advantages often work in favour of vertical marketing systems, independent operators seem to have an advantage in adapting to a heterogeneous demand. They buy in cash products of all sort of quality and maturity levels that farmer could not sell otherwise.

Table 2.2 Functional characteristics of VMS

Strengths

- Particularly efficient with products differentiated in terms of quality or logistic requirements
- Better fulfilment of functions as a result of coordinated and more centralised structures
- Operational efficiencies and uniformity in quantity and quality through logistic improvement of channel activities
- Market institutions can market more widely and offer stronger market position in bargaining
- Aims at improving market infrastructures, which balance supply and demand and curb waste and price variation
- As demanded output is planned in advance, farmers face lower risks related to uncertain sales
- Uniform measurement of quality and quantity simplifies buying and selling and permits economies of scale
- Feedback, training and extension improve labour productivity and reduce investment risks
- Provision of inputs & finance make farmers less concerned with production financial constraints
- Efficient if economies of scale are large for agricultural production (e.g. labour intensive production systems)

Weaknesses

- Contract enforcement may be costly and opportunistic behaviour of contractors and farmers is possible
- With inexperienced growers, detailed instruction and supervision may be necessary
- Contractors may abuse their monopsony position to violate contracts
- Farmers may lose their independence when producing just what the contractor wants
- Market risks tend to be higher when a fix-priced scheme is used and yields are relatively unstable
- Arrangement coverage is limited to certain number of producers
- Shifts from subsistence production systems to commercial production systems may affect food provision

Source: Based on Minot (1993), Kotler (1997), Stern et al. (1996), Kohls et al. (1998), Abbot (1979) and Meulenberg (1992).

Vertical market coordination, conversely, is particularly critical in farm products because of the length of the marketing channel, the large number of specialised firms involved, the inherent uncertainty of prices, supplies, and qualities of farm products, and the urgency of marketing perishable products. In particular, contractual arrangements between farmers and firms are favoured when special quality requirements must be met; when local growers are unfamiliar with the production technology; when supplies must be carefully scheduled; and when other kinds of marketing information are more available to the processor than to the local growers. The extent of contracts is greater with high-value perishable commodities which are processed such as vegetable, fruits, milk, poultry, tobacco, tea and many traditional tropical exports. Many contracts involve the provision, by the buyer, of agricultural inputs to the farmer. Seed and fertiliser are the most commons, but other inputs, pest control services, machinery hire, and harvesting services may also be supplied. VMS has the greatest development impact when the crop is labour-intensive, transaction costs have become unbearable, and when it does not completely displace home food production. The risks associated are farmer leaking, contract violation from the contracting firm, loss of independence by the farmer, and costly enforcement and supervision.

2.3 Marketing channels for small farmers in developing countries, a functional approach

In developing countries, small-scale farms are mostly production units in which family members provide most of the labour, management and finances. Most farms produce partly for the market and partly for their own consumption, while they also purchase some of their inputs (e.g. fertilisers) from and provide other inputs (e.g. labour) to the market. Due to their limited means, farms specialise in producing basic staple commodities. Because of their size, numbers and competitive position, farmers have limited influence in the marketplace (price takers) and generally make fewer marketing decisions than other members in the marketing channel[6]. This is because agricultural production absorbs a great deal of the householder's time and energies. As a marketer, the small-scale farmer either sells very small amounts at a time or very few times a year.

Products from small farms are generally produced for the domestic market and tend to be more expensive in the highly urbanised metropolitan areas since problems with deterioration increase once the distance between producer and consumer increases. Products from large farms[7] show lower price variability because of better integration of the markets for commercial and export products, access to communications and other infrastructure and because of agricultural policy environment which favours large producers.

Product prices vary with supply and demand changes, storage, transport and processing costs. They also depend on other factors such as the variety of consumer needs and purchasing power, product characteristics (perishability, processing required and product differentiation), the number of transactions needed, the quality of the infrastructure, the degree of specialisation in the marketing channel, and the availability and quality of market information. In developing countries the complexity of these factors is particularly critical. Agricultural marketing in those countries is complicated by factors such as underdeveloped infrastructure (e.g., roads, communications, finance, storage), by the very large number of separate production units and by unclear (agricultural) policy frameworks (Abbot, 1993; FAO, 1991a, b; Abbot and Makeham, 1979; Pritchard, 1969).

The development of agriculture and its marketing is at the heart of the growth process of many developing countries. Table 2.3 shows that in most developing countries, agriculture provides up to 32 percent of the Gross Domestic Product, and agriculture often supplies from one-third to three-quarters of total employment.

Table 2.3 Selected indicators from a number of developing economies in 1998

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[6] Nevertheless, small-farms is not a homogeneous group. They may produce a standard commodity (not differentiated in the market), such as maize and have not much influence on marketing their product. Or they can be dairy farms producing farm cheese and selling cheese at the doorstep as a unique product to consumers.

[7] Large farms are production units devoted to the large-scale production of high-input products. These farms are both capital and technology intensive and produce primarily for domestic and foreign markets.

	Popul'n (millions)	GNP per capita (US $)	Agriculture value added as % of GDP	Agriculture as % of total exports[1]	Agricult'l employm't %[1]	Urbanised popul'n %[2]
Bangladesh	126	350	23	44	64	19
Nigeria	121	300	32	3	43	41
Kenya	29	330	29	6	80	30
India	980	430	25	17	64	27
China	1,239	750	18	6	74	32
Low-income economies	3,515	380	25	n.a.	67	28
Bolivia	8	1,000	16	22	47	62
Indonesia	204	680	16	12	57	37
Colombia	41	2,600	13	34	25	74
Thailand	61	2,200	11	16	64	21
Lower-middle income economies	908	1,710	12	n.a.	36	42
Mexico	96	3,970	5	12	28	74
Brazil	166	4,570	8	29	23	80
Malaysia	22	3,600	12	11	27	55
Upper-middle income economies	588	4,890	7	n.a.	21	74

Source: World Development Report, 1999/2000 and 1997, and FAO Trade Yearbook, 1999; 1= in 1995; 2= in 1997.

In developing countries, agriculture, more than any other economic sector, is the bastion of small-scale, family enterprises (Abbot, 1993; Barkin, 1994). In these countries, small farms have traditionally been limited to mountain and/or marginal areas with the less fertile and more fragile lands, while large-scale capitalist and plantation agriculture monopolises prime lands in fertile valleys (Barkin, 1994; Ashby, 1985; de Janvry and Garramon, 1977). The political and institutional structure is frequently dominated by the interests of large-scale enterprises producing export commodities (such as sugar and cotton) or staple foods for urban consumers (such as wheat, rice or beef). Political pressure by large farmers' lobby might be effective for obtaining preferential treatment of national production (Dijkstra, 1997; Ashby, 1985; Pachico, 1981). Such interests influence policies for farm commodity prices, agricultural input prices, farm wages, and import tariffs, likely to create a market structure unfavourable to small farm crops, such as tubers, some non-processed grains and vegetables (Barkin, 1994; Crounch and de Janvry, 1980).

Marketing channels of small-farm products in developing countries can be described by means of marketing functions (Kohls and Ulh, 1998).

Exchange functions involve selling and buying. In marginal areas with poor infrastructure, farms tend to be small, numerous and scattered, and exchange small surpluses of farm products in local markets. The town market square is the primary place of direct transactions between producers, intermediaries and consumers. Each producer accepts full responsibility for promoting his produce, finding customers and obtaining information to guide him in bargaining over price. His task is facilitated by marketing intermediaries who buy surpluses and take the products to other markets where there is unsatisfied demand. In general, four groups of marketing intermediaries are distinguished: traders, agents, brokers and facilitating intermediaries. The traders take title to the merchandise, the brokers and agents restrict themselves to the negotiation of title, and the facilitating intermediaries assist the traders in their marketing activities (Kotler, 1997). Intermediaries such as brokers and agents are infrequent in rural areas with small peasants, as the output is too low to attract these types of agents.

Each group of marketing intermediaries can be divided into smaller subgroups. Wholesale traders can be subdivided into rural assembling traders (who collect products at the farm gate), wholesalers (who collect products at the town market) and distributing wholesalers[8].

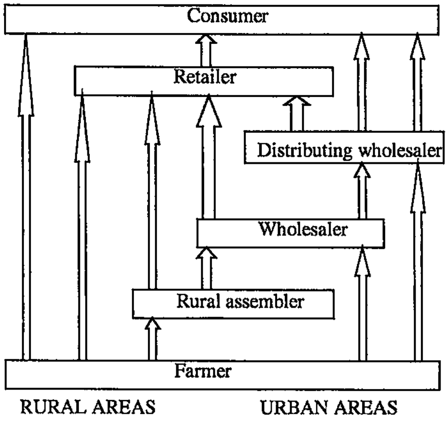

Figure 2.3 Small-farm commodity marketing channels

Figure 2.3 shows a typical marketing channel for a small-farm commodity in developing countries. It shows that, from the consumer point of view, rural marketing channels are simpler and more direct than urban marketing channels (Janssen, 1986; Tilburg et al., 1992). In the rural areas, retailers or even consumers might buy directly from farmers, whereas in the urban areas those products involve more traders, with rural assemblers, general wholesalers and distributing wholesalers appearing in between the farmers and the consumers. The farm product may flow in the following manner: rural assembling traders accumulate produce in the production areas to sell to collecting wholesalers, who carry the commodities to larger towns[9]. On arrival they sell to distributing wholesalers, who in turn sell to retailers. A marketing board may be present as a wholesaler for selective commodities. The retailers may have a fixed base (either a stall, a shop or a place on the ground), or they may be hawkers who carry their produce around (e.g. on a large platter on their head).

Information helps farmers, traders and consumers to balance supply and demand at markets and thus avoid gluts and surpluses with their corresponding fluctuations in prices. The knowledge that a farmer can compare one price offered by a trader with another price elsewhere, also influences buyers in offering fair prices. Access to better information enables wholesalers to reduce their business risks and to operate profitably on lower margins. Consumers, in turn, can also be influenced by market news. They can be encouraged to leave products that are in short

[8] See for instance Dijkstra (1997) on Kenya; Shechambo (1993) on Tanzania; Moustier (1992) on Congo-Brazzaville; Central African Republic and Madagascar; van Tilburg (1981) on Indonesia; Boekholt et al. (1983) on India; Torres and Lantican (1977) on the Philippines; and De Morée (1985) and Janssen (1986) on Colombia.

[9] Concurrently, other rural assemblers or even farmers may bypass the collecting wholesalers to sell to distributing wholesalers, or directly to retailers. This might be the case with high-value perishable products such as vegetables.

supply and buy alternatives that are plentiful.

Physical functions comprise activities such as storage, transportation and processing that involve handling, movement, and physical change of the commodity. Most of agricultural products are seasonal and perishable. Small farms normally lack appropriate storage facilities and cannot benefit from keeping part of the crop to await seasonally higher prices. Once harvested, perishable farm products must be marketed immediately. The flow of a perishable farm product through the channel may start with harvest in daytime, being sold in the afternoon, transported to the wholesale markets at night, traded to the retailer in the early morning and finally bought by the consumer within a day after harvest. Grains can be stored and marketed over a longer period allowing to conserving supplies for family use later in the year and avoiding having to sell at the low prices usually prevailing just after harvest.

In developing countries, traders rely on their own small-vehicles or on transportation firms to move the produce to designated places. Transportation means include trucks, trains or boats. Roads and other communication ways are often poorly developed in rural areas and this can limit the range of marketing and confine sales to nearby consumers. Poor infrastructure coupled with perishability of agricultural products form a major obstacle to marketing functions. Poor storage and inadequate transport with an absence of other physical distributional support systems are factors largely responsible for this. As a result, deterioration costs comprise a significant percentage of the total margins of small householders and influence high fluctuation of prices. Deterioration is sometimes overcome when products are processed so that a value is added and deterioration is mitigated over a long journey. More adequate packing containers are also a solution to market the perishable produce widely and efficiently.

The facilitating functions combine grading, financing, risk bearing and market intelligence functions. These functions enable the smooth performance of the exchange and physical functions. Efficient marketing demands a fairly degree of uniformity in products. Produce heterogeneity is particularly common in places with poor market structure and inadequate communication between traders and producers. Product heterogeneity affects prices and complicates storage and marketing of small-farm products. Assorted products are subject to strong price discounts in spot markets. Often, rural areas of developing countries lack established uniform measurements of both quality and quantity, which complicates buying and selling. Official grading standards are mainly used in main markets and used to a limited extent in rural markets. Also, small farmers do not show high willingness to clean, sort and grade the produce. Explanations for this are first, traded quantities are often too small to justify the work; second, prevailing prices discourage the effort required in selecting uniform lots. Hence, traders need to do most of the grading and sorting so that other traders can choose the kind of produce they want and be prepared to pay a higher price when they are sure of the produce quality.

Traders may use marketing service companies such as marketing research and consultancy firms, and advertising agencies; and financial intermediaries, including banks and insurance companies. In developing countries, food marketing service companies such as advertising agencies are insignificant, except in the case of processed products. Business insurance is still far beyond the scope of agricultural traders and insurance companies in many third world countries. The insuring of vehicles by transportation firms is probably the only exception.

Financing is an essential function at all stages of marketing. From the time of purchase at the farm-gate until the consumer finally pays for the finished product, capital is tied up in the processing and marketing system. Credit is generally needed for each link in the chain. Indeed, the strength of the processing and marketing system is circumscribed by the extent to which credit is available to finance its weakest link. Growers need credit before and during production to meet input costs. While financial intermediaries such as commercial banks are predominantly state owned, private banks are not very eager to finance agricultural marketers, in particular, of highly perishable farm products. They also find the risks too high and ask for collateral that peasant farmers and small traders lack. Other source of financing are sought such as developing own savings and credit associations. Informal credit from conventional middlemen often is quicker and less difficult to obtain, but, because of the risks involved, it may be very restricted in quantity, and involve heavy commitments on the terms of resale. Defects in credit may create distortions in demand and supply. Farmers may be obliged to sell most of their output at harvest time to repay loans when price is at its lowest level.

Risk bearing, i.e., physical and market risks, depends heavily on the market infrastructure. Physical deterioration of the product is mainly caused by inappropriate handling, storage or transport. Besides the normal market risks due to price fluctuation, market risks may be induced if information of movements originated from consumer taste changes or from changes in the operation of competitors are not known clearly and timely. The burden of these risks also contributes to the cost of marketing and must be covered by the profit margin obtained. Most of the market risk may stem from lack of knowledge. Coordination of marketing functions is often attempted to reduce or transfer risks between parties by agreeing prices, production and other aspects.

Lastly, market intelligence is a facilitating function that has intrinsic trade-offs with other channel functions. It involves collecting, interpreting, and disseminating market information. Prices need to be clearly disseminated and known early so that production programmes can be adjusted. Market information is often poor in marginal rural areas. Small-scale farmers have as a chief source of market information the local market place, while information of prices in urban markets is not always easily obtainable. Farmers with bad access to market places have as a chief sources of information neighbours and rural traders.

In rural areas of developing countries, some marketing functions can operate simultaneously while others might be absent. Promotion, for instance, is often omitted because it is of minor importance, in particular, in non-processed commodities (Dijkstra, 1997). Ordering is frequently subordinate to negotiation since both functions are performed by the same market intermediaries during the same meetings, particularly in spot markets. It is also frequent that storage has a limited importance with highly perishable products because of lack of appropriate facilities. Instead, the produce is quickly distributed to the final consumer.

2.4 Marketing channels for small farmers in developing countries, a marketing management approach

The small-farm faces decisions in relation to the use of its factors of production. The decisions involve several considerations. The first consideration is *what* to produce given the demand-supply panorama. The second consideration is *when* to grow given the price seasonality and the climatic conditions. The third consideration is *where* to sell, or better rephrased, through which marketing channel to commercialise the farm produce. In the decision process, farmers are subjected to several stimuli from the marketing channels. Farmers have to accommodate to developments of markets by organising their marketing mix, whatever limitations exist in this respect for individual farmers. Normally, a farmer will accommodate to market developments by coordinating his marketing decision making to the needs, wants and decisions of the channel actors as much as possible. As a result, the selection of the marketing channel matters a great deal. Farmers differentiate marketing channels through the way channel functions are performed. As elements of the marketing channel, farm household's decisions are greatly influenced by the structure of the channel. The relationship between a farmer and his marketing channel may be better described in terms of the marketing mix (Khols and Uhl, 1998): product (type and quality), price (price discovery process), communication and promotion (need for promotion) and distribution (logistical requirements, credit). While the marketing management approach is different from the functional approach, there is some overlap between the topics analysed in both approaches. For instance, there is overlap between the analysis of distribution in the marketing management approach and the study of the physical and facilitating functions in the functional approach.

Product

Homogeneity or heterogeneity of the transacted product with respect to quality, size and other characteristics does matter in farm's marketing channels. Homogeneous products such as basic grains and other staples can be appropriately traded in CMC. In the case of a commodity, which is in abundant supply and offers a transparent market such as wheat, a spot market is also preferred above a contract arrangement.

Conversely, differentiated products such as dairy products and added-value products, such as processed fruits, are probably better traded in VMS channels. VMS is better organised to maintain product quality in the channel and differentiate the product in the market, regardless if the difference lies on value, quality, service or any other characteristic. For example, coordination of functions is often seen for the proper undertaking of sorting, assorting[10] and processing functions of vegetables and fruits. Growers can be instructed by other VMS firms on these undertakings to avoid rough treatment in picking, handling and grading because they are essential for produce quality. Much deterioration and flavour loss[11] can be avoided if these operations are well coordinated. In seeking to meet quality requirements and market standards, firms may provide inputs and technical assistance on production methods, input doses and packing methods in order to obtain the desired product. As the farmer-intermediary relationship is tighter than in CMC, firms find it highly convenient to provide expertise on essential production and processing activities.

Price

Price discovery is also a determinant when selecting a marketing channel. Kohls and Uhl (1998) identify five systems of price discovery: (1) individual, decentralised negotiation (each farmer bargains separately with buyer); (2) organised, central markets (where prices are determined in terminal markets or auctions); (3) formula pricing (prices are a result of a formula developed by a private or official board); (4) bargained prices (where farmer collectively agree a price); and (5) administered pricing (established by the government, e.g., price ceilings). Systems (1) and (2) relates to price discovery in CMC, while systems (3) and (4) relates to price discovery in VMS channels. System (5) could be applicable to any channel.

Small-farms are essentially price takers as they are unable to influence market prices. In CMC, price discovery obeys free forces of demand and supply. Price depends on the presentation of the product in terms of sorting out and assorting. Conventional traders are flexible with poor graded produce and discounts can be strong. They also are flexible receiving products with different maturity and visual characteristic levels. Thus, farmers with poor quality produce may seek for spot sales (CMC). Under prevailing market forces, prices tend to vary largely in CMC, with traders having a dominant position in bargaining. Business transactions in CMC are informal and speedier than in VMS, and payments are often in cash.

[10] Sorting out involves breaking down a heterogeneous supply into separate stocks that are relatively homogeneous, notably through the grading of produce. Assorting involves the building up of an assortment of associated products for sale (wholesalers building assortments of goods for retailers).
[11] Fresh consumption might be more demanding in visual quality, whereas processed consumption is probably more concerned with taste.

Kohls and Uhl (1998) points out that in decentralised markets[12] it is difficult to collect adequate information from the widely scattered, private transactions; and specification buying makes it more difficult to compare market prices. Farmers face large-volume buyers and price discovery is a more subjective process, open to the relative bargaining power of buyers and sellers.

In VMS, production contracts are often associated with the pre-planting or pre-harvesting determination of crop prices. Prices can follow fix or formula schemes (Minot, 1993), which commonly are based on historical prices over a period of time. The agreed price can be higher or lower than the price in alternative outlets at a given moment. As noted before, if products are differentiated, farmers could find more profitable to sell the produce through VMS channels, which are more prepared to grant higher price for better quality than a spot market outlet such as a rural assembler or a street middleman.

However, as with CMC, there is considerable debate over the effect of coordination on pricing efficiency. As the use of contractual arrangements becomes a major part of the market structure of a commodity in a given area, it becomes increasingly difficult the discovery of the market price. As coordination progresses, less and less of the production moves through the "open market" for pricing purposes and more difficult is to discern a market price.

Even though VMS is geared to pursue transactional efficiency in order to attain economies of scale, growers are occasionally discouraged for the amount of time required in business transactions. The transaction procedure includes produce checking, weighting, registering, receipt issuing and check payment. This further implies to cash the check to be able to use the money for buying home and farm supplies.

Communication and promotion

As coordination of activities in CMC are primarily directed by market prices, communication with regards to other market news such as market opportunities or feedback on issues such as product presentation, sorting, assorting and processing functions is rare. Producers in these channels are mainly guided by market prices since high demand is basically reflected by high prices. Nevertheless, communication depends to a large extent on the policy of the channel leader. The channel leader may see, for instance, that it is beneficial for his business to share market information with the producers, especially when prices are falling. If market information is not easily obtainable from traders, producers might rely on other information sources such as communication means (radio and television), trade newsletters, extension officers, etc. in the case of a good infrastructure.

The coordination of exchange, physical and/or facilitating functions in VMS presupposes a speedier and more accurate flow of information on market news in regards to price, changes in demand, new opportunities, etc, among channel stakeholders. While it is true that market transparency is of mutual concern in these channels and is one of the reasons for market coordination, the efficiency in the dissemination of the information depends largely on the policy of the channel ruler. If the channel leader is powerful, he might monopolise market information and affect market transparency in the rest of the channel. Another aspect in information is decision-making. Being structured channels, VMS adapt more slowly to a changing market environment than CMC, because of the rigid planning related specific investments.

Advertising and promotion seek to expand consumption without sacrificing prices and profits. Advertising and promotion seek to stimulate and/or stabilise product demand and, consequently, increase sales and efficiency of marketing operations. Advertising and promotion are more used

[12] Decentralisation means that farm products move from farms and into the hands of processors and wholesalers without utilising the services of established terminal facilities. Buying agents of processors, wholesalers and retail firms contact producers and take title to the products in small markets in the production area.

in differentiated and branded products than for generic classes of homogeneous products. Marketing firms tend to promote products on the basis of quality, price, service and non-price themes. Advertising and promotion, like other market activity, have a cost and are better undertaken by organised marketing channels where financial support and coordination with other marketing activities can be done.

Distribution

Distribution is concerned with decision making with respect to place and time of marketing a product or service. It relates to the flow of products and services from the production side to the consumption side. Distribution involves tasks such as collection, transportation, storage and inventory. The weight and volume of farm products are comparatively great in relation to their monetary value, implying the importance of the distribution strategy to keep distribution costs down. Distribution costs vary with the perishability, bulkiness and fragility of the product as well as with the distances and the service to be provided. Certain commodities may require more conditioned warehousing or use of refrigerated vehicles for efficient distribution (e.g. dairy products and meat). Some perishable farm products such as fresh fruits puts constraints on transportation distance, which makes necessary to minimise the shipping distance and the number of handling in the movement from producer to consumers.

CMC can be efficient in the distribution of homogeneous products such as grains because the coordination of collection and transportation tasks are not complex and the logistics required for storage and inventory are not very demanding. Conversely, differentiated products, such as dairy products, vegetables and added-value products, are probably better distributed in VMS channels. VMS is better equipped to cope with the logistics of distribution tasks for these types of food products and also tries to focus distribution planning on stimulating product demand.

2.5 Final remarks on marketing in developing countries

In developing countries, the market structure for small farm products generally consists of many small and competing traders. In rural areas, market structures tend to be atomistic and labour-intensive, which restrains producers and traders to trade limited volumes at any one time. Unstable price formation and the large margins are visible symptoms of this.

Market infrastructure tends to be deficient in rural areas of developing countries. It often lacks of appropriate roads, communication means, electricity and storage. As a result, deterioration costs become a significant proportion of price margins. Deterioration diminishes marketed volumes and causes price fluctuations. Due to lack of electricity, adequate storage is not easily available. In consequence, market supply depends heavily on the quantities harvested and cannot be adjusted from stocks. This reinforces seasonality and price volatility within the marketing channel.

In many developing countries, financing of agricultural activities is hardly attainable from private banks, which find it risky to finance farmers and marketers who lack of collateral. Financing is obtainable from state owned banks, if collateral is available (e.g. land titles, capital assets), and, primarily, from fellow farmers and other traders. Prices from rural town to urban centres can show large differences and change in different ways reflecting delays in market news flow (see for example the case of cassava, rice and plantain in Janssen, 1986, 1988; vegetables in Henry et al., 1992). As a result, channel stakeholders can load price bargaining against them.

Deficiencies in market infrastructure and in other market supporting systems in rural areas creates low stimuli for the coordination in marketing channels (e.g. cooperatives) and the specialisation of marketing activities (added-value and processing activities). Consequently, basic food grains, such as beans and corn, and other unprocessed products are predominantly commercialised in CMC, though other products such as tobacco and wheat can be commercialised in auction markets. Few other products, such as high-value perishable commodities (e.g. some vegetables) and semi-processed products (e.g. coffee), can be commercialised in vertically integrated channels (mainly in the form of administered VMS). This indicates that there is considerable room for improving communication and coordination in the marketing channels.

This points to the need for improvement in infrastructure (electrification, roads, bridges, and other needs of transport) and organisational structures (marketing and financial institutions, insurance agencies and rural transport companies) as a means to decrease marketing margins, improve price formation and market efficiency, and promote added-value activities. Nevertheless, such apparent solutions often involve investment and running costs far beyond those justified for agricultural marketing alone (Abbot, 1993) and hardly affordable for poor countries.

In conclusion, the marketing channels for small farms in rural areas of developing countries are predominantly conventional due to several limitations in market infrastructure. Waste and excessive margins are common. Farmers in these conventional channels tend to show a short-term planning behaviour from only one harvest to another. These conditions have an impact on the level of efficiency in which these farmers allocate their scarce productive resources and are not stimulating sustainable farming practices.

3 SUSTAINABILITY AND AGRICULTURE: AN OVERVIEW

This chapter discusses sustainability with particular reference to agriculture in developing countries. In order to put research of farm sustainability into context, the first section starts with a brief review of the evolution of environmental concerns. The section describes how environmental concerns have evolved from an awareness of air and water pollution in the 1960's to non-price trade rules that involve environmental criteria in the 1990's.

The next section reviews main aspects of global sustainability. It is argued that soil degradation is the most serious sustainability problem in the third world. Section three classifies the environmental impact of farm activities into direct (on-site) and indirect (off-site) impacts. The section pays attention to the support that economic theory gives to government intervention to regulate environmental impacts while recognising that in less developed countries such interventions are often costly and of reduced impact. It is argued that marketing mechanisms may be appropriate for improving sustainability if profitability and sensitivity to long-term are characteristics of farm policies. This argument gains support in Section four.

Section four offers reasons for farm environmental degradation in developing countries, with political/legal and marketing factors highlighted as root causes for such degradation. However, it also emphasises the relevance of marketing mechanisms to pursue farm sustainability. Section five presents a review of empirical studies of the diverse factors affecting adoption of sustainability and distinguishes six general approaches. Section six reviews other empirical work that has addressed the study of sustainability by means of optimisation models in order to explore the associated impacts of farm resource allocation and income on farm sustainability.

Finally, section seven discusses the limitation of sustainability in this study to soil factors. Soil is selected as the resource of focal point in this study, given the fact that soil degradation is the most critical environmental problem in tropical hillside farms. The study is further focused on on-farm direct effects because of their apparent impact on farm's economy (e.g. depressed yields). The section ends defining the concept of sustainability in the study that will facilitate the empirical appraisal of soil sustainability.

3.1 The evolution of societal environmental concern

Concern about the impact that commerce and consumption have on the natural environment, upon which we all depend, is not a new development (see for example Peattie, 1995, p.1, for a historical review on environmental concern; see also Lowe and Goyder, 1983). However, the 'modern' concern about economic activity impact on the environment has become an issue of growing importance on society's agenda over the last four decades.

After the Second World War, food consumption increased substantially in the world, in particular in the Western World, both in terms of quantity and quality. In the post-war period between 1945 and 1970, the industrialised society enjoyed the increasing welfare without reservation. It was also a time when many of the effects of decades of environmental neglect began to manifest themselves; among others in the form of rivers polluted with toxins and atmospheric contamination. Predictions of an impending environmental crisis were widely debated and addressed as a significant item on the business agenda for the first time. This was largely prompted by the publication of books such as Carson's Silent Spring in 1962, Paul Ehrlich's The Population Bomb in 1969 and the Club of Rome's Limits to Growth in 1971. These books drew attention to the fact that we live in a finite world in which continuous and uncontrolled economic growth and population expansion would eventually exhaust the natural resources and systems upon which we all depend. With the shift to freer markets in the 1980s, a number of analyses of the environment were published, which included the Worldwatch Institute's State of the World reports (several issues), the World Resources Institute's World Resources reports and Environmental Almanacs (1992), the Organization for Economic Cooperation and Development's (OECD) State of The Environment report (1988) and the Second Report of the United Nations Environment Programme (1991) These reports showed that according to a wide range of indicators, the environment was coming under increasing stress.

Concern about the environment increased steadily among the population during the 1980s, to become the primary concern among 85 percent of people of the industrialised world (Carson and Moulden, 1991) and over 50 percent in less industrialised nations (Gallup, 1992). Scientific evidence and environmentalist concern about ozone depletion, climatic instability linked to global warming, and satellite evidence of rapid rainforest destruction all drew the attention of the media (Table 3.1). Concern among consumers and the electorate began to mount, with the inevitable consequence being that environmental issues moved from the fringes to the centre of the business and political agenda.

Table 3.1 Causes of public environmental concern

- Pollution of river and oceans
- Ozone layer damage
- Greenhouse effect and air pollution
- Extinction of flora and fauna species
- Shortness of drinkable water
- Land degradation and contamination
- Deforestation

From the 1980's onward and particularly since the appearance of these reports, there has been a continuous stream of criticism directed at the system of production and consumption. After the publication of the World Commission of Environment and Development's (WCED) The Brundtland Report in 1987, the concept of sustainability began to receive considerable attention.

In the last two decades, political pressure on Western governments from environmentalist groups and the electorate provoked the updating of policy frameworks to consider environmental regulations (e.g. in EC and USA). Similarly, in the early 1990's, the Uruguay Round and the broadening of the GATT (WTO since 1995) framework, that forced rapid changes which are affecting national economies, were accompanied by heavy debates on environmental issues. These debates focused on the trade-off between improvements in economic welfare offered by increased trade, as opposed to the costs that this increased trade will cause in terms of contamination from transport and wastes of the production process and a more rapid use of natural resources, especially energy (Heerink et al., 1994)[13]. Fears were (and are) based on the apprehension that there are not adequate environmental policies that prevent the negative impact of trade liberalisation on the environment (Grubb et al., 1993; Gabelnick et al., 1997; Singh Jodha, 1997).

Part of these recent trends was based on fears on the damage that currently agricultural production systems are causing to the environment. Sustainability issues have become even more acute problems in agriculture because of specific issues in agricultural production and policy.

[13] One of the last debates was the Third WTO Ministerial Conference in Seattle (US, December 1999), which aimed at negotiating the progressive liberalisation of international trade as a way towards economic development and poverty alleviation, among other objectives. Nevertheless, the deliberations were postponed due to strong demonstrations from opponents to the discussions.

These include issues such as:

- soil, water and vegetative degradation of rural areas from farming (soil erosion, water pollution)
- environmental pollution generated by agro-processing and waste disposition (atmospheric pollution, global warming, and soil chemical contamination from farming and processing)
- soil conservation problems in agriculture (nutrient depletion, physical soil deterioration)
- the impact of western agricultural policies on agriculture in developing countries (e.g. export opportunities, crop subsidies)[14]
- Human and animal welfare (e.g., child work, workers and animal rights)
- Unclear effects of genetically modified foods and other organisms (GMOs)[15] on the environment as well as on human and animal health.
- The use of growth hormones in beef and the risks it might pose on consumers' health[16].

As a consequence of these fears, new trade barriers have arisen in the international arena. Eco-consumers from developed countries have been pushing governments for the establishment of new regulations and bans on food imports from developing countries. Examples include the setting of standards for pesticide registration and food residuals (Hofsten and Ekstrom; 1986 Archibald, 1990), eco-labelling of meat and timber and certification for organic production, and bans to genetically modified food. Governments of exporting countries argue that this type of trade barriers are simply used as an environmental excuse and that they are just a form of disguised protectionism to favour commercial interests. Regardless of the motivations, environmental concerns are a fact and a growing issue in international trade. The potential of these new developments to affect market access to international markets is huge[17]. They indicate that certification and labelling schemes are shifting from market-based non-legislated mechanisms to mandatory legislated mechanisms. These new developments put added pressure on developing countries to seek for sustainable forms of agro-food production and analyse the marketing opportunities derived from changes in the international markets in the mid-term. Countries are urged to promote sustainable farm production systems in order to halt environmental degradation and avoid possible setbacks in terms of market access.

3.2 Sustainability and developing countries, particularly soil degradation

As indicated in the previous section, sustainability concerns involve not only the physical environmental impact of human activities on soil, water, air and energy but also other issues originating in the social, cultural and ethical domains, such as animal welfare, maintaining the landscape, no child labour and supporting agriculture in developing countries. Physical

[14] See for example some of the experiences of the *Non Traditional AgroExport* (NTAE) scheme in several Latin American and Caribbean countries (Thrupp, 1992).

[15] GMO includes genetically modified crops (GMC), such as 'biotech' cotton, maize and rice, that have been perfected with pest resistance and herbicide built into their genes as well as with 'terminator technology' that produces sterile seeds (Financial Times, 11 November 1999).

[16] An example of this issue is the dispute between the USA and the EU with regards to the ban of this latter to meat and meat products from animals treated with hormones used as growth promoters (European Union website, 2000, www.euronion.org/news/press). Studies requested by the European Commission in 1998 and 1999 have found some evidence that certain growth hormones used in cattle raising could be carcinogenic or genotoxic and that further research about their precise effects was needed.

[17] Clark (1998) provides evidence that non-tariff measures used by the U.S. on imports from developing countries might be expected to limit growth prospects for these countries.

environmental issues are, however, perceived to be more relevant than social, cultural and other issues because of the low welfare and cultural factors in developing countries.

The following review will examine the level of land degradation in the third world and allow focusing the study of sustainability on the soil resource. Over the last two decades, agricultural output in developing and industrial countries has expanded at an impressive rate. For developing countries as a whole, the expansion rate during 1965-80 was 3.1 percent per annum, and the same rate for the period 1980-90 (FAO, 2000)[18]. This growth in production was due to a rise in productivity and an increasing use of marginal lands unsuitable for agriculture (Oldeman, 1994; Scherr, 1999). That performance has also been achieved by the adoption of new crop varieties along with the use of new techniques, high-energy inputs such as fertilisers and pesticides and increasing irrigated areas (Lutz and Young, 1993).

There is mounting evidence, however, that some of the output growth in the agricultural sector has occurred at the expense of long-term resource degradation. An increasing number of countries are plagued by impoverished and eroded soils brought about by inappropriate farming practices and the overproduction of food and export crops. The Global Assessment of Soil Degradation (GLASOD) world map was the first worldwide comparative analysis to focus specifically on soil degradation (Oldeman, 1994). GLASOD was designed to provide continental estimates of the extent and severity of degradation from World War II to 1990. The study concluded that human-induced soil degradation amounts to 17 percent (1.97 billion ha) of the land surface[19] (or 23 percent of globally used land) in the beginning of the nineties (Figure 3.1).

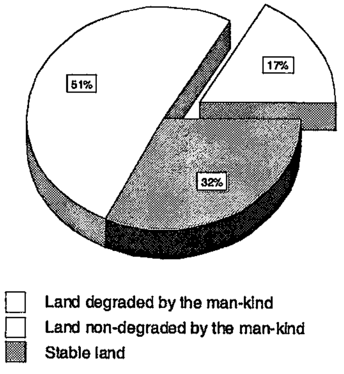

Figure 3.1 Status of world land degradation
Source: Oldeman, 1994

In Figure 3.1, stable land corresponds to areas not affected by human intervention at all because of very low population. Table 3.2 parcels out human-induced soil degradation by continent. Overall soil degradation is appreciably above the average in Central America, Africa and Europe.

[18] According to FAO (2000), the annual expansion rate of agricultural output slowed down in the period 1990-99 to 1.1 percent.

[19] This area discounts deserts, ice caps and natural eroded areas.

Table 3.2 Human-induced soil degradation (in percentage)

	Degraded Area	of which: Water Erosion	Wind Erosion	Chemical Deterioration	Physical Deterioration
Africa	22	46	38	12	4
Asia	20	59	30	10	2
South America	14	50	17	29	3
Central America	25	74	7	11	8
North America	5	63	36	0	1
Europe	23	52	19	12	17
Australasia	13	81	16	1	2
World	17	56	28	12	4

Source: Oldeman, 1994; Oldeman et al., 1991

From the table above it can be seen that water erosion is by far the most important cause of soil degradation, especially in Australia, Asia and Central America. Furthermore, it is undoubtedly the main soil burden in all continents. Wind erosion is relatively more important in Africa and North America. Loss of topsoil from water and wind erosion turns out to be by far the most important soil degradation problem. Water erosion and loss of nutrients is the major chemical deterioration problem in South America. Physical deterioration is comparatively a minor problem in all regions, excepting Europe where it is caused by soil compaction as a result of overgrazing.

The main causes of human-induced degradation can be observed in Figure 3.2 (Oldeman et al., 1991). Deforestation, overgrazing and agricultural mismanagement account for the biggest share of world soil deterioration. Deforestation is the major cause of soil degradation in Asia, South America and Europe. Overgrazing is by far the most important cause of human-induced soil degradation in Australia and Africa. For North and Central America, improper agricultural management is the most important cause of soil degradation.

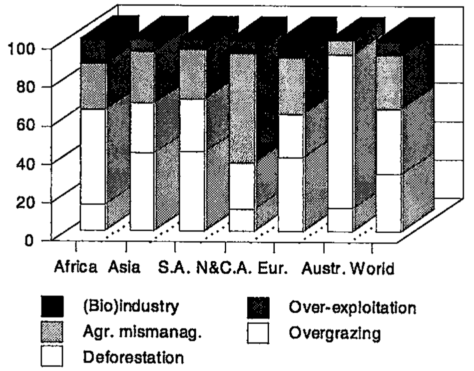

Figure 3.2 Causative factors of soil degradation (%)
Source: Oldeman, 1994; Oldeman et al., 1991

Moreover to the alarming environmental situation, an FAO report (in the Brundland Report) predicted that, without effective conservation measures, the total area of rainfed cropland in Asia, Africa, and Latin America will shrink by some 544 million hectares over the long-term, due mainly to soil degradation and erosion. This is a reduction of nearly 65 percent of the current amount of rainfed cropland in these regions (Brundtland Report, 1987, p.125).

Soil degradation is a very serious problem in the third world. Erosion has been identified as one of the most pressing resource management problems on the hillsides. In Central America alone, for example, over 60 percent of the hillsides is subject to severe, recent water erosion caused by agriculture (Smith, 1995). Erosion is particularly conspicuous in the tropics because agricultural production is, by its very nature, more complex and demanding than in temperate zones (Ruthenberg, 1980). The tropical farmer replaces the usually 'balanced' natural system by others that give the production he wants, but either consumes soil fertility or requires much labour and high material inputs if both a high level of output and soil fertility are to be maintained. The higher temperatures, greater high/low extremes of rainfall, and greater rainfall intensity, typical of the tropics, subject soils to significant risk of climate-induced degradation. The warmer and more humid the zone is, the speedier are biological processes, the quicker is organic matter decomposed and nutrients leached, the more quickly is the fertility of the soil consumed, and the greater must be the farmer's efforts to maintain fertility so that the tendency to increasing entropy is slowed down. A unit loss of soil has more impact on yields in tropical than in temperate environments. The turnover of organic matter may be four times faster than under temperate conditions (Ruthenberg, 1980). Rainfed annual cropping systems do not possess perennial biomass that acts as protective buffer between soil and atmosphere. In the tropics, removal of a perennial vegetative cover, followed by permanent cultivation, consistently results in a gradual, but clearly noticeable breakdown of the soil's potential to support life: nutrient leaching increases, organic matter decomposition is accelerated, erosion of the topsoil by means of wind and/or water is often very visible, and soil organisms decrease in numbers, while some species even completely disappear (Budelman and van der Pol, 1992).

Tropical farmers, therefore, face a fertility management choice. In sub-humid zones and, specifically, in steep slope lands, fertility issues are particularly critical. Soil losses and loss of precious topsoil (the nutrient layer) are the leading conservation difficulties. Many authors agree that most of the observed degradability of the natural resource is due to lack of knowledge and information on the environmental consequences of agricultural and development policies (Barkin, 1994; Grubb et al., 1993; Woodward, 1996). Nobody doubts that soil conservation technologies are indeed available to overcome many of the current degradability problems. Although an abundance of resource protective technologies exists, adoption of these technologies in tropical countries has been disappointing (Mbaga, 1998; Laing and Ashby, 1992; Kaimovitz, 1992). The next chapter discusses some of the reasons for the unsatisfactory results. The next section turns the attention to the environmental impact of farm activities and makes distinction between on-site and off-site effects.

3.3 Farm environmental hazards

Environmental hazards are highly relevant at farm level because production and processing activities rely heavily on such basic resources as land, water, air and energy. Hazards to farm sustainability may take on added significance because of the farm system's function, geographic spread and the number of people involved. Therefore, environmental degradation affects both the sustainability of the farm system itself and, via the farm and marketing channels, society at large (FAO, 1991a, b).

On-site and off-site farm environmental problems

Agricultural production activities may have an impact on human health, the flora and fauna, the soil, the water, the air and the energy. Some effects are on-site, others off-site. Some effects are immediate, others are long term (Figure 3.3). Farm on-site effects encompass the environmental impacts within the farm boundaries such as soil erosion and irrigation water depletion, whereas farm off-site effects are the 'side effects' that farm activities have on others such as surface water contamination. In welfare economics theory, off-site environmental effects are known as *externalities*[20] (Perman et al., 1996; Carlson et al., 1993). Farm on-site environmental hazards are apparent in relation to:

- soil loss (erosion), physical degradation of the land base and deterioration of soil structure, exhaustion of soil nutrients, salinisation of irrigated areas and alkalinity
- air and water pollution from agricultural chemicals, waterlogging
- deforestation, degradation through overgrazing, loss of vegetative cover and bio-diversity

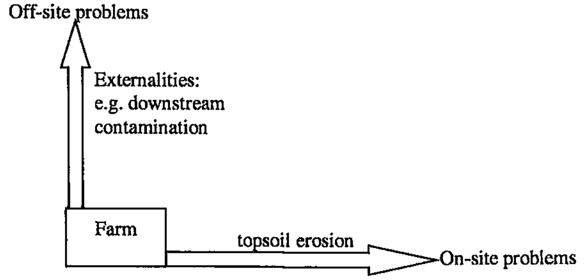

Figure 3.3 On-site and off-site farm environmental problems

An externality is said to occur when agriculture production (or consumption) decisions of a farmer affect the utility (satisfaction) of another farmer or society member in an unintended way, and when no compensation is made by the producer of the external effect to the affected party (Perman et al., 1996)[21]. Soil erosion, pesticide drift and health risks, water contamination and ground water overuse are all examples of agricultural resource issues with important externality elements. Externalities arising from agricultural production and processing activities include:

- nitrate runoff from over-fertilised fields that filters into groundwater aquifers and surface waters
- contamination of water systems by residuals in untreated animal manure[22] and noxious farm (processing) residues jeopardising water life, human health and recreational activities
- ground water depletion as a result of overuse for irrigation water
- aerial dispersion of pesticide sprays, which provokes pest migration to nearby fields and hinders the nearby public's use of the air for breathing
- Soil erosion and floods in downstream areas as a result of deforestation of watersheds

[20] Externalities can also be the other way around. Evidence suggests that acid rain and the accumulation of tropospheric ozone in urban areas besides to pose serious threats to human health, also leads to agricultural crop damage in surrounding areas (Perman et al., 1996).
[21] Externalities, however, can also be positive. A classic example is the increased productivity of the orchard generated by the activities of a nearby honeybee keeper.
[22] Which causes *eutrophication*, that is, the harmful loading of soil and water media with dissolved nutrient matter.

Both, farm on-site direct effects and externality problems have not only space but also inter-temporal repercussions (Figure 3.3). Pesticide usage, for instance, has long-term consequences on farmer's health as it does on other people's health (through the consumption of contaminated water and food), non-targeted benefit species and pest resistance. Similarly, many agricultural resource problems, such as waterlogging, pesticide resistance, and ground water depletion and contamination are dynamic in nature and become acute to the extent to the accumulation of past farm activities.

Resolutions of farm environmental problems

Sustainability problems arise from the degree of efficiency in which farm resources are allocated and managed. In economic theory, an allocation of resources is said to be efficient[23] if it is not possible to make one or more persons better off without making at least one other person worse off (Pareto optimal allocation). An efficient static and inter-temporal allocation would be sustained if free market and perfect market competition conditions are satisfied for all goods and services originated from that allocation (Perman et al., 1996). When these conditions are not met, the economy will be characterised by market failure. The failure of markets to exist for many environmental resources is often a reflection of the fact that the resources in question are not fully privately owned but are publicly owned. The air and a proportion of water resources, for instance, generally constitute public goods.

In less developed countries, externalities may be caused inadvertently either for ignorance[24] or negligence. Whatever the case, the resource user has not any incentive to cease causing externalities as public resources have 'not cost' and environmental problems do not affect the farmer directly. Thus, the burden of the externalities is not carried by resource users but by society. Farm in situ environmental problems, conversely, such as soil erosion and irrigation water exhaustion, can directly affect farmers because of the consequences on crop yields (lower profit), input needs (production costs) and long term productivity (economic instability).

In some situations, externality problems are solved between the affected parties before they reach a public forum. For example, a small peasant community may agree to protect the upstream forest buffer to secure enough volume of river water for all. Free rider problems might then appear where those who share a common concern are, nevertheless, reluctant to join, since the benefits of the community's activity will accrue to them anyway (Carlson et al., 1993)[25]. Resolution of externality problems is feasible when there are a small number of players involved and the costs of negotiation (transaction costs) between them are relatively low. In other situations, however, the numbers of players involved are large and bargaining costs are so high that Pareto-improving negotiations will not take place. The contamination of surface water by dairy waste run-off from cattle ranches is a case in point. In these situations, when free market forces alone do not bring about efficient outcomes, economic theory supports a role for

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[23] The allocation of resources can be static or inter-temporal (Perman et al., 1996). Static allocation refers to the allocation of resources at some single point in time, while inter-temporal allocation is the allocation of resources over time and where decisions taken today have implications for the consumption and production possibilities available in the future.

[24] This presupposes lack of perfect information on the part of all transactors of goods and services, of both direct and external effects. For example, those affected by ozone pollution should be fully informed of its origin and of the damage it causes. In some cases, poor information reflects fundamental scientific uncertainty (for example concerning the Greenhouse Effect). In other cases, poor information about pollution simply reflects the fact that most people are poorly informed about many things in a complex world.

[25] In these cases, private agreements (market resolutions), where all members consent to restrain themselves from causing negative externalities, will ensure that *free rider* problems do no take place.

government intervention[26]. The normal rule in law is to give the recipient of the externality the entitlement against the generator –polluter must pay in order to compensate society for their polluting activities ('polluter-pays mechanism'). In agriculture, externalities do not have a direct economic effect on farmers' income, but can have an indirect effect as a result of government fines or of a poor product image (environmentally unfriendly production process)[27]. Whether government regulations are effective or not, depends on if the efficiency savings and/or effectiveness gains are larger or smaller than the costs of implementing environmentally friendly measures. In the former case, farmers might be expected to introduce environmentally friendly measures. In the latter case, it will be more difficult to convince farmers and much will depend on whether consumers are willing to pay higher prices for the environmentally friendly produced product.

Nonetheless, the applicability of regulatory strategies at farm level in less developed countries is albeit limited (Lutz & Young, 1993; Barkin, 1994; Laing et al., 1992; ISNAR, 1998). Applicability is troubled by the fact that implementing sustainable practices at farm level is costly, requires institutional strength and demands great effort from small householders that, often, only have limited economic means. Additionally, regulatory strategies do not have much pertinence to deal with on-site farm environmental problems. As argued in the next chapter, small farmers do not see economic benefits that offset investment and effort devoted to land conservation. In these cases, marketing strategies (e.g. coordinated marketing channels) and management strategies (IPM[28] and crop residues management) may be more appropriate to deal with on-site farm environmental problems (Figure 3.4).

[26] Carlson (1993) distinguished several provisos to achieve substantial efficiency gains in government intervention. Firstly, if government can create and maintain appropriate institutional arrangements for markets and property rights. Secondly, if government policy takes the direction of using fiscal instruments -tax and subsidy systems, and marketable permits- to create economically efficient patterns of incentives on private behaviour. Thirdly, if governmental intervention also takes the form of providing information or funding research activity that can reduce uncertainty and increase the stock of knowledge.

[27] Even though, government intervention offers the possibility of realising substantial efficiency gains, by eliminating or mitigating situation of market failure, it is no guaranteed that intervention leads to improve efficiency in the allocation of resources (Perman et al., 1996). Firstly, the removal of a cause of market failure in one sector of the economy does not necessarily result in a more efficient allocation resources if other sectors of the economy are characterised by market failure. Secondly, any government policy can itself induce market failure elsewhere in the economy. Tax and subsidies schemes, for example, may distort the allocation of resources in an unintended way. Thirdly, intervention often involves the establishment of regulatory organisational structures, which by bureaucratic or other reasons may just fail to achieve the desired outcomes.

[28] Integrated Pest Management.

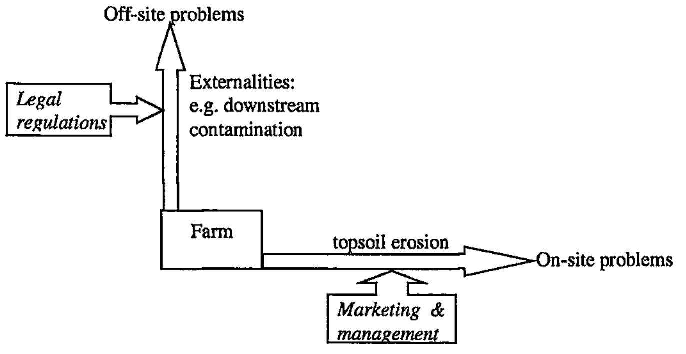

Figure 3.4 Strategies to farm environmental problems

Conversely to externalities, on-site environmental problems do have a direct effect of farm household's economy as they result in lower agricultural revenues (depressed yields) and greater production costs (soil nutrient depletion) in the short and long term. The extent of farm economic losses arising from on-site environmental problems will be higher the shorter is the time horizon of the farm planning operations. As marketing and management strategies can be aimed at promoting income and optimal production costs, they may increase disposition of farmers to avert farm environmental problems that affect the productivity of the land.

Accordingly, the resolution of externality problems is beyond the scope of this study and, hereafter, it is not further discussed. The study rather focuses on the potential role of marketing mechanisms in averting on-site farm environmental hazards. By way of prelude to Chapter 4, the next section draws attention to the underlying causes of on-site farm environmental degradation. The discussion will reinforce the arguments that supporting the use of marketing is a pertinent approach to better address farm on-site environmental hazards.

3.4 Underlying reasons for farm environmental degradation

By the time society began to realise the effects of the decades of environmental neglect on the atmosphere, soils, water bodies, forests and other natural resources, current production systems and consumption patterns were to blame for the degradation of the environment. Although they are direct causative reasons, the underlying cause of environmental degradation relates to the way in which economics and technology neglect the importance of the physical environment (see for example Peattie, 1995; Woods, 1991; Gray, 1990; Henderson, 1991). Among others, the physical environment is often described in geographic terms regarding the relative locations of customers, producers, and material inputs, or as land, as a factor of production, in economic terms. Some other assumptions of conventional economics are that:

- apart from land size, the physical environment imposes no limit on economic activity[29]
- externalities do not directly affect the operation of the market and the decision makers
- no value is assigned on anything with no market (e.g. air, atmosphere, common land, habitat,

[29] It is important to note that economists are aware of the limited availability of other production factors, such as water, and of the constraints they impose on economic activity (e.g. in Israel and some Persian countries).

species, enjoyment of natural landscapes)
- productive services offered by environmental resources for which financial payment is not made are ignored (e.g., natural waste assimilation, provision of clean air and water for cleaning and cooling)

In this context, national development models for economic growth have been somewhat biased towards economic development and welfare, generally at the expense of the natural environment (Peattie, 1995). Under these circumstances, resources and the services derived from them were considered as free goods as they were in unlimited supply or the use of the service was not subject to competition. With the passage of time, however, most natural resources have become increasingly scarce as the scale of economic activity has expanded, and many have been exploited or degraded to very considerable degrees. The deterioration of the natural environment has been particularly acute in less developed countries as their development policies are heavily focused on the primary sector and often copied from old models without proper adjustment. In consequence, the associated degradation of the environment has been 'invisible' to governments and business, although it has been evident to environmentalists and the general public.

Economic behaviour involves environmental effects and these are common, important and endemic in modern economies. Economic development, production and population growth combined with unsustainable consumption patterns place increasingly severe stress on the life-supporting capacity of our planet. Although the world is still a long way from following a sustainable path for future development, major steps have been taken towards that goal. Leading economies have been very active in updating their policy frameworks to consider environmental issues. The third world, however, is behind in pursuing this goal for the reasons explained below.

Fundamental causes of farm degradation

As an element of the marketing channel, the farm is diversely linked to society beyond the provision of consumer needs. From a sustainability perspective, farm linkages at the farm-household, community, regional, national and international levels are all of relevance. Actions taken and policies applied at any of these levels may have impact on both the sustainability of the farm itself and, via the marketing channel, on society at large. Being pervasive, farms are subject to a myriad of influences that may cause or compound sustainability problems. Major relevant influences involve the general macro-environment in all its dimensions (Kotler, 1997; FAO, 1991a; Barkin, 1994; Earth Summit, 1992):
- demographic (e.g., population growth and pressure)
- physical (e.g., endowment of farm resources, renewable periods)
- economic (e.g., wealth distribution, farm financing)
- technological (e.g., access to modern farm input technology and infrastructure)
- political (e.g., sectoral policies related to agriculture, marketing and resource conservation)
- social (e.g., education, culture, consumption patterns).

These macro-environmental influences vary, obviously, both across the developing world and over time, and some may be more significant than others in their influence on farm sustainability[30] (Reca and Echeverria, 1998; Perman et al., 1996; Barkin, 1994; Carlson et al., 1993). More specifically, it could be argued that the root causes of farm unsustainability lie directly on factors such as population pressure, unbalanced distribution of wealth, the prevalence

[30] The political and legal macro-environment, for instance, not only affects the agricultural sector with direct policies but also indirectly through policies exerted on other macro-environmental factors. Culture, in contrast, can provide little protection against the environmental degradation that may be induced by over-population and poverty.

of poverty and short-term behaviour of farmers, lack of infrastructure, information and other support services, market failures and inappropriate policies (Table 3.3).

Table 3.3 Root causes of farm unsustainability

1. The pressure of sustenance needs
Farm householders have a need for sustenance and their involvement in the agricultural marketing channel provides their principal source of sustenance. The major problem, however, lies with poor farm households as often they have no choice but to exploit their resource base if they are to survive. The sheer necessity of sustenance for survival can cause them to make resource-use decisions and follow farm practices that lead to resource degradation. Even though they may see the need to implement conservation practices, they lack the required resources to invest in resource conservation.

2. Short-term behaviour
Self-interest of participants in the seeking of income and profit over and beyond that necessary for their sustenance can be found at the farm and the marketing channel. Farmer's short-term attitudes may be originated from extreme poverty, which compels day-to-day survival behaviour. Short-term attitudes are also originated from the marketing channel to which the farmer is engaged. Actors of the marketing channel bounded with self-interest and concerns with own short-run performance (quick profit) pass on analogous behaviours to their farm counterparts. In any case, such as short-term attitudes are translated into higher discount rates to future needs, which likely lead to patterns of resource use that are more rapacious, implying greater resource depletion in earlier years.

3. Consumer demand
Consumer demand and food needs sustain the economic viability of the food marketing channel. Consumer demand is therefore an important influence affecting the sustainable management of the farm system[31]. In general, demand effects are transmitted via the price mechanism and so influence the behaviour of marketers, processors and farmers in their profit-seeking endeavours. This may lead to the use of production practices, which are inimical to sustainable development both directly within the farm system and indirectly through the adverse externalities.

4. Lack of knowledge
Sustainability is by definition a time-related concept. Its achievement implies not only knowledge of the future effects of past and present decisions about resource use but also, relative to economic and institutional sustainability, knowledge of the future socioeconomic path of society. The optimal allocation and use of farm resources presupposes perfect information of both direct and external effects resulting from that allocation and use. Shifting cultivators, for instance, should be acquitted of the fact that destroying needed forest cover often results in wide-spread soil erosion and damaging floods in downstream localities. Lack of knowledge of the consequences of farming practices is thus a significant impediment to sustainability.

5. Risk and uncertainty
Risk and uncertainty are associated with lack of knowledge as they are a reflection of imperfect information. Due to uncertainties in their natural (climate, pest attacks), economic (unpredictable markets) and socio-political (unreliable policies) macro-environments, risk is endemic to farm systems. Economic and political uncertainties are subject to change. The former is mainly associated with unclear market prospects for agricultural products. Farmers must account with a fair certainty knowledge of market prices (of own products and substitutes) and foresight of probably developments in the market. Under conditions of uncertainty, farmers can overestimate or underestimate market demands in terms of product and input prices. The risks associated with the socio-political environment involve primarily lack of legal regulation in regard to agricultural prices, land tenure, etc. and to changes in government policy. In any circumstance, resource users cannot make rational decisions which lead to efficiency loss, excessive costs, overall economic unfeasibility, and via the need for sustenance, can also induce resource effects adverse to sustainability.

Source: Based on FAO, 1991a, b; Barkin, 1994.

Factors four (lack of knowledge) and five (socio-political uncertainties) in Table 3.3 fall within the public domain and are pertinent to the governmental role played through national policies. Factors one to three and a part of five (lack of economic resources, short-term behaviour, consumer's demand and market uncertainty) fall within the marketing domain and are pertinent to the actual functional performance of the marketing channel.

[31] In this regard, Chapter 4 of Agenda 21 (UNCED, 1992) reflects the first official international recognition that unsustainable consumption patterns, particularly in industrialised countries, are aggravating the natural environment in food exporting countries.

3.5 Sustainability and agriculture: research on actual farmers' decisions

Studies of the diverse factors affecting adoption of sustainability in agriculture started in the '50s. Theory and evidence concerning the process whereby farmers choose or adopt sustainable practices have been addressed from different disciplinary vantage points. Based on Nowak (1993), six general approaches can be identified: diffusionist, economic rationality, personal, physical, institutional and integrated approaches[32]. Research on adoption began with rationality and diffusionist approaches in the 1950's and 1970's and gradually evolved to personal, institutional and physical approaches in the 1980's. In the early 1980's, an integrated approach was developed combining the previous five approaches into one complete model approach (see, for instance, Ervin and Ervin, 1982). The following review grouped the studies into the several approaches regarding the adoption of sustainable practices. Although the studies considered in the following review are included in either one of the six approaches, some of them may incorporate a combination of these approaches.

Diffusionist approach

This approach gathers early research whose major orientation was to explain the concept of innovativeness[33], which manifests itself in adoption behaviour determined by communication, peer pressure, social networks and other social processes. Innovation diffusion theory -psychological innovativenes, profitability orientation, or orientation to farming as a way of life, has been applied to adoption of environmental practices since the 1970's. Sociological research works on adoption processes are mainly based on the paradigms developed by Rogers and Svenning (1969) and Rogers and Shoemaker (1971)[34]. Some empirical studies of this approach include Pampel and Van Es (1977) who found that orientation of farmers to farming is important in predicting the adoption process of environmental innovations such as crop diversification. Tylor and Miller (1978) concluded that the amount and type of instruction that farmers receive on technology, influenced an innovation decision process for pollution control technologies. Formal and informal communication from conservation agencies had a positive effect in the discovery and evaluation stage of the adoption. Both, Pampel et al. and Taylor et al. found that orientation to farming best explained adoption of environmental practices, while variables relating to the size of farm operation best explained adoption of commercial practices. Ervin and Ervin (1982) found that stewardship (the belief that farmers have a moral obligation to protect natural resources) was highly associated with the use of conservation practices. Lindner et al. (1982) found that distance from the farm to the town has a negative impact on adoption and that information reliability plays an important role in farmers' adoption decisions. Conversely, Bultena and Hoiberg (1983) did not find a relationship between distance from the farm to the town and adoption of conservation tillage.

In another work, Novak and Korsching (1979) concluded that research results using diffusion theory are inconclusive, due mainly to the problem arising from the assigning values to variables such as monetary incentives and farming orientation. As part of a response to this criticism, other

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[32] See also Mbaga (1998) for a comprehensive review of studies of these approaches.

[33] Person's *innovativeness* is defined as "the degree to which an individual is relatively earlier in adopting new ideas than the other members of his social system" (Rogers, 1962; Nowak, 1993). For instance, farmers can fall in either category of innovators, early adopters, early majority, late majority or laggards with respect to adopting new environmental practices.

[34] According to them, the distribution of the adoption of innovation among farmers over time tends to follow a normal S-shaped curve (the adoption curve). In this curve, adopters are classified as innovators (about 2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and late adopters or laggards (16%) (Rogers and Shoemaker, 1971).

studies approached the adoption of soil conservation according to three stages of the innovation-adoption process. These stages are perception of the resource problem, adoption of resource conservation practices and effort to control the resource problem. These studies included economic factors in the model frameworks. Ervin and Ervin (1982) modelled adoption of soil conservation using the three-stage perspective. They found that farmer's perception of the soil erosion problem, number of soil conservation practices adopted and farmer's effort to control soil erosion are influenced by education level of the farmer, farming experience, risk aversion of the farmer, farm income and governmental support programmes. Gould et al. (1989) treated adoption as a two-stage decision making process in soil conservation, involving perception and adoption. Their farm-level study found that the operator's perception of the soil erosion problem is influenced by farm size, slope of farm location, and the operator's characteristics such as education, on-farm training and contact with soil conservation personnel, age of the operator, and operator's future farming plans. Farm income, age, education, off-farm employment and land tenure, influenced, in turn, adoption.

Mbaga (1998) used a three-stage perspective to study the adoption of improved soil practices. She found that personal factors were important explaining farmer's perception of soil problems; participation in peer groups contributed to farmer's adoption of soil practices; and conservation programs and farm labour were important contributors to farmer's effort to control soil problems. Nonetheless, Mbaga results refute the sequential decision process. She concludes that the perception of the soil erosion problem is not a necessary condition for using soil conservation practices, and, in turn, for determining farmer's conservation effort. A reason for this inconsistency is "the influence of promotional activities and support services provided by institutions, which interferes with household adoption behaviour. Promotional support services intervene between the household's attitude towards the soil erosion problem and his adoption behaviour, making the adoption decision for soil conservation inconsistent with his attitude."

Economic rationality approach

The economic rationality approach is supported by economists who argue that the adoption process is based on farmers' cost-benefit judgement. This approach explains the rate of adoption in terms of profitability, describing innovative farmers as those in the best position to increase profit from the adoption of innovations. Adoption is then treated as the process of profit evaluation, i.e. the adopter is seen as a profit maximiser. Empirical work on adoption of soil conservation technologies with economic rationality perspective began in the 1950s. For example, a report from NCFM (1952) found that lack of information on costs and benefits, reluctance of farm operators to change familiar methods of farming, organisation and income constraints on small farms, reluctance to forego short-term income for uncertain benefits, debt constraints, and institutional factors such as rental arrangements are obstacles to conservation. Blase (1960) found that off-farm income, perception of soil erosion as a problem and ability to borrow funds, were significant explaining adoption of soil sustainable practices. Saliba and Bromley (1986) found that high debt-to-asset ratios had a significant negative effect on conservation effort whereas farm type, farm income were positively related to adoption of conservation practices.

Norris and Batie (1987) showed that farm size and income were significantly and positively related to investment in land conservation. Significant negative influences were off-farm employment, debt level, ratio of rented to owned farmland, and tobacco acreage. A different pattern was detected for adoption of minimum or no-till systems. Significant factors with negative influences on the use of conservation tillage included income and off-farm employment. Significant positive economic influence was farm size. Featherstone and Goodwin (1993) used a dynamic economic approach to analyse long-term farmer decisions on conservation investments. Adoption was analysed as both a discrete decision on whether to invest or not, and to examine continuous level of investment. They identified factors influencing long-term conservation investment by farmers as net farm income, total farm land rented, total crop acres operated by farmer, total current assets, total value of non-farm assets, age of operator and cropping efficiency. The results of their empirical study indicate that older farmers have a lower level of investment in soil conservation. They observed that farmers who belong to farm organisations and receive government assistance are more likely to make long-term soil conservation investments. The analysis indicated that in making long-term conservation decisions farmers compare the net present value of the expected benefits with the net present value of expected costs.

Labour costs have also been found to be an important determinant of conservation adoption. Eplin and Tice (1986) in their study of farm size and adoption, showed that differences in rates of adoption of conservation tillage among farmers occur because of differences in start-up costs rather than differences in post-adoption costs.

The influence of risk on farmer's attitude towards adoption of soil conservation technologies is another economic factor that has received empirical attention. De Janvry (1979), Hiebert (1974) and Lipton (1976) found that risk related to lower income levels creates a barrier to innovation. McSweeney et al. (1986) indicated that risk-averse farmers are less willing to invest in soil conservation practices. Carcamo et al. (1994) showed that the adoption of soil erosion control practices by farmers on the steep hillsides of Honduras is negatively influenced by risk aversion, while the costs of constructing soil conservation devices have no significant influence on adoption of these devices. Other studies found opposed results. Norma (1977) and Setia (1985) found that soil conservation practices were adopted regardless of farmer attitudes to risk. Lopez-Pereira et al. (1994) concluded from their on-farm study in Honduras that risk aversion, availability of crop land and initial cash have no substantial effect on the predicted adoption level of improved soil conservation measures. A possible explanation for these conflicting results on the role of risk aversion in adoption of soil sustainable practices is the difference in the methods used to measure risk. For example, Binswanger (1980) measured risk aversion through gambling experiments whereas Ervin et al. (1982) used an index of farmer's attitudes to risky situations.

Personal approach

Other studies were conducted on the assumption that not only economic but also personal factors were important in the adoption decision taking process. Personal factors include farmer's characteristics such as education level and age. Brown et al. (1978), for instance, found that levels of adoption of recommended conservation practices (e.g. no till farming, the use of round bales) in Ohio, USA, were higher among young farmers with a higher level of education, in full-time farming, with a higher level of debt and higher economic status (higher income and acreage). Earle et al. (1979) observed that increased farm income, education, farm size and perception of the soil erosion problem in Australian farmers influenced positively the use of soil conservation practices. Hoover and Wiitala's (1980) results indicated that younger and more educated farmers were more likely to perceive erosion as a problem and therefore perceive benefits from using conservation practices. This finding might suggest that younger farmers have lower discount rates or longer planning periods, ceteris paribus, than older operators.

Carlson et al. (1977) showed that increasing levels of education, farm size, and gross income were associated with higher numbers of sustainable farm practices in Idaho, USA. Also, Rahm and Huffman (1984) showed that farmer's education level influences efficiency of soil conservation adoption decisions. Shortle and Miranowski (1986) found that education among other personal characteristics and economic variables influences the likelihood of adoption of conservation tillage practices in Iowa, U.S.A. Norris and Batie (1987) also found that age and intergenerational expectations were among the significant factors with negative and positive influences on the use of conservation tillage.

Institutional approach

The institutional approach focuses on forces, at a societal level, which determine the farm micro-level decision process such as institutional arrangements (e.g., land tenure), fiscal and monetary policy components such as prices and interest rates, and agricultural programmes. Studies show that macro-level policies defining access to extension services, credit and information (knowledge) are a major determinant of the rate of adoption among the users. For example, Olayde and Falusi (1977) identified access to credit as an important factor explaining the adoption of soil conservation practices in Nigeria. Veloz (1985) holds that inability to borrow funds hampers farmers' decision to adopt soil conservation technologies. Chamala et al. (1989) found that information exposure is related to greater levels of adoption among Australian farmers. Farmers who had a greater interest in and exposure to soil conservation methods through conservation programmes and extension services often adopted conservation methods. Also in Australia, Coughenour and Chamala (1989) concluded that farmer adoption behaviour is affected by farm conservation policies backed by civil penalties in Queensland compared to voluntary policy implemented in Kentucky (Australia). Norris and Batie (1987) found that land tenure and the existence of a conservation plan positively influence conservation expenditures.

Few studies have identified marketing factors as important institutional determinants of soil conservation adoption. Ervin and Ervin (1982) found that farms emphasising more on rapid payoff cash crops used fewer conservation practices because of their focus on short-run profits. The authors concluded that the findings suggested that these farmers might have high discount rates, short planning periods and a lower degree of farm orientation. Bonnard (1995) carried out a research to evaluate the link between land tenure, land title and the adoption of improved soil management practices using Honduras as a case study. The analysis was based on both informal interviews and formal primary data collection. Conversely to Ervin and Ervin. (1982), Bonnard's results showed that production of cash crops was positively associated with adoption of improved practices. Other factors with positive association included perceived ownership, land tenure, availability of labour, the presence of extension agents or land management development projects, and the slope of the land. Farm size, soil quality, planting of coffee and off-farm employment were inversely related to adoption. Debertin and Sjarkowi (1989; in: Bonnard, 1995) reported that producer prices were positively related with conservation use.

Mbaga (1998) found that households more market oriented were more likely to adopt improved soil conservation measures than households who were consumption oriented. Farmers cultivating coffee or tea, crops often produced in VMS arrangements had higher and significant probability to adopt soil conservation measures than farmers who were consumption oriented. The findings suggest that market orientation and higher incomes provided the financial ability to invest in soil conservation. Although other previous studies did not focus on marketing factors, several works have found marketing related issues as influencing adoption factors. De Janvry (1979), Hiebert (1974) and Lipton (1976), for example, found that lack of information, imperfections in credit markets and lower incomes create a barrier to innovation of conservation technologies in farmers.

Physical approach

The physical approach emphasises the applicability of soil conservation practices on local-specific characteristics. Studies falling in the physical approach focus their model frameworks on the land's potential for soil erosion. For example, Saliba and Bromley (1986), using a Logit model on a farm survey, found that proximity to urban markets and erosion potentiality (described by soil type and topography) were significantly and positively related to the use of soil erosion control practices. Rahm and Huffman (1984) found that soil type and crop rotation are significant determinants of reduced tillage adoption. Caswell and Zilberman (1985) found that farm location also determines the adoption of irrigation technologies.

Integrated approach

As mentioned earlier, research work on adoption of soil conservation evolved from rationality, diffusionist, personal, institutional and physical approaches to the integrated approach. The integrated approach is a more comprehensive framework that incorporates a great deal of the previous five approaches. Examples include several studies carried out in the 1980's. Ervin and Ervin (1982) used a three-stage innovation-adoption model (see diffusionist approach above), which included physical, personal, economic and institutional factors to identify factors affecting the use of soil conservation practices in Missouri, USA. Ervin's model used a sample of 98 farmers and multiple regression analysis as the estimation method. The results showed that personal factors such as perceived profitability of conservation practices and risk aversion are the most important in explaining the number of practices used. They also observed that government funded technical assistance programmes have no significant effect on conservation efforts. Younger farmers were also found to be more receptive of conservation technologies. Bultena and Hoiberg (1983) examined socio-economic and physical factors affecting farmers' adoption of conservation tillage, in Iowa, USA. Examined variables included risk orientation, age, education, farm size, tenure, farm income, perceived erosion, perceived attitude of others, perceived adoption by others, and erosion potential based on rainfall and soil erodibility, and steepness of the slope. The results indicate that land tenure (as opposed to other authors such as Norris and Batie, 1987) did not relate to adoption, while personal attributes of farm household's characteristics and erosion potential of the farm determined adoption.

Jamnick and Klindt (1985) considered social, economic and physical factors in studying no-till practice decision among the no-till users using a Logit model. They found that the probability of adopting no-till soil conservation practice increases with age of farmer, farm size, farmers whose primary occupation is not farming, proportion of land experiencing soil erosion and use of other conservation practices. Nowak (1987) examined adoption of agricultural conservation technologies considering diffusion, economic and physical explanation factors. The results indicated that economic and diffusion aspects such as awareness, information and knowledge are important in predicting adoption of conservation practices. Hansen et al. (1987) tested sociological and economic factors to explain adoption of soil conservation. They used regression analysis on an index of adoption of soil conservation practices on the basis of a sample of 281 farmers in the Dominican Republic. They found that economic factors were poor predictors of adoption of soil erosion control, while institutional factors (access to extension and credit services) and personal factors (orientation to change and propensity to adopt) were significant predictors of adoption.

Lynne et al. (1988) examined attitudinal, social and economic motivations to assess farmer behaviour towards conservation decisions using a Tobit model. They found that all factors were important determinants of conservation behaviour. D'Souza et al. (1993) used the Logit estimation to examine the effect of personal, economic and physical factors on the number of practices adopted by farmers in Virginia, USA. Using information from a sample of 600 farmers, they found that high education level, debt concerns and potential contamination of ground water exerted positive effects on adoption; whereas age, off-farm income, hired labour and state programmes exerted negative effects. Mbaga (1998) examined the effects of personal, socio-economic, institutional and physical factors on the farmer's decision of whether or not to use soil conservation measures. The study encompassed 300 Tanzanian hillside farmers and the results indicated that commercial orientation, farm size, participation in resource conservation programmes and soil erosion concerns increase the likelihood of adopting soil control measures. Furthermore, households with off-farm income were less likely to use these measures. Mbaga (1998) used the integrated approach to explain the adoption of improved soil practices. She found that participation in soil conservation programs and labour-sharing groups, farmer's priority to soil problems, plot size and cash-crop cultivation increased the likelihood of adopting improved soil practices, while off-farm employment affected negatively the adoption decision.

Discussion

First it can be concluded from these studies that not only economic but also personal (including social), physical and institutional factors play a role in affecting the adoption of farm resource conservation practices. Most studies focus on the actual adoption decision for soil conservation practices, although some have employed the innovation-diffusion process (perception, adoption and effort stages) to capture the dynamic nature of an adoption process (Ervin and Ervin, 1982; Gould et al.; 1989; Mbaga, 1998). Regardless of the approach used, a common denominator of most of studies up to the 1980's is that they approach the problem of sustainability adoption from single viewpoints. The limited consideration of one or a few factors to the exclusion of other affects the explanation power of the empirical models (Maddala, 1995). It is therefore concluded that an integrated conceptual model of sustainable practice adoption, that consider all possible factors that may determine adoption of farm sustainable practices, is preferred.

A common characteristic of these studies is that most of them define the adoption of sustainability as a dichotomous variable, based on whether or not the household adopted soil conservation practices. The reason for this definition is the difficulty that entails an accurate measurement of this variable. Nevertheless, the categorisation of a farmer's behaviour as an adopter or non-adopter may be made at the expense of the original variability of the adoption process. This variability relates to the degree in which the adoption is actually made by farmers, which involve different levels of intensity or degree of adoption. This means that in-between movements towards sustainable farming are largely ignored. The loss of original variability misses large a part of the insight of the adoption process and hinders the detection of the nature of the cause-effect relationships, which results in poorer explanatory capacity of the model and unclear patterns of association between sustainability and the independent variables. Thus, a second conclusion is that the sustainability variable should preferably be measured by a variable that expresses the adoption of soil sustainable practices as a continuous process.

3.6 Sustainability and agriculture: research on optimising farmers' decisions

Studies of the diverse factors affecting adoption of sustainability in agriculture have also been addressed by means of mathematical programming models. These models are used, for example, to explore the consequences of potential interventions on sustainability and on the allocation of farm resources (land, labour and capital) based on pre-defined assumptions.

Mathematical programming models are normative models that can be used to determine an optimal combination of farm plans that is feasible with respect to a set of fixed farm constraints (Hazell and Norton, 1986). Linear programming (LP) is the mathematical programming model most used to address farm sustainability (e.g., land degradation). In most empirical applications, these models are used to assess the optimum combination of land use management and conservation techniques. LP provides greater flexibility in the sense that more than one land degradation problem (e.g., soil erosion and nutrient depletion) can be analysed at a time using several conservation techniques and land uses, organised as sets of activities and constraints. The method can be used to analyse decision problems at a certain point in time and those involving a sequence of interrelated decisions over several periods (multi-period LP).

When, apart from a singular objective, other objectives are also sought, the LP model can be specified to incorporate multiple objectives. The most practical LP approach to such analysis is multiple-goal linear programming (MGLP). MGLP are appropriate for situations in which the decision-maker desires to consider multiple criteria in arriving at the overall best decision. This method has been attracting intense interest over the past several years for its demonstrated ability to serve as an efficient and effective tool for the modelling of situations that involve multiple and often conflicting objectives, the type of models that most naturally represent 'real-world' problems (Ignizio, 1991).

A MGLP model can be seen as a LP model but with more than one objective. All objectives in MGLP are transformed gradually into goals (i.e., adding a right-hand side value or target) through an interactive procedure[35]. A typical application of MGLP in household modelling is to board the problem of farm allocation and farm income concerning to the impact on the natural resource. It may involve the definition of profit maximisation, farm sustainability and risk avoidance, among others, as model objectives. Examples of these models include FLORA (farm household level optimal resource allocation) by van Rheenen (1995); the DLV Peasant Model developed by Ruben et al. (1994); the REAL (Regional Economic Agriculture Land-use) model developed by Schipper et al. (1996); and the multi-period economic land use model with an application to Costa Rica implemented by Kuiper (1997). Other examples for solving optimal farm resource allocation on sustainable basis include Schipper, 1995; Ruben et. al, 1994; Alfaro et al. 1994; Fresco et al., 1992; Fresco et al., 1994; Jansen, 1995; de Wit et al., 1988; Heerink et al., 1994. Technical considerations can be found in FAO, 1991a; Singh, 1986; Ellis, 1993; Romero and Rehman, 1989; Ignizio, 1991; and Hazell and Norton, 1986.

The DLV Peasant Model developed by Ruben et al. (1994) was developed for response analysis of farm households in terms of adjustments of land use and technology choice, to specific changes in the socioeconomic environment. The model, applied to the Atlantic zone of Costa Rica, aims at calculating the effect of simulated price changes for agricultural output, fertiliser and biocides, transaction costs, wage rates and industrial goods. The results indicate that the area cultivated with beans and cassava is affected more strongly by output price changes than the area under maize and plantains. Sustainability indicators are hardly affected by output prices due to the substitution of actual by alternative technologies with similar or higher biocide and fertiliser requirements. However, reductions in fertiliser prices affect positively income, utility in consumption and fertilisation efficiency. They conclude that changes in fertiliser prices seem to be an appropriate instrument to induced desired land use modifications.

Van Rheenen (1995) developed a MGLP model with an application to East Java, Indonesia. The farm household level optimal resource allocation (FLORA) model specifies several objectives: agro-technical (food production), socio-economic (minimisation of work capital and labour and maximisation of gross margins) and environmental objectives (nitrogen and soil loss and biocide accumulation). The model focuses on a 30-year term and its results showed that increasing input prices by 50 percent reduced growth margin by only four percent. These results indicated that reducing subsidies on agricultural inputs will have minor effect on farm gross margins showing the potential of policy strategies to boost sustainable input use. Three scenarios were evaluated: food production, household socioeconomic and environmental scenario. The soil loss constraint prevented higher level of gross margins but after certain soil loss level in each scenario, it appeared to have no effects on farm gross margins.

Veeneklaas, (1990) designed a multiple goal linear programming model for a reconnaissance study of agricultural potentials in the Fifth Region of Bali. In the model sub-regions are considered as one big farm. The objective variables are total food production, total marketable crop production, total monetary revenue, total employment, total number of animals, total monetary inputs and total grain deficit in a dry year. Moreover, soil nutrient depletion is monitored for all activities. Two scenarios are compared: the R-scenario, indicated a high revenue but risky development, and the S-scenario indicated a self-sufficiency, safety-first development.

[35] Adding to each goal a rank ordered according to importance is also a possibility.

Schipper (1996) developed REAL, a sub-regional model constructed for Costa Rican Neguev settlement. This one-period model aimed at deriving relevant options for land use balancing economic and ecological criteria. REAL, which stands for Regional Economic Agriculture Land-use model, was part of USTED (from the Spanish translation of the sustainable land use in the development; Schipper, 1995) and LEFSA frameworks developed by Fresco, Schipper and others (1992). The model considers several scenarios (base, biocide reduction, soil nutrient depletion, discount rate and output price scenario scenarios). One of the model conclusions is that stricter standards for biocide use and nutrient depletion do not necessarily lead to large income reductions.

Kevin (1994) used an LP model to examine the impact of farming activities on land degradation and to assess the trade-off between profitability and resource depletion by incorporating economic aspects influencing farmer's decision-making in Eastern Australia. Carcamo et al. (1994) used LP to examine factors affecting the cost to farmers of applying soil loss reduction strategies on the hillsides of Honduras. A representative farm model was constructed using field surveys. The model was solved by using the LP procedure, with an objective of maximising net returns subject to various levels of soil loss and risk.

The preceding review illustrates that MGLP allows objective comparisons of land use alternatives, in situations where multiple conflicting land use plans are involved. In most of the models, sustainability is specified either as a set of constraints or as an objective. Several scenarios and farm type distinctions allow tracing the trade-off of multiple model objectives.

Due to the multidisciplinary nature of the approach (involving different aspects of resources), diversified expertise (multidisciplinary team) is needed to carry out the multiple goal analysis. Consequently, these types of models are likely to be demanding of skilled manpower and data particularly. The models demand a great deal of technical coefficients and the valuation of costs and benefits involved tend to be difficult, which means that much of the analysis may have to be based on assumptions and sensitivity analysis. Optimising approaches by mathematical programming are indeed useful exploration tools, but they offer no panacea to improvement of farm system sustainability on an overall system basis. The reason for this is that any model of the farm system which mimics reality adequately would be too large and costly to be worthwhile. Though it is never possible to deal with sustainability or any other problem in all its 'real-world' complexity, experience suggests that it is often possible to quantify and model farm systems with an acceptable loss of realism (McCall and Kaplan, 1985; Harrington, 1992).

3.7 Defining and focusing sustainability in this study

In spite of the consensus that exists in society about the urgency to overcome environmental problems, there is a great deal of confusion about how to create a system of production and consumption that can guarantee a sustainable society (Meulenberg and Schifferstein, 1993). Among the reasons for this confusion are the facts that the concept of sustainability is hard to define and the controversy over whether it aims to sustain the natural environment or to sustain economic development (FAO, 1991a; Peattie, 1995).

The term *sustainability of a production system* is generally used to indicate the successful way in which resources can be used to meet changing future needs, remaining productive and without undermining the natural resource base. In the production process this means only consuming resources at a rate that allows them to be replaced and only generating pollution at a rate that the environment can assimilate (some compendiums of definitions are found in Lynam et al., 1989; Conway, 1985; Shearman, 1990; and Brown et al., 1990). In reality, the concept of sustainability is interpreted and used in different ways by planners, politicians and conservationists. Broadly, sustainability can include the following three elements (Meulenberg and Schifferstein, 1993; see also Kruseman et. al., 1993 for an analysis of several points of view on sustainability):

- The quality of the physical environment - soil, water, and air - is a core element in sustainability. This means that the concept of sustainable food production should be conceived in its broadest sense, i.e. food production should be related to all stages of food production, marketing and waste removal.
- The efficient use of the sources of energy and raw materials. Agricultural producers should be energy conscious and economical in their use of energy and raw materials. They can contribute to the efficient use of energy, for example, by optimising the use of energy and farm inputs (e.g. in irrigation, fertilisation, mechanisation, agro-processing or transport) and disposing appropriately of waste. Theoretically, it is possible to recycle waste to generate energy (e.g. biomass combustion) and fertilisers (e.g. compost).
- Social elements can be integrated into the concept of sustainability. Nowadays, many food consumers include an awareness of animal welfare, poverty in developing countries and the social life of workers in rural areas in their understanding of the concept of sustainability.

The controversy over sustainability also revolves around whether it aims to sustain the environment or to sustain economic progress (FAO, 1991a and Peattie, 1995). In the first, the quality of natural resources is maintained and the vitality of the entire agro-ecosystem -ranging from human beings, crops and animals to soil organisms- is enhanced. In the second, farmers produce to meet his needs of food, income generation and gain sufficient returns to warrant the labour and other costs involved without compromising the ability the ability of future generations to meet their own needs. In this context, economic viability is measured not only in terms of yields but also in terms of conserving resources, minimising risks, and creating marketing prospects. Although conflicting in practice, ultimately, the two aims are so intertwined that to attempt to separate them become meaningless. Without economic progress the poverty will ensure that much of the environment continued to be exploited unsustainably for mere survival. Without environmental protection, economic progress will be increasingly hampered by the costs associated with environmental problems and health effects[36].

The diversity in the existing definitions of agricultural sustainability can result in confusion and different interpretations. Thus, for the convenience of sustainability appraisal, it is not always necessary to insist on the sustainability of all system components (Graham-Tomassi, 1991; Harrington, 1992), what is a major issue is deciding exactly *what* it is that must be sustained. The farm system is, as per this study context, the central point of concern. Air, soil, water and energy resources compose the farm system. Section 3.2 identified soil degradation as the most critical environmental problem in hillside tropics. Section 3.3 demonstrated that soil degradation has direct economic consequences on crop yields, input needs and long-term productivity, which concern resource users. Therefore, the study of sustainability is centred on on-site soil effects of farm management activities.

The focus of the environmental problem to on-site soil effects of farm management activities in this study paves the way for the definition of sustainability. To this end, the definition adopted by the Consultative Group on International Agricultural Research (CGIAR) is rather convenient. Sustainability of an agricultural production system is defined as *'successfully management of resources for agriculture to satisfy changing human needs while maintaining or enhancing the*

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[36] The concept of sustainable development provides a common ground on which these issues can meet to attempt to achieve mutually acceptable progress (see FAO, 1991; Peattie, 1995; Reijntjes *et al.*, 1992). Nonetheless, increasingly studies are being published that abandoned the idea that sustainability requires it to be stated of equilibrium between production, on the one hand and natural resources and nature, on the other, with exportation of uncompensated anthropogenic environmental risks to future generations deemed unacceptable (Hueting and Reijnders, 1998; Seragelding and Steer, 1994; Goodland, 1995).

quality of the environment and conserving natural resources' (CIMMYT, 1989). In contrast to other definitions, the convenience of this definition lies on the specificity to farm production systems and the taking into account of the need for food production and the increases in demand for food arising from continuous population and income growth. In other words, it stresses the care for agricultural natural resources while recognising the need for continued use[37]. This definition provides the basis for the measurement of soil sustainability and its appraisal in subsequent chapters.

[37] Concurrently, from this perspective, in a particular land use system, a sustainable farm production system is seen as one involving the continued or increased use of a combination of appropriate practices or technologies (or the discontinuation or the reduced use of production practices that (may) cause environmental damage) (Repetto, 1989; FAO, 1991; Ruthenberg, 1980; Lutz and Young, 1993; D'Souza et al., 1993).

4 FARM SUSTAINABILITY AND MARKETING, IN PARTICULAR THE INFLUENCE OF MARKETING CHANNELS

The farm and other stakeholders of the food marketing channel exist to meet the needs of consumers through the marketing channel. Consumer demand is an important factor affecting the marketing channel and the sustainable management of the farm system. In general, demand aspects are influencing, via the price and other mechanisms and stimuli, the behaviour of traders, processors and farmers in their profit-seeking endeavours. This may lead to the use of agricultural production practices, which work against sustainable development both directly within the farm and indirectly through the generation of adverse externalities. Farm sustainability effects, in particular, may vary to a great deal depending on the structure that the marketing channel adopts in order to transmit stimuli from consumers and marketers to producers.

As noted earlier, in developed countries most environmental concerns revolve around curbing down pollution levels. Wealth and unsustainable consumption behaviour lead to excessive waste. The interaction between marketing channels and consumption here would be that consumer requirements for quality encourage farmers to use more rational and constrained levels of inputs. In developing countries most environmental concerns pertain degradation: poverty leads people to over-exploit their resources (Barkin, 1994; Earth Summit, 1992). The interaction between the marketing channel and production in poor countries would be that a marketing channel with a more stable long-term price perspective leads to investment and care for the resource base. A more stable marketing channel controlling price volatility and stimulating a longer-term perspective may move people out of the vicious poverty-degradation cycle.

This chapter aims at discussing the effect of marketing channels, in particular their structure, on farm soil sustainability in developing countries. To put the discussion into context, the first section draws attention to the studies dealing with the interactions of marketing and agricultural sustainability. The second section reviews the impact of agro-food activities by the actors in the marketing channel on the physical environment. It is noted that this impact is particularly pervasive at farm level as farm activities fully rely on the use of soil, water, air and energy resources. The third section of the chapter enumerates some of the marketing strategies that marketers have developed to mitigate the environmental hazards of marketing activities.

Section fourth identifies essential elements that make the contribution of marketing mechanisms highly relevant to farm sustainability. First, coordination of functions in the marketing channel has a great potential to correct many market distortions and to enable rational farm decisions. Second, market strategies being economically appealing to farmers can be used to promote sustainable production systems. This discussion is conducive to the arguments that support the role of VMS in farm sustainability. It is argued that farmers participating in VMS have a longer term view and likely appreciate the long-term benefit of these systems in terms of guarantee purchase, economic stability and expertise. Concurrently, these long-horizon viewers place a higher value to the long-term benefits of better resource management and soil conservation. The section suggests that VMS is better structured to provide farmers with the appropriate stimuli that are conducive to a more rational resource allocation and associated farm sustainability.

The last section of this chapter draws attention to the agricultural sector and describes the strategies of this sector to tackle adoption of environmental issues. As an illustration, a number of successful and unsuccessful cases of adoption of sustainable agricultural practices are reviewed. The cases reviewed reveal that effective adoption of sustainable practices by farms in developing countries was attained when marketing strategies of actors in the marketing channel accompanied the promotion of these practices. The review reinforces the argument that while regulation is recommended to control externalities (that usually do not affect farm households directly), its applicability at farm level in developing countries is limited if it is not accompanied by market strategies that bring economic benefits to small-scale farmers.

4.1 Research and viewpoints on marketing and sustainable agriculture

The attention of the literature to the interactions of marketing and agricultural sustainability has been growing in the last decade. Research citations on that subject embrace the impact of poverty and uneven market access on agricultural sustainability; the lack of a proactive role of marketing in targeting sustainable agriculture; the need of market-based agricultural policies for environmental issues; and the enhancement of marketing channels (in terms of infrastructure, organisation and coordination of functions) to target environmentally sound agricultural production systems.

The most common aspect mentioned refers to poverty as a result of unequal access to markets, infrastructures and income opportunities and its repercussions in agricultural sustainability. Many authors conclude that unsustainable farming patterns are influenced by unbalanced access of small-holders to market and marketing services, which in turn exacerbates poverty (see for instance Barkin, 1994; Kikula, 1997; Dasgupta and Maler, 1997; Wilson, 1997). Authors stress the relationship between poverty and the state of the environment. According to them, the poor in many rural areas of the developing world are constrained in the access to capital market, credit and insurance. In such settings, farmers have less incentive to husband their lands and to make investments that would enhance their productivity. In some regions, for instance, livestock assumes an important role as assets and forest clearing as a common practice to follow. In drought-prone areas of sub-Saharan Africa and Latin America, the absence of access to capital and insurance markets leads to herds being larger than the optimum carrying capacity, which, in turn, creates additional stress on grazing land, particularly during periods of drought.

The Mountain Institute (1997) claims that the sustainable development of rural areas, in particular mountains and watersheds, is constrained by market related issues. According to the Mountain Institute, often, marginalised mountain communities are not provided by the state with the same, or even adequate, social infrastructure enjoyed by flatland communities. Basic infrastructure projects, such as electrification, local driven extension and environmentally sensitive road construction, all serve to secure mountain communities and facilitate communication and goods exchange. With such services, outmigration and marginalisation are prevented while alternative livelihood opportunities can be promoted, through cooperative and other similar farmer organisation schemes, small-scale agro-industries, etc. These considerations were also proclaimed in the Earth Summit Conference at Rio and documented in Chapter Thirteen of Agenda 21 (UNCED, 1992).

Holden et al. (1998) analysed the factors correlated with the personal rates of time preference (RTPs) of farmers in Indonesia, Zambia and Ethiopia. They found that market imperfections, particularly in credit and insurance markets, lead to variation in RTPs. Poverty in assets or cash liquidity constraints (e.g., lack of credit) led to higher RTPs. The findings supported the hypothesis that poorer farmers are associated with higher RTPs and fewer dispositions to invest in environmental conservation.

Other authors suggest a more proactive role of marketing in targeting sustainable agriculture. In April 1991, FAO held a conference on agriculture and environment in The Netherlands. One of the background documents deals with the management of farming, processing and marketing systems and their contribution to sustainable agricultural development. The document notes that little has been written of how best the marketing system might be managed in order to ensure its fullest contribution to sustainable development. It stresses the need of developing countries to learn from other experiences that show the benefits to the farm and marketing systems of political stability and a free-market orientation combined with regulatory and other policy mechanisms aimed at ensuring sustainability. The document identifies some areas of action where agricultural marketing can lead to sustainability:

- appropriate and improved technologies in processing, storage and prevention of food losses
- legislation and incentives to encourage or enforce use of agro-industrial by-products for energy generation or as animal feed
- appropriate public health and environmental regulations with regard to hygiene, the use of dangerous chemicals and the disposal of waste
- improvement of the physical infrastructure (i.e., rail and road systems, storage facilities, market information systems, spare parts for vehicles)
- incentive prices for farmers, especially for food crops
- improved credit infrastructure
- more recognition of the role of women in processing and marketing

The document ends concluding that sustainability must be based on market development. It highlights the role of rural banks and other marketing institutions in this development. According to the authors, these institutions are uniquely positioned to provide the incentives to farmers to assist in sustaining the environment. Finally, it stresses that associated with a market-based development strategy, government intervention via incentive, tax and regulatory policies may be desirable so as to facilitate sustainable management.

Chapter Eight of Agenda 21 (UNCED, 1992), which discusses the integration of environment and development in state decision-making, criticises the separation of economic, social and environmental issues as an important obstacle for sustainable development policies. It recommends that market incentives and economic instruments should be applied within a legal and regulatory framework provided that market-oriented approaches play a complementary role and a more effective and widespread use of them is proposed. The document adds that farm product prices should appropriately reflect the relative scarcity and total value of resources and help prevent environmental degradation. To this end, the document recommends governmental activities to reorient towards an effective combination of economic, regulatory and voluntary measures, reduction of subsidies, appropriate pricing policies, etc. to target sustainable development. According to some authors (Koch and Grubb, 1993), this chapter forms potentially one of the most powerful of all forty chapters in Agenda 21. It stresses the need for effective policy dialogue and better economic-environmental indicators, and for a balance between regulatory and market instruments for promoting environmental goals.

Other analysts discuss the role of agricultural and economic policies in case of market uncertainty and environmental degradation. Authors such as Piñeiro et al. (1979), Crouch and the de Janvry (1980) and Ashby (1985), in their studies of the causes of farm environmental degradation in less developed countries, argue that unbiased policies for farm commodity prices, agricultural input prices, farm wages, and input tariffs create a market structure unfavorable to small farm crops. These policies result in price volatility, low profit margins and high risks, especially in staple products. According to them, these conditions are translated in market and economic uncertainties, which have a major influence on conservation decisions, increasing reluctance of farmers to invest in conservation techniques.

Becker (1998), in his analysis of the potential of sustainable development in Costa Rica within the Latin American context, concludes that it is not sufficient to provide the broad framework of sustainable development such as resource protection and social services at the macro level if progress toward sustainable development locally is not accompanied by several improvements such as those in credit suited for small operators and long-term investment. Frank Ellis (1998), in reviewing diversification as a way-of-living strategy of rural households in developing countries and as a contributor to sustainable agriculture, concludes that policies that reduce constraints to diversification and widen its possibilities involve those directed to targeting risk reduction, micro-credit, rural services, rural non-farm enterprise, rural towns, infrastructure and education.

Other authors are specific in the manner that marketing could contribute to sustainable agriculture. Recommendations include strengthening of transport and communication systems, organisation of farmers in cooperatives and coordination in marketing channels. For instance, Omano (1998) argues that rural farm households in developing countries being dispersed over wide areas, which have poor infrastructure, have significant trading costs in the food marketing channel. His analytical results obtained from an empirical model indicate that transaction costs in Kenya matter and are sufficient to explain the cropping choices of the farmers. Farm resource allocation and use involve cropping-mix decisions, which ultimately result in varying levels of farm sustainability. Omano concludes that rural households can capture potentially large economies by 'vertically integrating' their food production and consumption sectors for staple products both sold and consumed. To this end, he stresses the need for, firstly, policy interventions that reduce structural impediments to exchange (e.g., improved transport and communication infrastructure in rural areas aimed at lowering transaction costs) and can promote specialisation that raises farm incomes and, over time, leads to more equal distribution of wealth. Secondly, as the existence of transaction costs is the basis for the organisation of all economic activity, a choice of the best institutional arrangement is fundamental. The combination of activities that minimises the sum of production and transaction costs, Omano concludes, has important sustainability implications for observed patterns of production in small-scale agriculture.

Barbier (1990), in a study carried out in the uplands of Java, Indonesia, found that farmers facing significant costs in adopting soil conservation measures and changes in farming systems are unlikely to make changes in their land management unless they can see an economic advantage in doing so. He concluded that although the predominantly poor farmers with small land holdings are very much aware of the productivity loss from soil erosion, many cannot afford the initial investment needed nor take on the extra risk to improve their existing cassava and cassava-maize farming systems. He finalises adding that, in terms of farm sustainability, extending input subsidies to the uplands maybe less appropriate than more direct investments to build up the physical infrastructure of the uplands, such as rural transport, integration of markets, credit facilities, and post-harvesting technology and harvesting.

Laing and Ashby (1992), in their review of successful and unsuccessful cases of adoption of soil conservation practices by small farmers, conclude that marketing factors are one of the underlying reasons for adoption or non-adoption. According to them, market and other policy-related factors can significantly assist or impede the success of such an investment strategy. Successful cases involved price incentives and the existence of markets for farm crops. Laing and Ashby noted that, in general, studies of conservation practices pay too little attention to the impact of markets and farm-gate prices on success or failure of sustainability adoption. They stressed the importance that conservation technology needs to be developed as part of an overall rural investment strategy which takes into account not only the trade-off between production and conservation but seeks to provide market incentives to the farmer.

In a study in a hillside area on Southern Colombia, Hansen (1996) showed that price variability and credit availability, among other factors, have the greatest effect on farm sustainability. A regression analysis showed that lack of credit and, particularly, price volatility contributed much more than weather variability to farm risks and farm sustainability. These findings, he concluded, suggest an opportunity for VMS arrangements such as marketing cooperatives to improve farm-gate prices. Giraud (1997), in his analysis of marketing sustainably-produced food products in Europe, argues that this marketing corresponds to marketing food of high quality and that marketing this kind of high quality food products is a guarantee for a more enhanced sustainable farming. In this manner, this author assigns a noteworthy role to marketing in farm sustainability.

Winter-Nelson and Amegbeto (1998), in their study of the option values to conservation in agricultural policy, state that not only price changes but also price variability have an impact on resource conservation. According to the authors, while changes in policy that increase output prices tend to encourage agricultural investment, simultaneous increases in price variability could reduce incentives to invest in conservation. First, risk-averse individuals might prefer not to adopt a technology exposing them to increased income risk, even if it offers higher average returns. Second, if potential investors are credit-constrained due to imperfect capital markets or resource poverty, they may shy away from non-divisible investments (e.g., conservation investments cannot be easily liquidated in case of an emergency), regardless of their risk preferences. Finally, profit-maximising farmers may opt to delay an investment in resource conservation until gaining more information about future price levels. The authors used an econometric model to study the effect of prices on the decision of eastern Kenyan farmers to invest in terrace construction. They concluded that market deregulation must be combined with marketing institutions that moderate sharp price movements suggesting coordination in marketing channel functions to reduce price volatility. They warned that if such institutions to contain price volatility do not emerge with market deregulation, liberalisation could produce undesired environmental and welfare consequences.

A recent interesting initiative in Latin America has been an ISNAR-coordinated project attempted to identify responses to the new technological demands for agricultural research in the region (ISNAR, 1998). The initiative's report, which involved several national agricultural research institutes (INIAS), makes clear emphasis on promoting agro-industry as a means to achieve sustainable agriculture. According to the authors, in certain conditions, it is possible to reconcile efforts to increase the profitability and competitiveness of the agro-industrial sector while improving the management of natural resources. This assumption is based on the fact that production processes can be made more efficient and effective through a more rational use of inputs and natural resources. Three special cases are distinguished. First, by rationalising the use of inputs in the production phase (lower application and use of integrated crop management), more careful application of fertilisers can increase yields while reducing the leaching of nutrients. Second, use of better equipment in the transformation process from the primary to the end product in the post-harvest phase (i.e. more efficient processing lowers production costs and decreases waste -often a major environmental burden). The conversion of cane into sugar, cassava into starch, cotton into fiber, and soybeans into oil are examples of agro-industrial processes that leave room for improvement. Third, the growing market requirements in terms of absence of residues of pesticides -particularly in fruit and vegetables-, suggest the use of programs such as integrated pest management which minimises the need for pesticides, and reduces production costs as well. The report pointed out that the recognition of INIAS that improved use of natural resources and competitive production may well be compatible and can lead to the in-depth modernisation of agricultural production, transformation and marketing.

In one of the studies of this ISNAR initiative, researchers have identified several case studies where marketing strategies not only save costs but also increase the levels of sustainability on-site as well as off-site. One of these studies refers to livestock production in Northwest plains of Colombia. One of the main environmental setbacks in this region is soil compaction and erosion as a result of overgrazing beyond the land's carrying capacity (Velesquez et al., 1999). Studies have shown that overgrazing patterns result in lower fodder quality at the short run which lowers biomass production and milk composition and increases production costs. This is particularly conspicuous in the dry season when soil compaction diminishes to nil the water absorption capacity of the soil. The central conclusion of this study is that grazing should be adjusted to optimal carrying levels as there is a synergistic relationship between mitigation of unsustainability factors and increase of economic competitiveness.

Empirical research of the possible interactions of marketing and agricultural sustainability has received little attention in the literature. Instead, empirical work has addressed sustainability from the non-marketing viewpoints (Nowak, 1993). As it has been discussed, approaches are based either on diffusion theory, economic rationality, personal aspects, physical characteristics, institutional factors, or a combination of these approaches (see Chapter II, Section 3.5).

Besides the works of Hansen (1996), Holden et al. (1998) and Winter et al. (1998) that identified price volatility and credit constraints as causes of farm unsustainability, a few other studies have identified marketing factors as important determinants of sustainable agriculture. Ervin and Ervin (1982) found that while education level, perception of the degree of the erosion problem, farming experience, risk aversion, farm income, and governmental support programmes promoted use of soil conservation practices, farms emphasizing more on quick payoff cash crops used fewer conservation practices because of their focus on short-run profits. This finding suggested that the latter farmers might have high discount rates, short planning periods and a lower degree of farming orientation. Bonnard (1995) found that production of cash products was positively associated with adoption of improved farm practices. Debertin and Sjarkowi (in: Bonnard, 1995) reported that producer prices were positively related with conservation use. Mbaga (1998) found that farmers cultivating coffee or tea, crops often produced under VMS arrangements, have significantly higher probability to adopt soil conservation measures than farmers who were less market oriented. These findings suggest that market orientation and higher incomes from agriculture activities provided the financial ability to invest in conservation of the farm soil. Other works have found that imperfections in the marketing channel refrain farmers from the adoption process. De Janvry (1979), Hiebert (1974) and Lipton (1976), for example, found that lack of knowledge and imperfections in credit markets creates a barrier to innovation of conservation technologies in farmers.

In summary, the literature reveals the need for rural strategies designed to provide better market infrastructure to rural areas in terms of communication, financing, law and regulations when targeting sustainable agriculture. Many authors agree with the fact that unsustainable farming patterns are cyclically linked to poverty due to the unbalanced access of small-holders to market and marketing services. These conditions force farmers to resort to quick payoff cash crops and other short-run activities to ensure their livelihood. The literature recognises that small-scale farmers with scarce resources face significant costs adopting soil conservation measures and that changes in land management is unlikely unless they can see an economic advantage in doing so. It stresses the importance of combining policy mechanisms with market-based initiatives that seek to provide market incentives to farmers to cultivate their land and to make investments that would enhance land productivity in time.

Other studies urge for market strategies addressed to control price volatility by promoting a more coordinated structure of the marketing channel. These strategies seek for price stability, improvement of farm-gate prices and greater economic incentives to invest in sustained land productivity. Thus, market-based policy strategies towards sustainable agriculture are in need, especially when considering the environmental burden that agro-food activities can have on the natural environment as it is discussed in the following.

4.2 Impact of actors in the marketing channel on environmental issues

The impact of agricultural marketing on the environment is substantial and inevitable as its activities are essentially associated with the use of natural resources (Kotler, 1997; Peattie, 1995; Henion, 1976). Marketing can contribute to environmental degradation because in aiming at satisfying consumers' wants and needs, it does not consider sustainability as a marketing goal in its own right. In fact, by stimulating consumption, marketing is often fostering a rapid use of natural resources having a negative impact on sustainability (Peattie, 1995). Table 4.1 shows the extent (denoted by H:high, M:moderate and L:low burden levels) of the most common and significant externalities arising from the agro-food activities that may be adverse to sustainability in the third world.

Table 4.1 Observed environmental burden caused by agro-food activities[38]

	Farmer		Wholesaler			Industry			
	Prod'n & processing	Commer-cialisation	Packing & ad	Storing	Trans-port	Processing	Packing & ad	Storing	Trans-port
Soil	H		L	L		M	M	L	
Water	H		M			H			M
Air	M	L			H	H	L		H
Energy	H			H	H	H	M	H	H
Human health	M	L	M	M	M	M	M	M	M
Flora & Fauna	M					H			

H: high, M: moderate, L=low
Source: Based on Pattie, 1995; Lutz and Young, 1993; FAO, 1991b; Repetto, 1989 and UNCED, 1992

At *farm level*, activities derived from production and processing activities exert more environmental pressure than marketing activities. Major effects are observed in basic resources such as land, soil and water. Land over-intensification depletes soil nutrients while other inappropriate farming practices increase susceptibility to erosion. Soil salinity problems are aggravated by misuse of irrigation water. Downstream water pollution is brought about by inefficient use of chemical fertilisers, herbicides and pesticides. Surface water and groundwater aquifers are polluted by nitrate runoff from over-fertilised fields, making them unfit for drinking, recreational and other uses (Lutz and Young, 1993). Production and processing activities also have considerable effects on energy use. Suboptimal use in irrigation, fertilisation, mechanisation, agro-processing, transport, cooking, heating, etc. results in waste of energy. Production and processing activities have moderate impact on the air, human health and flora and fauna. Slash-and-burn practices pollute the air and increase the level of carbon dioxide in the

[38] Although consumer activities are not included in agro-food activities, they certainly have an impact on the natural environment. The associated effects of consumers to the environment arise from consumption patterns. They include waste disposal and misuse of energy. Consumers do not properly handle non-biodegradable waste from food packaging, which has an impact on natural resources (especially, air and water). Energy is used, sometimes excessively, employed in food refrigeration and cooking, heating, transport and communications.

atmosphere[39]. Consumption of contaminated water and food, aerial dispersion of pesticide sprays and air pollution from residues burning pose risks to human and animal health (Repetto, 1989). Injudicious applications of pesticides target harmless weeds and other flora and exterminate beneficial micro/macro fauna. Deforestation and exploitation of marginal lands threaten fauna and flora genetic diversity.

Environmental risks originating from farm marketing activities are less conspicuous. They include chemicals sprayed on stored produce to keep pests away that put some risks on human health. Inefficient transportation of farm produce to the market place results in dioxin of carbon emissions from transport vehicles, which pollutes the air.

At *wholesaler* level, waste and inappropriate use of energy in storage and transportation are the main causal agents of environmental stress. In wholesalers' packaging and advertising, non-biodegradable packaging and improper residue and waste disposal from packing have a moderate impact on soil and water resources. Cold storage and transport has a high impact on energy use. Perishable farm products such as fruits, vegetables, poultry and dairy products and meat need refrigeration while waiting to be commercialised. Grains require protection from damp, mould and insect or animal pests. Applications of insecticides on stored food may have a moderate impact on humans. Inefficient transportation and distribution systems contribute moderately to uneconomic fuel consumption and to air pollution with smoke emissions from distributing vehicles.

Agro-processing, packaging and transport are the *industry*'s activities that generate considerable environmental pollution. Industrial processing poses high stress on the natural environment, notably on water, air, energy and natural life. Unfiltered emissions from factories are the main contributors to the 'greenhouse effect'. The agro-industry residues and effluents have the greatest potential negative effect on the environment (UNCED, 1992). They include the dairy, animal slaughter, sugar refining, fat and oil, sugar and fish-processing industries. Solid wastes are the second most important pollutant in agro-processing. Materials such as bran, hulls, stalks and chaff are produced in large quantities. The low bulk-density of these materials makes them expensive to store. Canning and bottling industries also produce solid wastes such as shells, peels, pits and skins. All these waste materials contaminate the soil but particularly the water in the form of untreated residual waters. Flora and fauna, especially aquatic life, are threatened by untreated residual water and toxins drained to water bodies. Both, air pollution from industrial emissions and water contamination from wastewaters have moderate impacts on people's well-being. With respect to energy use, industrial food processing often shows uneconomical patterns in the form of excessive consumption of electricity, fossil fuels and mineral coal.

In facilitating functions such as packaging and information, non-biodegradable waste from industrial packaging is a significant pollutant. Excessive use of synthetic packaging and wrapping material misuses energy unnecessarily and can overwhelm habitats with waste. Heavy advertisement of branded food for mass consumption might generate wastage that pollutes the physical environment. Transport and storage also have effects on the environment. Agricultural products such as eggs, dairy products, meat and other perishable products require refrigeration for storage as well as for transportation. Inefficient transportation and distribution systems (either by sea or by land) of mass food products result in emissions of dioxin of carbon which pollute air.

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[39] Farm activities contribute, although to a lesser extent, to the increase of green house gases in the atmosphere (Rosenzweig and Hillel, 1998). When lands are cleared of trees of other plant growth to develop agricultural field carbon dioxide in the air increases. The same result occurs from release of stored carbon in the organic matter of soil when the soil is ploughed in preparation for planting. Use of fossil fuels for energy also releases stored carbon, herds of cattle and other ruminant animals produce methane insignificant quantities as thus production of rice in rice paddies. Use of nitrogen fertilisers as well as burning of plant residues releases significant quantities of nitrous oxides to the atmosphere.

In summary, the environmental burden caused directly and indirectly by agricultural marketing activities in less developed countries varies across the farm and marketing channels and has an undeniable impact on sustainability. The impact of agricultural production on the sustainability of the environment is particularly pervasive at farm level as farm production and processing activities fully rely on the use of soil, water and air resources.

4.3 Improving agricultural sustainability by marketing policies

As noted earlier, marketing activities can contribute to environmental degradation because they play a role as a force leading to growth of unsustainable consumption and production. But, while marketing is part of the problem, it is also part of the solution towards sustainable development. This section discusses the responses of Marketing to social environmental concerns.

In the last decades, consumers' environmental concerns have stimulated the attention of marketing for environmentalism[40]. Consumers, in particular consumer and environmental groups, sent market signals to decision-makers (marketers, processors and producers) to diminish exploitative resource use within the food marketing channel. Enviromentalists wanted externalities to be included as environmental costs in producer and consumer decision making (Kotler, 1997; Henion, 1976). They favoured using taxes and regulations to impose the true social costs of anti-environmental behaviour, requiring business to invest in antipollution devices, taxing nonreturnable packing, and banning products that, either in production or consumption, have harmful impacts on the environment. These elements were viewed as necessary to lead business and consumers in the direction of environmentally sound agriculture. Under this perspective, the goal of a marketing channel would shift from quantity toward quality, including sustainable quality.

These market signals prompted market stakeholders to change their marketing activities and to diminish negative externalities affecting environmental sustainability outside and inside the system. Marketing has become more complicated since the emergence of environmentalism and has to face up to the threats and opportunities associated with the new demands. Companies have absorbed high costs when implementing changes in production systems but have tried to optimise input-use and distribution schemes to keep on competitive (Kotler, 1997; Henion, 1976). Table 4.2 gives some examples of business responses, in particular marketing responses to societal environmental concern.

[40] For a review of theories of Ecological Marketing see Fisk (1974) and Henion and Kinnear (1976); for Green Marketing see Peattie (1995) and Charter (1992); for Environmental Marketing see Coddington (1992); and for Sustainable Marketing see van Dam and Apeldorm (1996).

Table 4.2 Marketing responses to societal environmental concern

Shortage of scarce resources	The potential damage to the ozone layer of certain propellants used in aerosol cans forced the development of alternative products. Companies have had to invest in pollution-control equipment and costlier fuels. Companies in the forestry business are required to reforest timberlands for sustainable exploitation. Industries in countries like The Netherlands have used labels of sustainable production as marketing strategy in wood articles. Similar situation is observed in food products. Alternative trade organisations market commodities produced organically.
Cost of energy	The increased cost of oil and its polluted characteristics have created a frantic search for alternative forms of energy. The gasoline industry has formulated new low-lead and no-lead gasoline. The auto industry has introduced emission-controls devices and energy efficient cars. Alternative form of energy include efficient and small-scale systems operated with fossil fuels; biomass combustion, gasification and pyrolysis; biogas; solar, thermal and photovoltaic applications; wind pumping and power generation; geothermal energy for greenhouses; and small hydropower systems.
Levels of pollution	Increased level of pollution has been generated by industrial residues in the water; chemical pollutants in the soil and food supply; and the littering of the environment with nonbiodegradable bottles, plastic and other packaging materials. The public concern triggered off companies to develop pollution-control solutions such as scrubbers and recycling centers. It also led to a search for alternative ways to produce package goods that do not cause environmental damage. The chemical industry is investing more in biological control of pests; the soap industry has had to develop low-phosphate detergents; the packaging industry has had to develop ways to reduce litter and increase biodegradability in its products as it is the case of recycled paper and returnable bottles.
Government & international pressure	Marketing management has started to pay attention to the physical environment, in terms of obtaining needed resources and also of avoiding damage to the environment. Business has begun to receive strong controls from both government and pressure groups. International trade has initiated the introduction of non-price barriers associated with cleaner production systems.

Source: Kotler, 1997; The Economist, several issues.

The examples in Table 4.2 illustrate that a changing marketing environment created market opportunities that channel agents were prompted to analyse to find adequate responses to. These responses comprised the adjustment of production and marketing channels towards more efficiently serving new consumer wants while complying with environmental regulations. Marketers have been developing new marketing strategies to motivate and convince consumers to buy products being produced in a sustainable way. Success or failure of these 'green marketing' strategies depends on consumers' environmental consciousness and government policies (legal framework, subsidies, education and information).

In the agricultural sector, regulatory and market based strategies have also been attempted to lead agricultural activities to move in sustainability directions. However, as the next sections discuss, in contrast to the industrial sector, regulatory approaches are less effective in small farm agricultural production as small householders are less responsive to taxes and regulations.

4.4 Improving agricultural sustainability by marketing channel organisation

The contribution of marketing to agricultural sustainability has especial relevance to farm on-site environmental effects (see Chapter 3), because, as opposed to off-site environmental effects, they directly affect farm households in regards to economic issues such as lower crop yields and greater needs for crop inputs[41]. The potential contribution of marketing mechanisms in influencing sustainable farming derives support from two important elements of marketing. First, marketing activities are the farmer's main generator of economic resources. Thus, a market-based strategy, promoting sustainability as a means to improve product image and product prices will appeal to farmers. This will be even more the case if such a market-based strategy is stimulating higher economic efficiency and stability too. Second, marketing channels could address market distortions (e.g., such as defects in information and credits) that affect rational decisions by farmers in the use of farm natural endowments. The correction of distortions is expected to rebound as an environmentally 'friendlier' farm management.

In this connection, certain types of marketing channels might be more able to stimulate farm soil sustainability, the focal point of this study, than others. VMS seems better equipped than CMC in bringing about farm soil sustainability because it is geared to attain coordination between channel members and, related to this, is more long-term oriented.

CMC

As noted earlier, CMC is a very efficient marketing channel when markets are transparent (perfect information) and product differentiation is minimal (product homogeneity). But when markets are not transparent (lack of communication) and products are well differentiated (added-value and high-value products), CMC is probably not as efficient as coordinated channel structures. CMC relies more on price coordination and less on the coordination of other elements of the marketing mix such as product differentiation, services and market information. From this perspective, CMC disposes of a limited number of tools to incite an environmentally friendly policy among members in the channel. Moreover, since products are not differentiated, CMC is probably not well positioned to differentiate product quality attributes in the market. The specification of environmental criteria and the control of environmental friendliness of production have to be institutionalised. This is a difficult task for small farms in developing countries.

Lack of coordination and organisation also make CMC less well positioned to address some of the market distortions that may hamper sustainable farm resource use. In particular, deficiencies in market information, defects in credit availability, inappropriate access to inputs and other market services, exaggerated transport and storage costs constrain production and marketing decisions. They lead to economic uncertainty, high marketing costs and low overall profits. Under these conditions, environmentally adverse resource-use outcomes may occur (e.g. soil depletion and pollution). In some cases, farmers may overexploit farm resources by crop intensification, adopting shorter fallow periods, and expanding cropping onto steeper and more marginal step areas in order to generate needed income. In other cases, farmers may limit their output for the market, either because of the low prices perceived, demand uncertainty, or because of poor market information. This leads to a vicious cycle of depressed income and lower economic capacity to invest in conservation measures.

These conditions may also inhibit the allocation of labour and capital resources to soil conservation in poor farm households. Those scarce resources are preferably allocated to activities that have quicker economic returns to diminish risk and increase income regardless on

[41] Marketing can also contribute to address some of the farm externalities by taking sustainability into account as an important dimension of all aspects of the marketing operations, including product development, packaging, promotion and distribution (Peattie, 1995). Whether such marketing policy is successful depends on the willingness of consumers to consider environmentally friendly products, such as organic food, an attractive alternative. Consumers must perceive environmentally friendly produced food attractive for one or another reason, e.g. health, empathy for small farmers, concern about the natural landscape, etc.

their environmental impact[42].

VMS

It has been argued earlier that VMS channels try to improve efficiency and effectiveness in market functions related to product quality, marketing services, branding and market power. In addition to coordination by price, VMS pays attention to coordination in product specification, product services, exchange of market information, promotion and logistical operations. From this perspective, VMS seems better organised and more long-term oriented to bring about sustainable farming than CMC.

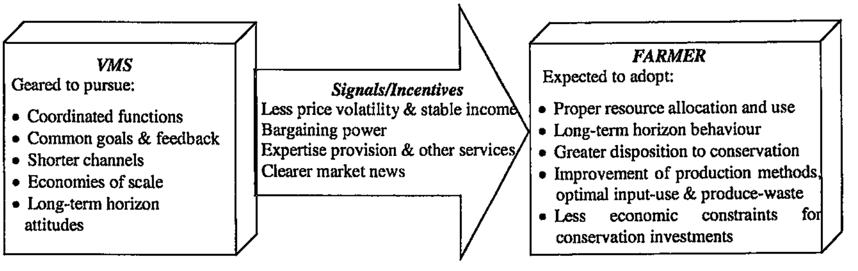

Figure 4.1 VMS incentives to farm sustainability

Coordination of marketing functions makes VMS more able to stimulate and maintain a common marketing policy in the channel, which is particularly important for the production and marketing of environmental friendly products. In this connection, VMS structures, such as contract farming, often rely on technical assistance to farmers as a means to obtain products with certain quality (formula production). VMS, for instance, can be used to promote the production of environmentally 'friendly' products by orienting assistance and extension towards sustainable production systems (e.g., organic produce). This strengthens farmers' positive attitudes toward conservation. Another example is instruction on techniques such as picking, handling and grading in order to improve efficiency and minimise waste. Information on the use of chemical inputs is another potential contribution to farm sustainability. VMS is probably more able than a CMC to encourage and maintain product quality in the channel ('environmental quality') and is more able to differentiate this attribute in the market.

If VMS is oriented to offering economic stability, it may lead to investments in land conservation (Lynne, Shonkwiler and Rola, 1988). Economic stability is likely to be positively associated with conservation practices since farmers with larger profits are less financially constrained to invest in soil conservation (Dasqupta et al., 1997; Wilson, 1997). Hereafter, the time horizon of VMS matters and is a significant factor for farm soil sustainability. This is because soil sustainability is a factor of time and it is soil management that determines the yield capacity of the land in time. Soil mining farm practices and other unsustainable soil management practices lessen the productivity of the soil as well as, eventually, the income of the farmer. The economic burden of these practices will be particularly noticeable in the long run as the effects of soil degradation build up. Hence, long term orientation to VMS is essential for farm soil sustainability.

[42] Even though sub-optimal market performance may bring about land use intensification and quick removal of the perennial vegetative cover, it also may induce crop diversification in order to account on market risks. Crop diversification promotes sane cultural practices such as rotation, intercropping, genetic biodiversity and diminish vulnerability to pest and diseases.

VMS places emphasis on the quality of production, on stable long-term price perspectives, on controlling price volatility and on a long-term horizon among channel members[43]. This relationship is noteworthy due to the fact that long-term planning is seen in economic theory as a key determinant of adoption of sustainable farming (Peattie, 1995).

VMS and long-term planning

Economic theory can explain the potential contribution of VMS to farm soil sustainability. Figure 4.2 illustrates that soil depletion, in many cases, is rational from the farmer's point (Scherr, 1999; Walker, 1982; Anderson and Thampapillai, 1990; Carlson et al., 1993). As the soil degenerates over time, yield and income losses build up. At the early stages of soil depletion, however, the net returns without soil conservation exceed the net returns with conservation. Although crop yields are decreasing, these are almost imperceptible or not meaningful enough. From the farmer's standpoint, there is neither need nor economic motivation to invest in soil conservation at this point. Over time, however, as the soil degenerates further, the gap narrows until, eventually, at time period t_1, net returns with conservation are higher than those without. Farmers thus have a strong incentive to invest time and money in conservation measures[44].

But if farmers are offered a market incentive (e.g., a VMS marketing channel) intended to encourage timely adoption (at time period t_0) of soil conservation practices, farmer's planning period is extended and so are the net returns. Farmers with an extended planning period will not favour the short-term benefits from mining the land but place a higher value on the long-run benefits from soil conservation. The perspective of sustained economic returns of a VMS market incentive will stimulate greater care for the long-term condition of the productive resource.

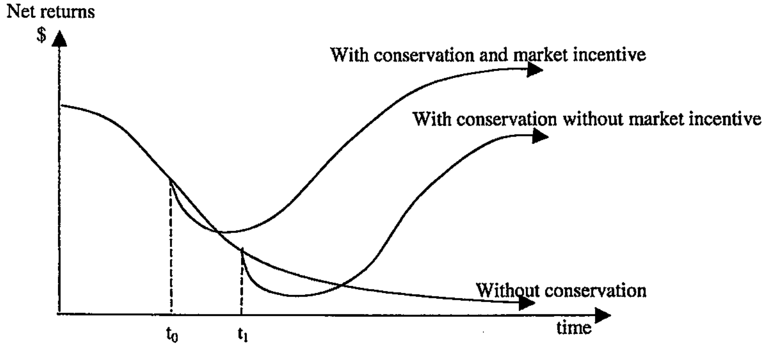

Figure 4.2 Net returns and conservation decision with different planning periods

[43] In the case that farmers are taking a long-term view in their strategy they realise that maintaining or improving soil quality is very essential for their incomes. In this case it does not seem difficult to convince farmers to adopt sustainable farming. As a result, this type of sustainable farming is not depending on the willingness to pay a higher price for food produced in a sustainable way. In behaving unsustainably, farmer does not experience a lower income, perhaps a higher income and society has to foot the bill to get rid of soil pollution, such as minerals or spoilage of the landscape.

[44] Adoption of soil conservation technologies is unlikely to occur until time period t_1, which one study calculates to be at least 40 to 60 years after soil degeneration begins, depending on the discount rate used (Seitz and others, 1979). Thus, there is a conflict between the farmer's logic and ecological considerations (Gutman, 1988). The literature also reveals that even if farmers consider the monetary benefits of erosion control, such as yield increases, they are unlikely to consider non-monetary benefits, such as soil resilience or downstream benefits, which accrue to others. Thus the extent to which farmers voluntarily adopt soil conservation practices will be sub-optimal from society's point of view (Izac, 1994).

VMS can also have, however, a negative influence on farm sustainability. The noteworthy capability of VMS to encourage sustainable production can be affected by the prevailing public climate and the marketing policy of the channel leader. Firstly, vertically integrated channels must be considered as an essential element rather than a rural development strategy to improve agricultural production and marketing. Inequitable agrarian structures, absence of a favourable policy framework for marketing to perform and skewed development policies, put at risk the economic and environmental benefits that marketing strategies like this may have.

Secondly, the marketing policy of the actors in the marketing channel, in particular, of its most powerful partner (the channel leader), also matters for farm sustainability. If the marketing channel leader is much more concerned with short-term benefits, such as high volume turnover and low costs, regardless of production methods and produce quality, the proficiency of farm planning can be eroded. This, in turn, can trigger reluctance on the part of farmers to invest in long-term sustainability (Hansen, 1996). If marketing channel incentives are wrongly addressed, they can, for example, stimulate chemical use, forest clearing or monocropping, and, therefore, lead to land degradation, rather than preventing it. Illustrations of this are the cases of the Non Traditional AgroExport (NTAE) schemes in several Latin American and Caribbean countries. Under these schemes, new market opportunities were promoted to overcome economic stagnation and promote income diversification, but collateral outcomes were major challenges in terms of its economic environmental sustainability and social equity (Thrupp, 1992). Similar examples include land depletion and water chemical contamination by banana production in Central America (see also Thrupp, 1990; Murray et al., 1992; and Smith, 1995).

Thereby, VMS could constitute a potential strategy to encourage timely adoption of soil conservation practices. VMS could act as an economic incentive and offer clearer market signals and economic stability, stimulate care for the soil asset, increase the returns to conservation practices, resulting in longer planning use of farm resources and earlier adoption of sustainable practices, at time period t_0 (Figure 4.2). The full consideration of the risks associated with this strategy must be accounted for, for a meaningful impact of VMS on farm sustainability.

4.5 Promotion of sustainable marketing policies by government and industry

In agriculture, as in other sectors, countries attempt various strategies to respond to environmental concerns. In line with the classification of promotional strategies in marketing (Kotler, 1997), the strategies utilised to promote adoption of environmental issues in agricultural marketing can be classified as:

1. *Push strategies*, which stimulate businesses to adopt more environmentally sound production processes by legal measures or financial initiatives. These strategies are sub-classified in legal-based strategies (taxes, subsidies) and market-based strategies (market incentives).
2. *Pull strategies*, which stimulate consumers by means of subsidies, education and extension to consume environmentally 'friendly' products.
3. *Interface strategies*, which make use of information and environmental labels/seals to help consumers/producers make the right purchase-decision with respect to environmental issues.

Push strategies call for using incentives and promotional mechanisms to push environmentally friendly practices through the market channel. Thus, all channel members, producers, wholesalers and retailers, can be entitled to receive incentives to adopt sustainable agricultural production. Push strategies can be in the form of legal-based or market-based strategies.

Legal-based push strategies include output price-raising policies to promote certain products, input taxes to encourage less intensive and more ecological use of the land, input subsidies to modernise agriculture and increase production, and exemption schemes to promote crop shifting. Table 4.3 illustrates some examples of government interventions aimed at stimulating environmentally 'friendly' behaviour in agriculture.

Table 4.3 Legal-based 'push' strategies to promote environmental adoption

Output pricing	Floor prices, export enhancement schemes and various forms of income tax exemption plans aimed at promoting environmentally 'friendly' produced or processed products.
Input taxes	Taxes on inputs are used to discourage intensive land use and make farmers pay for at least part of the cost of pollution prevention and control.
Input subsidies	Subsidies are addressed to promote adoption of alternative methods such as Integrated Pest Management (IPM) and stress-resistant varieties.
Other subsidies	Governments of some industrialised countries provide clean up subsidies and grants for landscape quality, wildlife preservation and the conservation of species diversity.
Land tenure and credit	Land tenure policies include mainly land reforms (e.g. land redistribution) pursuing tenure security and better treatment to the land. Credit policies look forward to improving farmers' access to capital.
Other initiatives: quotas, extension/ education	Other initiatives include pollution quotas or standards, pollution charges and marketable permits. Also, instruction is aimed to persuade farmers to adopt environmentally favourable practices and to strengthen positive attitudes toward resource conservation.

Source: Lutz and Young, 1993; FAO, 1991a; Repetto, 1989.

The approach in legal strategies to avert environmental problems is through the principles of 'user pays' and 'user gains'. These imply policies whereby the causing agents of negative externalities bear the cost for causing them or gain a subvention if they cease causing externalities. The instruments for such policies are incentives, disincentives (taxation) and/or regulatory mechanisms and are generally used in developed countries. Although well intended, in developing countries, these policies have often failed (ISNAR, 1998; Barkin, 1994; Carlson, 1993; Laing et al., 1992). The reasons for failure are related to the fact that subsidies are costly and, in many cases, induce distortions in other sectors of the economy, while regulations are extremely difficult to implement and of reduced impact (Smith, 1995; Lutz and Young, 1993). Legal approaches are difficult to implement in developing countries because institutional capabilities are generally weak, enforcement is difficult and monitoring expensive. Furthermore, although well intended, some of the policies have been short-sighted, looking at isolated problems, without considering collateral implications and externalities[45].

[45] One example is the income tax and capital market policies in Brazil, which accelerated the pace of settlement in the Amazon and led to deforestation (Binswanger, 1989). Another example is the subsidy of livestock production in several regions of Latin America, which led to clearance of tropical forest for grazing purposes in lands with low carrying capacity. Moreover, tax and incentives schemes often involve the establishment of regulatory organisational structures, which by bureaucratic or other reasons may just fail or be susceptible to corruption.

Table 4.4 Market-based 'push' strategies to promote environmental adoption

In Kenya, terracing was adopted when a market for vegetables was guaranteed (Tiffen and Mortimore, 1992). The opening of new market opportunities, the growth of Nairobi and communications to it, and agri-extension, directed to profitable crops and water conservation, created incentives for private investment in land improvement.
In Honduras, higher prices for maize during the second crop season of the year were a significant incentive for hillside farmers to adopt green manuring systems (Buckles et al., 1992). The manuring system improved soil fertility and reduced labour requirement for weeding. The net rate of return on capital and labour, scarce factors, doubled with the new manuring system. In this case, a market opportunity 'pushed' farmers to adopt a soil conservation that contributed to enhance production, income and the return of the scarce factors of production.
A project funded by USAID/CARE, and implemented by the Ministry of Agriculture of Ecuador, successfully promoted the adoption of soil conservation practices by two-thirds of participating farmers in *Tungurahua* province (Nimlos and Savage, 1991). One of the principal reasons for success was the introduction of high-value crops (vegetables). In this case, the additional costs involved in very labour-intensive practices such as hillside ditches, bench terraces, earthen reservoirs and live barriers, were off-set by a very significant increase in productivity.
Alternative Trade (AT) organisations such as Max Havelaar (Netherlands), Caf*édirect* (UK) and TransFair (Germany) have successfully promoted community organisation, gender equality and sustainable agricultural production in farms/villages across Africa, Asia and Latin America by conferring a quality mark to organic and semi-organic products and facilitating direct long-term export contracts. The products benefited by these market opportunities range from fruits, vegetables and staple food to cotton, coffee, meat, poultry and dairy products (see Appendix A).

Market-based push strategies are interventions (from the government or non-government sectors) that involve a market incentive component as an economic strategy to encourage adoption of, for example, conservation technology. They embrace strategies such as price stabilisation schemes, opening of market niches, development of marketing channels, creation of new market opportunities and improvement of the return of a factor of production aimed at promoting adoption of environmentally friendly technology. The literature provides cases of market-based strategies successfully used as economic incentives to encourage soil conservation practices (Tiffen and Mortimore, 1992; Nimlos and Savage, 1991; Laing et al., 1992; Smith, 1995). Table 4.4 shows some examples.

The examples illustrate that improvements in market conditions through investments in market infrastructure and market access allowed the improvement of current agricultural activities or the introduction of high-value farm production activities and the adoption of conservation technology. In this context, the expectancy of enhancing income and the economic return of scarce factors of land, labour or capital becomes a great incentive for improving the condition of the soil resource.

Pull strategies are the second group of strategies utilised to promote adoption of environmentally sound practices in agriculture. These strategies apply more efforts to consumer promotion to build up demand for environmentally friendly food products by means of activities such as education, advertising, information and other promotional activities. They seek to relax consumer demands for aesthetic perfection for products, limit over-consumption behaviour and shift to 'green' produced food consumption. Mass media education is used to convince consumers that their buying habits have physical impact on farms and economic, social and health impacts on producers and that "perfect-looking" produce does not have a higher nutritional value but, generally a higher chemical content. Marketing promotion is also used to persuade consumers to leave products produced under intensive agriculture methods and buy 'green' alternatives.

Finally, *Interface strategies* are another group of strategies to stimulate adoption by making the market transparent with respect to the environmental friendliness of the products supplied to the market. Environmental labelling is an instrument to realise this, by differentiating products on the basis of higher environmental quality. Quality labelling assists the imperfectly informed consumers and producers in their buying process because it structures environmental information. Examples of these strategies include 'locally-grown', 'free-range' and 'organic' labelling (Lafferts, 1996) with eco-labelling standards developed by institutions such as Codex Alimentarius Commission and the International Organization for Standardization (ISO) (Barham, 1997).

The preceding review of strategies to address environmental threats bears out the view that the selection of an efficient strategy is a critical issue in agriculture. The strategy that best corresponds to a specific environmental concern will vary from case to case. *Pull and Interface strategies* may be more applicable in Western countries where consumers are better-educated and economic welfare and quality of life is high. The applicability of these types of strategies in the developing world is still unclear and they are probably not feasible with fresh products from small farm farms[46]. They require product differentiation and effective tracking and tracing procedures in order to be able to guarantee the environmentally friendly production procedures. Lower income per capita and schooling in developing countries also constitute a constraint for domestic demand of 'clean' or labelled products.

With regards to *Push strategies* that have a legal base, these seem to have more applicability in the industrial sector to help abate the environmental burden of production and processing as environmental impacts are large and complex in extension. It has been argued already in Chapter 3 that subsidies, taxes and other legal regulations are not effective control mechanisms of pollution for small farm households in developing countries. Small farms are numerous, geographically scattered, financially weak and, therefore, difficult to influence by regulatory approaches.

Comparatively, market-based push strategies seem better suited to deal with small-farm environmental hazards because of their capacity to bring economic benefits that help offset investment and effort devoted to land conservation. Marketing activities are the farmer's main generator of income and have a great influence in farm resource allocation and use. A lesson from the market-based strategies discussed before is that market strategies, appropriately complemented with ecological farming practices, bring economic benefits, specifically income stabilisation, and increased disposition of farmers to invest in resource conservation practices.

The successful adoption of sustainable farm production systems in most of the cases mentioned has been because it brings about other benefits. Farmers recognise that market incentives allowed them to offset increased costs and offered the opportunity to increase income with sustainable production occurring at the same time. If the strategy to promote sustainable farming systems is not accompanied by the prospect of increasing farm income, disappointing outcomes from the point of view of adoption are likely to occur. The literature provides examples that show that technically sound strategies have sometimes not been adopted because their promotion did not involve market incentives that stimulated farmers to invest in, and maintain, land improvement (Budelman, 1992; van de Graaf, 1992; see also Appendix A). Therefore, a well-organised and long-term oriented VMS channel could constitute the market incentive needed to encourage investments in land care and to break up the vicious poverty-degradation cycle common to small farmers.

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[46] Some exceptions are the cases of few dairy products such as farm-made cheese.

5 MARKETING SYSTEMS AND SOIL SUSTAINABILITY: HYPOTHESES AND ASSESSMENT METHODS

Chapter four highlighted the important role of marketing in pursuing sustainability in small farm agricultural production systems in developing countries. The enhancement of the marketing channel, towards a more integrated and coordinated system, is believed to provide important stimuli to resource users, to prevent market distortions and to offer reliable information. These conditions contribute to rational judgements and decisions that farmers can make regarding resource management. The proper use of marketing as a meaningful contributor to sustainable production in agriculture is essential and must be sought. From the preceding discussions arise some questions that, in this chapter, are turned into a general hypotheses.

The chapter is organised as follows. Section one introduces and discusses the general hypotheses of the study, which state that marketing plays an important role in adoption of sustainable soil management practices. Section two mentions the most common methods used to assess sustainability and its determinants and identifies regression and linear programming models as the most relevant appraisal methods for this study. Section three proposes the conceptual framework of an econometric model that integrates the approaches that Chapter 3 identified as important contributors to the explanation of sustainability (i.e. approaches from the psychological, socio-economic and geo-physical disciplines). Section four, in turn, proposes the general conceptual framework of a linear programming (LP) household model that incorporates farm income and soil sustainability as a model objectives. While the econometric models aims at appraising as precisely as possible the effects of marketing and other factors on the adoption of soil sustainable practices, the LP model is a tool aimed at evaluating the consequences of market interventions not only on soil sustainability but also on farm income.

5.1 General hypotheses

Figure 5.1 shows the research questions of this study, which are turned into general hypotheses.

Research question	*Hypothesis*
1. Is there any contribution of marketing systems to farm soil sustainability?	*1.*VMS are better equipped than CMC to stimulate farmers to adopt farm soil sustainability.
2. Does the conditioning macro-environment play a role in stimulating farm soil sustainability?	2. A government policy supportive of marketing and production activities encourages farmers' investment in soil sustainability.
3. Is the enhancement of farm soil sustainability at the expense of farmer's income?	*3.* Market incentives, promising income enhancement, are more likely to stimulate the adoption of farm soil sustainability.

Figure 5.1 General hypotheses

H1: VMS are better equipped than CMC to stimulate farmers to adopt farm soil sustainability

The focus of VMS towards relationships among channel actors and coordinated performance of marketing functions makes this system better able to stimulate farmers to practice soil sustainable agriculture. Compared to CMC, VMS capability in stimulating soil sustainable agriculture is apparent in relation to:

- enlarged planning terms implying greater concern for the future and, for that reason, greater awareness of the need to maintain natural production factors, such as soil, in a good shape
- more coordination, which makes quality control tracking and tracing better possible. In this context, VMS is better able to market a sustainable food product or any farm product with a sustainability credence attribute
- a tighter relationship between small farmers and suppliers (in the exchange of input materials and farm products) offers more opportunities to persuade farmers about the profitability of cultivating the land in a sustainable way

The advantage of VMS in stimulating soil sustainable agriculture will be particularly meaningful when:

- the channel leader or all channel actors are in favour of sustainable production
- farmers have opportune access to information on market changes so they are able to switch the crop mix in a more timely and skilful manner
- there is extension on production (e.g. input doses) and post-harvest (handling and processing) activities, which minimises production costs, waste and contamination
- economic stability is aimed, which contributes to remove economic burdens on farmers and promotes long-term horizon commitments to the land.

In contrast, VMS will likely not stimulate soil sustainable agriculture when:

- the marketing channel actors are purely price oriented. If channel actors are competing on price and quantity regardless of quality production and post-harvest efficiencies, farmers may be careless of sustainability issues as a result
- the marketing channel actors are short-term oriented and no concerned on the maintenance of farm natural production factors throughout the time
- the channel leader uses his power to keep market information for himself. As a result, farmers could not adjust the crop mix in a timely and skilful manner.

Ensuing, integration of marketing functions and better coordination of production and marketing operations in VMS likely lead to sustainable farming methods. Adjusting productive resources more opportunely, using inputs more skilfully and minimising produce waste bring farm systems nearer to sustainable food production. Concurrently, commercial stability and higher overall economic returns would motive more and constrain less the investments in soil conservation.

H2: A government policy supportive of marketing and production activities encourages farmers' investments in soil sustainability

Although marketing mechanisms can contribute to attain the goal of farm sustainability, government support and policy measures are necessary to create the market conditions for such an attainment. The government can create an appropriate climate for marketing channel actors by:

- providing a physical infrastructure to assist market operations. Proper physical and communication systems create advantages for the assembling of farm products, the distribution of food from the farm-gate to the final consumer and the flow of information among channel actors. Infrastructure development abates transaction costs and improves

competitiveness, which encourage specialisation in the marketing channel, growth of marketing institutions and the sustainable development of rural areas.
- providing the economic resources to finance operations and transactions at each link of the channel. Marketing channel stakeholders require money to finance the exchange, physical and facilitating channel functions. The supply of credit, inputs, machinery and assistance by marketing institutions to farmers is only possible if the institution is economically solvent. Alike other channel stakeholders, growers need credit before and during production to meet input and other costs. Defects in credit create distortions in demand and supply, economic uncertainty, economies of subsistence and sub-optimal farming methods.
- providing a legal protection to all members. Official weights, grading, information on markets and credit are all of general benefit. Regulations on weight, measures and quality specifications protect not only producers but also traders, reduce risk and costs, and extend the market of uniform lots. When in absence of clear regulation, wholesaler monopolies and price speculation will abound, which have inimical consequences to farm sustainability.

If, in contrast, government policies are not supportive of marketing and farm production activities:
- the success of marketing mechanisms addressed to promote economic and sustainable development might be jeopardised by constraints in physical, communication, legal, and financial infrastructures[47].

H3: Market incentives promising income enhancement are more likely to stimulate the adoption of farm soil sustainability

The third and last hypothesis refers to the particular advantage of market incentives in enhancing farmer's capacity to invest in soil conservation. Farm soil sustainability is more plausible to occur with market incentives such as VMS because:
- they assure the income level and price stability that farmers need to offset the significant costs of soil conservation
- farmers will have greater incentives to husband the land and invest efforts and capital in the long-term productivity of their soil resource
- improved access to the market and marketing services patronage farmers to move out of the vicious poverty-degradation cycle.

From this perspective, the enhancement of farm soil sustainability can be accomplished, not at the expense of farm income but, rather, as a contribution to the long-term productivity of such a fragile resource. Market incentives addressed to promote sustainable farming practices, bring economic benefits, specifically income stabilisation, and increased disposition of farmers to invest in soil conservation practices. Farm soil conservation problems affect farm agricultural revenues (depressed yields) and production costs (greater need for nutrients and other inputs). Thus, a market incentive intended to favourably affect the farmer's income and his commitment for the conservation of the natural productive resource will likely lead to farm soil sustainability. In this way, it is possible to reconcile efforts to increase the profitability of farm activities while improving the management of the soil resource.

The three basic hypotheses introduced above will be further elaborated in a number of specific hypotheses on the basis of empirical research (Chapters 8 and 9). The next section propounds two

[47] Although, government has a heavy influence in several other spheres that also affect farm sustainability (e.g. through direct policies in the agricultural sector and indirect policies in other economy sectors), this study's hypothesis puts specific emphasis on the policies affecting directly marketing and farm systems at the very rural level.

appraisal approaches for the evaluation of the hypotheses: a positive approach, in the form of an econometric model, and a normative approach, in the form of a programming model.

5.2 Methods employed to appraise farm soil sustainability

Methods to assess the relevance of the hypotheses formulated on sustainability are primarily driven by two criteria: the objective pursued in the analysis and the way in which sustainability (the response variable) is measured. If the objective of the analysis is to assess the economic advantage of alternative systems/projects, economic evaluation methods such as cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) are recommended (Peskin, 1989; FAO, 1991a; de Graaff, 1996). These methods are used in project appraisals and are addressed to evaluate the environmental costs and benefits in money terms of programs or projects.

If the objective is to measure as precise as possible cause-effect relationships between various factors and farm sustainability, regression models (e.g. econometric models) are more appropriate. This approach provides the means to detect those factors that are either significant or not significant in explaining adoption of farm sustainable practices. If the objective of the analysis is to assess the allocation of the farm resources (land, labour and capital) in order to appreciate the effect of potential interventions based on given assumptions, then normative models such as mathematical programming models are more appropriate. Through the description of farm activities in terms of agronomic and economic (input and output) coefficients, programming models permit the evaluation of potential scenarios and the trade-off between model objectives. On this basis, regression and mathematical programming models are relevant approaches for the evaluation of the foregoing hypotheses. While econometric models can be suitable instruments to appraise the approximate effect of marketing factors on adoption of soil sustainable practices, programming models are playing tools that can provide insight of the likely consequences of market interventions in the economics and sustainability of the farm.

The econometric model proposed in this study is intended to assess, as precisely as possible, the effect of marketing factors on farm sustainability. The model acknowledges the strengths of earlier empirical works, reviewed in Chapter 3, and attempts to overcome their weaknesses by adopting an 'integrated' approach including economic, physical and personal factors besides marketing. The assessment is further refined by use of relevant statistical techniques that substantially boost model explanation power. On the other hand, the linear programming (LP) model proposed is based on the experience of earlier works and is intended to estimate the potential effects of simulated market scenarios on farm soil sustainability as well as on income and other objectives. The LP model describe the Cabuyal farm in terms of production and consumption constraints and assesses the impact of selected market scenarios on the optimal allocation of farm resources. Both, the econometric and the LP models are introduced below.

5.3 The Econometric Model

The review of empirical studies on the adoption of sustainable practices (Chapter 3) revealed that economic, personal (including sociological), physical and institutional factors play a role as explanatory elements. In this study, although the focal point rests on the potential effect of institutional factors (e.g. marketing factors) on the adoption of sustainable agricultural practices (ASAP), other factors that also contribute to such an adoption are taken into account. In this way, the model will be more consistent and the effect of marketing factors more reliably estimated.

Figure 5.2 presents the general framework of the econometric model. ASAP centres on soil sustainable farming practices, since soil has been identified as the resource to observe (Chapter

3). Even though the proposed framework is soil-resource oriented, it can easily be extended with other dimensions of sustainability. In Figure 5.2, the adoption process is viewed as a product of the land-user's personal and sociological characteristics[48] that might cause awareness of the seriousness of the erosion, coupled with the actual physical characteristics of the land he operates. Marketing institutions, government and other institutional factors may heighten the decision of adoption. The degree of physical deterioration potential of a farmer's land also may persuade him of the type of soil conservation practice to choose. Economic factors may either enhance or constrain farmers' dispositions towards conservation.

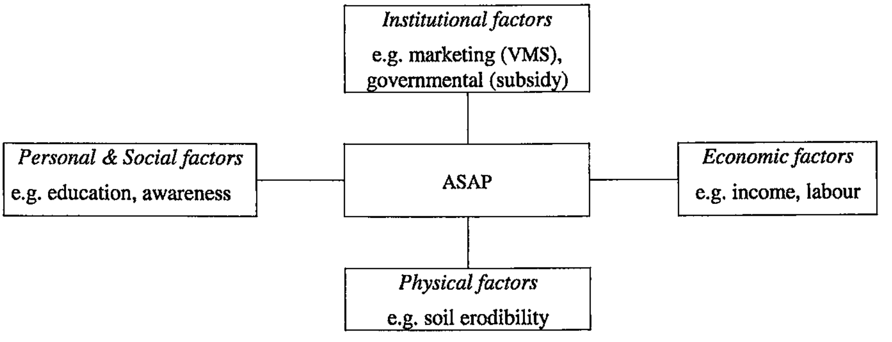

Figure 5.2 A general model of adoption of sustainable agricultural practices

The conceptual model highlights the marketing factors to account for the study hypotheses. The specification of the model can be generally formulated as follows:

$$ASAP = f(\text{Physical fact., Personal fact., Economic fact., Institutional fact.}) + \text{random error} \quad (5.1)$$

where ASAP = Adoption of Sustainable Agricultural Practices

The model is a single-equation[49] model that incorporates a number of independent variables as a detailed analysis of ASAP will reveal that farmer's soil sustainability management is built up on few distinguishable components (Chapter 7). ASAP is measured as a continuous variable that encompasses various levels of sustainability adoption in order to preserve insight of the adoption process and facilitate the detection of cause-effect relationships between the independent variables and farm soil sustainability. The model acknowledges the factors that earlier works have identified as significant explaining soil conservation adoption. Moreover, the model is flexible to include explanatory variables envisaged from farmers and local experts to have an impact on

[48] They include personal attributes such as age, education and ethnic group, and attitudinal characteristics such as farming orientation, awareness to soil problems, innovativeness and risk aversion attitudes.

[49] As noted in Chapter 3, although other authors such as Ervin and Ervin (1982) and Mbaga (1998) used a three-equation model to represent the three-stage adoption process (perception, adoption and effort stages) to capture the dynamic nature of such process, results are somewhat disappointing. Mbaga, for instance, concluded that the perception of the soil erosion problem is not a necessary condition for using soil conservation practices, and, in turn, for determining farmer's conservation effort. The influence of promotional activities and support services, provided by institutions, interferes with household adoption behaviour.

ASAP. With regards to marketing factors, the focal explanatory factor of the analysis, it is intended to consider variables such as level of integration to marketing institutions (i.e. CMC or VMS), access to market services, farmer's market orientation[50], distance to markets and other variables that could contribute to evaluate the impact of marketing factors on farm soil sustainability.

The main contributions of this model are threefold. First, the test of marketing factors, which could play a role in the farmer's adoption process, as well as other determining factors. Second, the proposal of a technically sound method for the measurement of the sustainability (dependent) variable (ASAP). Third, the use of robust multivariate statistical technique for the estimation of the econometric model. These contributions will bring benefits in terms of model explanation power, variable significance and overall soundness. Chapter 8 will further elaborate on the model, on the explanatory factors and their expected effect on ASAP

5.4 The multiple goal LP model

Chapter 3 reviewed a number of studies that addressed the issue of sustainability and agriculture, by means of mathematical programming models. They included the use of multiple goal linear programming (MGLP) models to determine the optimal combination of farm resources and possibilities in relation to soil sustainability. Sustainability was specified either as a set of constraints or as an objective, and several scenarios (and farm type distinctions) allowed tracing the trade-off of sustainability and other model objectives.

The MGLP model attempted in this study is designed to capture the relationship between production, consumption and resource availability in a consistent way, in order to provide insights into the consequences of marketing interventions on the soil sustainability and income as well as on the associated effects on resource allocation in small-farm households in Cabuyal. The model identifies farm household's restrictions (land, labour, capital), possibilities (farm activities) and objectives. Market scenarios are related to model constraints and pursue to provide insight into the consequences of marketing interventions on farm resource allocation and sustainability (Figure 5.3).

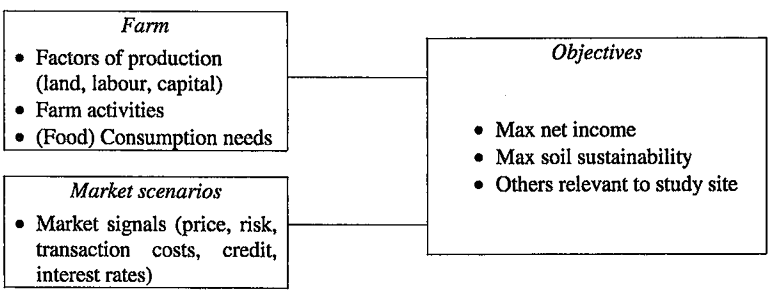

Figure 5.3 LP model objectives and constraints

The model is structured to resemble market conditions that may have an influence on farmers' soil resource conservation decisions. In contrast to the econometric model, which aims at

[50] Market orientation could be classified as an attitudinal characteristic under personal factors. In this study, it is included under marketing factors.

measuring and testing the actual effect of a number of explanatory variables (including marketing) on soil sustainability, the LP model aims at evaluating the possible impact of a number of 'what if questions' on soil sustainability, income and other variables. Questions such as 'What is the impact of the CMC and VMS on farm households' income?' and 'What is the associated impact on soil conservation?' are pursued. Moreover, the model provides information on the associated impact of these 'what if questions' on the uses of land, labour and capital resources.

The MGLP model is a basic household model whose main contribution is the comparison between a conventional market channel scenario (CMC) and a vertical market channel scenario (VMS) with respect to farm soil sustainability. The market scenarios are described, not only in terms of output prices, but also in terms of traded quantities, price and productivity risks, transaction costs, and credit fares. Chapter 9 presents the MGLP model in more detail and discusses its features.

6 CABUYAL: THE STRUGGLE OF HILLSIDE FARMERS IN FRAGILE LANDS

The exposure of ecologically fragile lands in Latin America to high risks of soil erosion reflects the political and institutional structure of land distribution (de Janvry and Garramon 1977). In Colombia, large scale capitalist and plantation agriculture monopolises prime lands with crops such as sugar cane, pasture, rice and cotton, while small farmers are limited to the least fertile and most easily destroyed sloping lands. This unequal distribution, together with a poor market infrastructure, is considered to have consequences for soil degradation.

The CIAT[51] Hillsides Program is focused towards finding adequate solutions to tropical America hillside agricultural zones, where most of the poor growers are and soil depletion rates are higher than the renovation rates (CIAT, 1993a and 1996). In those zones, there exists a serious divergence between the current land use systems and the appropriate ecological systems for fragile lands. The CIAT Hillsides Program has committed itself to the goal of developing participatory models of sustainable land use systems, which will allow improvements in agricultural productivity on hillside zones. These models are intended to be applicable to other areas with similar conditions. To accomplish this, the CIAT Hillsides Program designated experimental sites in Central America and the Andean Region.

The Cabuyal River watershed, located between 76.63°-76.49° W and 2.70°-2.88° N in the Cauca Department in southwest Colombia (Figure 6.1), is one of the primary research sites of CIAT. The site meets, not only the typical characteristics of bio-diversity of tropical hillsides, but also most of the problems related to high population density, lack of physical infrastructure and severe erosion. In this chapter, this pilot area is proposed as case study in order to validate the hypotheses of this study and to examine the relevance of the research framework proposed.

6.1 Site Location

Colombia is a middle size country (1,141,748 km^2) located in the northwestern corner of South America (Figure 6.1). The climate is tropical along coast and eastern plains, and cooler in the highlands. It is a country of great contrasts. Five zones can be distinguished within the country: the *Andean region*, the *Eastern Plains region*, the *Amazon rain forest region*, the *Pacific Coast region*, and the *Caribbean Coast region.*

The *Andean region*, the more economically active zone, is made up of three high and parallel mountains ranges that cross the country from the southwest to the northeast. Fertile valleys with technologically advanced agriculture lie between the mountain slopes, cropped mainly with coffee (Colombia's major export), sugarcane and cotton. The Andean zone comprises less that one-third the size of the country, but hosts more than eighty percent of Colombia's 41 million inhabitants in 1998 (World Development Report, 1999/2000). Agriculture in Colombia accounts for about 13 percent of GDP and a quarter of the employment of the population in 1998. Agriculture also accounted 34 percent of the total national exports (World Development Report, 1997). Crops make up two thirds and livestock one-third of agricultural output. Climate and soils permit a wide variety of crops. Colombia's main agricultural output includes coffee (second world exporter and main agricultural activity), cut-flowers (second world exporter, first in US market), fruits (second world export) and recently sugarcane (third world exporter of *saccharose*). Other crops are rice, tobacco, corn, cocoa, beans, oilseeds, and vegetables; forest products and shrimp farming are becoming more important.

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[51] The International Center for Tropical Agriculture (CIAT) is one of the Consultative Group on International Agricultural Research (CGIAR) centers with headquarters in Cali, Colombia.

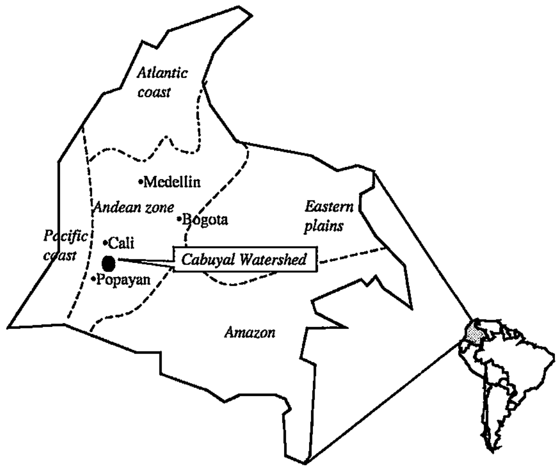


Figure 6.1 Location of the Cabuyal watershed

Despite the importance of agriculture for the country's economy, the agricultural sector has been beleaguered on a variety of fronts for the past years. High interest rates limiting credit and an overvalued and fluctuating currency, reducing international competitiveness, have cut into the sector's ability to modernise. At the same time, guerrilla activity in the countryside has led to substantial insecurity. Since the beginning of the 1990's, the coffee sector has faced serious challenges. Between 1990 and 1994, international coffee prices declined 40 percent due to increased worldwide output after the International Coffee Agreement collapsed.

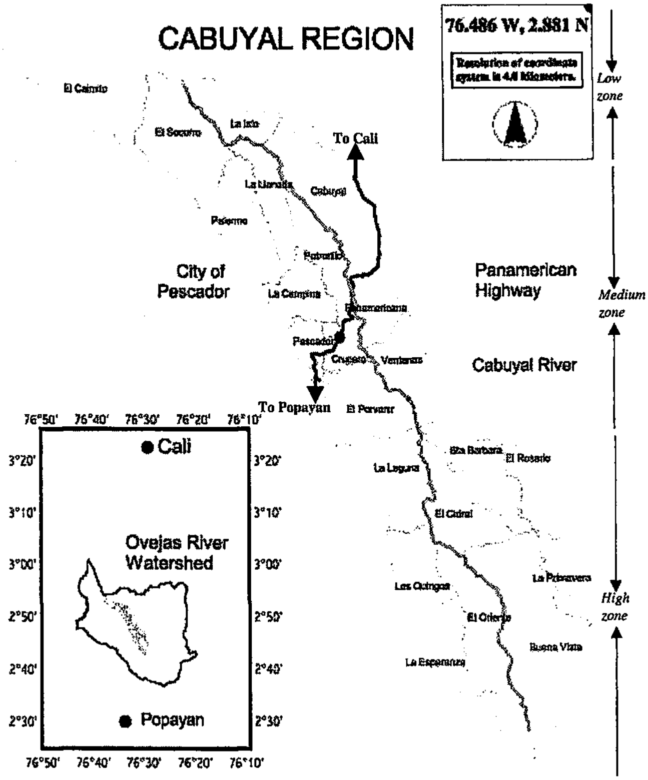


Figure 6.2 Administrative boundaries in the Cabuyal watershed

The Colombian territory is politically divided into 28 departments. The Department of Cauca, whose capital is Popayán, is located in the southwest (30,724 km^2, 2.7 percent of the country) between the Pacific and the Andean regions. In spite of its neighbourhood to the prosperous Department of Valle del Cauca (whose capital is Cali, Cauca's main market), Cauca is still a semi-unexploited region. Geographically it is made up of valleys cropped mainly with sugarcane, and mountain slopes cropped mainly with coffee, cassava, sisal, beans, and maize.

The CIAT Hillsides Program, together with a consortium of the governmental and non-governmental entities involved in research projects at the Cabuyal watershed (CIPASLA), evaluated the region by means of a physic socio-economic diagnosis. The diagnosis was carried out through a census in the Cabuyal watershed zone at the end of 1993 (CIAT, 1993b). Table 6.1 gives an overview of the studied region.

Table 6.1 Description of the Cabuyal watershed

Area (ha)		7,525 ha (75.3 km^2)	
Altitude (m)		1,175-2,200	
Annual rainfall		1,700 mm	
	<12	15	
Topography	12-30	36	
(slopes %)	>30	49	
Families/population (n)		1,100/5,204	
Population growth rate (% per year)		2.3	
Illiteracy (percent)		29	
Percent Land Owners		77	
Average farm area (ha)		3.5	
Soil characteristics		• acid soils of volcanic origin • poor fertility (high S, low P)	
Conservation problems		• erosion for overuse of sloping fields • deforestation	
Products and main surplus uses		Cassava:	sold on farm
		Coffee, beans:	sold at town market
		Maize:	consumption
		Plantain:	consumption and sold on farm
Nearby markets		Middle size:	Santander, Piendamó
		Small size:	Siberia, Pescador, Mondomo

Source: Cabuyal census (1993c)

The Cabuyal watershed is administratively divided into 22 villages or *veredas* (see figure 6.2) and is 7,525 ha (de Fraiture et al., 1997). The region is inhabited by over 5,200 people, mainly 'mestizo' (mixed race, indigenous and Spanish) and indigenous ethnic farmers. The region displays a combination of subsistence and commercial agriculture (Langford and Bell, 1997). Farms are small (about 3 ha) and located on acid soils of volcanic origin, characterised by poor fertility with very steep slopes. Elevation ranges from 1,175 to over 2,200 and nearly half of this area has slopes greater than 30 percent (Luijten, 1999). This is a matter of serious concern. Reigning (1992) argued that cultivating crops like cassava on slopes with gradient greater than 15 percent leads to severe soil losses and a decrease in soil fertility when no soil conservation practices are applied. Effective density (farm density) is very high. Illiteracy is higher than the national average. Two-thirds of the farmers own their farms.

Figure 6.2 shows that the Cabuyal watershed is divided in three agro-ecological zones: high, medium and low, related to their position along the Cabuyal river (UMATA, 1992). The low zone covers the biggest area of the watershed and has the lowest effective population density. Farmers have indigenous roots but most of the farmers are currently ethnic 'mestizos'. The medium zone is the densest area of the watershed due to the fact that an important highway runs through the region at this point. Coffee is the main crop in the high and medium zones. The high zone is the cold thermic floor with low levels of soil degradation. This zone shows strong geographic formations, and forest and pastures cover an important area. Some of the villages are practically isolated without roads. Mainly *Paez* Indigenous communities compose the population of this zone. Cassava is the main crop in the low zone. Pastures and cassava are important in the high zone, beans are important in the medium zone and sugarcane is a major crop in the low zone (Table 6.2). Rubiano et. al and Castaño et. al (CIAT's Hillsides Annual Report, 1996) provide further geographic, demographic and agronomic details of Cabuyal.

Table 6.2 Characteristics of the Cabuyal watershed zones

Village	Agro-ecological zone	Characteristics	
El Oriente Buenavista La Esperanza La Primavera El Rosario El Cidral	High	Altitude: Soil type: Area: Population: Density: Crops:	1,700-2,200 m (cold climate) Farallones-Usenda 2,216 ha 1,211 56 inh./km^2, 0.72 ha farm area/person coffee-plantain, sisal, cassava, pastures, cassava-beans, cassava-maize
La Laguna Sta Barbara El Porvenir Las Ventanas Crucero Pescador Pescador Panmericana La Campiña Potrerillo La Llanada	Medium	Altitude: Soil type: Area: Population: Density: Crops:	1,500-1,700 m (temperate climate) Usenda-Pescador-Suarez 2,375 ha 2,307 97.1 inh/km^2, 0.55 ha farm area/person coffee-plantain, cassava, cassava-beans, pastures, beans
Palermo Cabuyal La LLanada El Socorro La Isla El Caimito	Low	Altitude: Soil type: Area: Population: Density: Crops:	1,175-1,500 m (warm climate) Suarez-Pescador 2,775 1,686 60.8 inh/km^2, 0.74 ha farm area/person cassava, pastures, cassava-beans, coffee-plantain-fruit trees, cane

Soil types: Farallones = tipyc humitropept, Pescador = oxic dystropept, Suarez: ustic dystropept, Usenda= typic dystrandept[52]. Source: GIS; Cabuyal census; and Rubiano et al. 1995

6.2 Agriculture

The agriculture of the region is composed of coffee, cassava, beans, maize, plantains, sisal, fruits and vegetables (UMATA, 1992; Langford and Bell, 1997). Crops are rain-fed (biannual precipitation peaks: March and September) and irrigation is uncommon with few exceptions in vegetables (de Fraiture et al., 1997). Coffee (monocrop or associated with plantain) and cassava (monocrop or associated with bean or/and maize) are the most important crops in Cabuyal.

[52] *Suarez* soils (under 2,000 m.o.s.l.) have parental materials composed of sediments of sandstones and shale. Slopes are 25-50 percent with moderate to severe erosion. pH is acid (5.0-5.2). *Pescador* (high tableland of clime medium to humid) are soils influenced by volcanic ashes, deep, fine textures, well drained and have grey to grey-brown colour. Chemically, the soils have high cationic exchange capacity. *Farallones* (2,000-3,000 m.o.s.l.) is a craggy landscape with strong slopes originated from igneous rocks (andesites). Soils are limited by parental materials of fine textures with good drainage and dark brown colour. pH is acid (5.4-5.5). *Usenda* soils (2,000-3,000 m.o.s.l.) have parental materials composed of igneous rocks (andesites) covered by thick mantles of volcanic ashes. The landscape is located between flanks and undulations within intra-mountain zones of could-humid clime. The soils have very high organic carbon contents in the arable layer, low posphorus and acid pH (5.6-6.8). Source: Instituto Agustin Codazzi (IGAC) and CVC (1979).

Coffee was more widely cropped in the eighties but has lost importance due to depressed international prices and pest attacks. Still, coffee makes up to 60 percent of the household income (UMATA, 1992). The importance of coffee and cassava lies on the fact that once planted, they demand less work and investment, compared to other crops such as beans and vegetables. Coffee and cassava require only two weedings. In addition, cassava does not require spraying or fertiliser application. Pesticides are not normally applied to cassava unless there are attacks of *phyllophaga sp*, a worm known locally as 'gusano cachón' or 'mujujoy'.

The planting of beans, maize, peas and sugar cane is undertaken in September and March to coincide with the rainy season. Coffee is mainly planted in September while vegetables and cassava can be grown throughout the year. Land is prepared by ox ploughing or manually, with pick and spade. 'Gallinaza', a compost made of chicken manure and lime, very efficient on acid soils, is the most widespread fertiliser.

In the national context, the Cabuyal watershed is a marginal coffee producing region since craggy landscapes, infertile soils and inadequate processing result in low productivity and poor coffee bean quality. The coffee varieties found in the region are *Caturra* and *variedad Colombia*. *Caturra*, and in lesser occasions, *variedad Colombia* are intercropped with shade crops such as plantain and fruit trees, which are applied as nurse crops (shade for young trees) and sometimes retained when the trees have become mature. Under traditional coffee cultivation little use is made of chemical fertilisers while labour use is confined to sporadic weeding, pruning and spraying. New coffee plantations are planted in September with the first harvest taking place 14 months later. From then on, coffee yields two harvests a year for 7 to 9 years. Coffee processing starts the day after harvesting and includes 'depulping', fermenting, washing and drying. Coffee processing is rudimentary in Cabuyal. Poor post-harvest equipment available to farmers and lack of expertise are reflected in the low coffee quality in the region. Drying is the most important stage of the post-harvest process, and determines, to a large extent, the quality of the coffee bean. Most farmers do not possess drying facilities and instead, the coffee beans are sun dried on polypropylene sheets. Farmers suffering poor climatic conditions or lack of drying space opt to sell most of the coffee production green or humid to traders at a lower price.

'Broca' (*hypothenemus hampei*), a coleopteran that drills and eats the coffee bean and that has caused significant losses in coffee at the national level (up to 40 percent of harvest losses), affects further the quality of the beans[53]. Some farmers prefer to harvest coffee green to prevent 'broca' attacks, thereby reducing bean quality and paid prices. In general, three qualities of coffee are distinguished, namely 'federación', 'seconds' and 'pasilla'. 'Federación' are excel coffee beans that comply FNC[54] export requirements of 11 percent of humidity and 92 percent or more of homogeneity. 'Seconds' are coffee beans that do not comply with 'Federacion' standards. Finally, 'pasilla' are dissimilar coffee beans improperly dry. The first two qualities are for the export markets and the third quality is for domestic consumption. Broadly speaking, 70 percent of the coffee production in Cabuyal is 'seconds' and 30 percent is 'pasilla'. Figure 6.3 shows that farmers sell about 91 percent of their production, which leaves the remaining 9 percent for home consumption.

The north of Cauca is Colombia's major producer of bitter cassava starch, a starch fermented in water ponds, highly prized in the domestic bakery and pastry industry. About 90 percent of the cassava production in Cabuyal is for starch production and the remaining 10 percent is for fresh consumption. Starch processors have favoured bitter varieties of cassava because they yield well on poor soils and offer satisfactory starch content in processing. Cultivation of cassava drastically

[53] Rust in coffee leaves (known locally as *roya*, a fungus that affects coffee bean production) has been traditionally also a major problem. FNC has helped to control this disease by providing its coffee members subsidies in the form of adequate pesticides and training.

[54] Federación Nacional de Cafeteros (national federation of coffee growers) is the autonomous federation of coffee growers that provides technical assistance and credits to coffee producers.

reduces soil fertility because the plant is very efficient at extracting scarce essential nutrients from the soil (Reigning, 1992; Ashby, 1985). *Algodona* is the most common cassava variety in the region with a vegetative period of about 16 months[55]. In higher lands (e.g. in Esperanza and Oriente), a 20-month variety is cropped, which receives premium prices due to greater starch content.

Cassava planting is spread over the whole year. In March and September it is intercropped with beans and/or maize, and in January and June-August it can be found as a monocrop. Cassava is intercropped with maize or/and beans in the second semester due to the belief that maize yields better under the climatic conditions of that semester. Intercropping is an important activity for the growth of cash flow. Inter-crops can be harvested after three or four months of planting permitting farmers to recover large part of initial costs. Even though cassava is fairly available throughout the year, prices are highly variable (between Col.$50 and 145 a kg in 1995). Cassava yields in average 9 ton ha^{-1} if fertilised with 'gallinaza' and 6 ton ha^{-1} without fertilisation. Figure 6.3 shows that about 98 percent of cassava production are marketed.

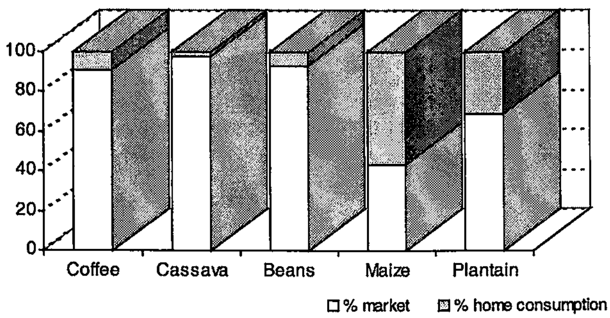


Figure 6.3 Uses of the production of five crops in Cabuyal (%)

Cassava intercropped with beans and maize is more profitable, whereas sole cassava could result in negative returns if cassava prices are depressed. However, many farmers crop solely cassava, because they do not have the money to meet the labour and input requirements of beans; soil nutrient is not fit for beans; or because of the belief that maize competes with cassava for light and nutrients. Sole cassava cultivation has implications for soil erosion as will be discussed later.

Bean varieties in Cabuyal traditionally are bush types with vegetative periods of three to four months. *Caucayá*[56] (a red-mottled and oval-shaped bean) and *Radical* (a red and round-shaped bean) are the major varieties. Red beans such as *Radical* are prized in Popayán and other Colombian southern markets whereas *Caucayá* and other red-mottled beans are prized in the Cali market.

From 1991-1993 the Cabuyal area enjoyed a 'bean boom' as a result of several factors (Ostertag, 1994). These factors included the introduction of *Caucayá (*a variety with great demand in Cali), the creation of a bean-seed producing micro-enterprise, the immigration of bean

[55] Other cassava varieties, such as *Batata* and *Chiroza* (known as sweet cassava varieties), are for the fresh consumption market.

[56] *Caucayá* is a bean variety developed by breeder scientists of CIAT and introduced in Cabuyal by CIAT IPRA.

growers from Nariño[57] and an added institutional support from CIAT, CORPOTUNIA, CETEC, FUNDAEC and other institutions (see section on institutions). Bean production in the Cabuyal region and nearby areas climbed from 100-200 ton to over 1,000 ton per harvest during the bean boom in 1991-1993 to become Colombia's second largest bean producing region. Surprisingly, in mid-1993 the Colombian government intervened by importing beans from Ecuador in order to lower the prices of this staple. This, together with an increased supply of beans promoted in other regions by FNC's diversification campaigns, depressed bean prices and bean production in the region. The region's bean production plunged back to around 200 ton after 1993.

After harvest, bean pods are thrashed manually or mechanically to extract the grains and then are dried, packed in 60-kg sacks and stored until sale. Figure 6.3 shows that about 93 percent of the bean production is sold and the remaining 7 percent is left for seeding and home consumption. Three qualities of beans are distinguished: 'first', 'seconds' and 'thirds'. 'Firsts' are beans free of mechanical damages, pest and disease attacks and properly dry with no visible stains. 'Seconds' are dissimilar beans with noticeable stains. 'Thirds' are damaged beans with not market value that are left for on-farm animal consumption. Beans picked before maturity (green beans) are also used for home consumption. Beans are susceptible to antracnosis (*colletotrichum lagenarium*), a fungus that causes dark round stains on the grain and affects its commercial value.

The regional variety of maize is *coruntillo* or *carpintereño*, which has a vegetative period of five months. In the high zone of the watershed, farmers crop a traditional variety with a longer vegetative period (one year). Maize is cropped in the second semester due to its higher yields in this semester. Figure 6.3 shows that maize is mainly produced for on-farm consumption, for exchange for food with neighbours or kept as seed. The best qualities of maize (yellow grains) are sold on local markets. Smaller grains are used for animal fed and self-consumption.

Plantain is the shade crop for coffee and provides two or three harvests in a period of three years. Two varieties of plantains are found in Cabuyal: *Común* and *Guayabo*. The quality of Cabuyal plantain is not high due to the low fertility of the soils. Plantain bunches are sold on-farm to occasional buyers or exchanged for staples at the market place. The biggest bunches, mainly from the medium Cabuyal zone, are taken by intermediaries to Cali. Figure 6.3 shows that about 70 percent of the plantain production is commercialised and the remaining is left for home consumption.

Vegetables, such as tomato (varieties *Chonto* and *SantaCruz*) and red pepper, are minor crops due in part to lack of irrigation facilities and high capital requirements. These vegetables are sown in January, May and September/October, in fields close to the household for easy access to irrigation equipment and water sources. Vegetable growers sell at the farm gate to rural assemblers who usually provide money and packing boxes in advance to ensure the deal.

6.3 Soil environmental problems and management

The loss of topsoil is one of the most important environmental problems in Colombia. About 170,000 ha of cropping land is lost every year in Colombia due to erosion (Institute *Agustin Codazzi,* 1997). Erosion some times reaches up to 20 cm of the top layer. Around half of the national territory presents some degree of erosion, particularly the Caribbean and Andean regions. In these regions, 829,00 ha of land show severe erosion. The reasons for this are the use of land inappropriate for agriculture and deforestation due to expansion of the agriculture frontier and colonisation.

[57] These farmers from southern Colombia were expert bean growers that contributed with production techniques (e.g. oxen traction and bean trashing techniques) and introduced *Radical* type varieties with great demand in the region and Northern Colombia.

As noted earlier, the Cabuyal soils are fragile, acid and with low fertility and landscapes are craggy. The fragility of the region has been challenged by an over-intensification use of the land. Over time, farming in the watershed has been characterised by shorter fallow periods, more intensive cultivation of annual crops and the extension of cropping onto steeper and more marginal areas (Ashby, 1985). Crops such as cassava have been cultivated on slopes leading to severe soil losses and a decrease in soil fertility (Reigning, 1992).

The fragility of the region's soil has increased as the population pressure increases, which annually grows 2.3 percent. As more than 90 percent of the watershed population depends on the agricultural sector (UMATA, 1992), property sub-division has expanded. This has further deterred the use of fallow practices and resulted in progressive erosion.

The small income obtained from low agricultural productivity, together with the poor availability of resources and the limited agro-industry opportunities, force Cabuyal farmers to rent out lands in fallow periods for short-term cash-crops with the resultant erosive land-use intensity and water pollution effects (Ashby, 1985). As irrigation water has a low cost, it is more economically attractive to clear the bush or deforest watersheds for agricultural purposes than to keep these areas in order to protect community water reserves. This is particular cumbersome in Cabuyal *minifundios*[58] where cassava plots have the highest observed erosion reflecting self-perpetuation of poverty. These circumstances create powerful economic incentives for farmers to clear forestland: higher profits are obtained from clearing new land than continuing to plant on previously cultivated cassava plots. Cabuyal farmers have been adopting a marked preference for short-term benefits since they can only plan from one harvest to the next, and in extreme cases of poverty, from one operation such as crop establishment to marshalling of resources for the next operation, such as weeding (Ashby, 1995).

Poverty and unequal access to markets, infrastructures and income opportunities have repercussions in agricultural sustainability in Cabuyal. With constrained access to capital market, credit and other services, farmers cannot adequately husband their lands or make investments that would enhance their productivity. In such settings, the exchange of farm goods and alternative livelihood opportunities are prevented, which forces the use of the fragile lands beyond their capacity. These conditions have promoted the widespread use of practices such as steep-slope cultivation and monocropping that are inimical to soil sustainability.

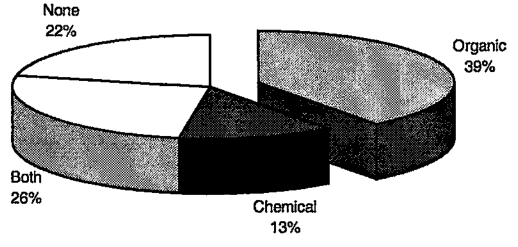
The underlying reason for the disappearance of soil conservation practices and over-intensive farming lies in the prevailing agricultural policies (de Janvry, 1975; Crounch et al., 1980; Piñeiro et al., 1979; Ashby, 1985; Ostertag, 1994). National policies have controlled commodity prices with a certain bias to large-scale crops. Such a bias influences policy for farm commodity prices, agricultural input prices, etc., which create an unfavourable market structure, fluctuating prices and low profit margins. As a result of such economic circumstances, conservation attitudes have been influenced to a large extent (Pachico, 1981). Consequently, small-farm products have to confront very low and highly fluctuating prices.

The response of the government to the growing environmental crisis has been marginal, and mainly canalised through FNC's campaigns of crop diversification. There have been other unsuccessful attempts to promote investment in conservation techniques. The NGOs and other institutions involved in research activities in Cabuyal have also been promoting the use of soil conservation practices with modest results. Although practices were initially adopted, in many cases, they were not maintained. The implementation and maintenance of soil conservation practices were costly and demanded great effort from small householders that have limited land and economic means. CETEC, a financial NGO, conditioned credit to the adoption of live barriers such as 'Citronella' (*Cymbopogon nardus*) and 'Limoncillo' (*Cymbopogon citratus*), pastures very effective in soil erosion control. Although initially adopted, farmers abandoned the

[58] Small farms of owners who have to work as day labourers.

practices because the pastures either did not have other use, such as fodder for animals, or demanded effort and space[59].

Cabuyal farmers practise two fertilisation strategies to tackle low and falling soil fertility: chicken manuring and crop rotation. Chicken manure ('gallinaza') is by far the main fertiliser employed to recover fertility. Cabuyal farmers apply between 5 ton (e.g. coffee) and 10 ton (e.g. beans) of 'gallinaza' per ha. Lower (4 ton per ha or less) and higher applications (20 ton per ha or more) are seen in maize/cassava and vegetables, respectively. 'Gallinaza' is applied at the preparation of the land and is used for more than two thirds of the farmers (Figure 6.4).



Source: Cabuyal census (1993c)

Figure 6.4 Fertilisers used

The predominant use of organic fertilisers is due to several factors. First, farmers cannot afford chemical fertilisers. Second, farmers live too far from centres where other inputs could be obtained. And third, 'gallinaza' seems to suffice on farms located on richer soils of the high agro-ecological zone.

Crop rotation includes fallowing and rotation of crops. Fallowing land embraces leaving the land in secondary brush, scrub pasture or remnants of wood for a period of two to four years or just few months in the case of cash-crops of short cycle. After fallowing, the land is cleared by cutting and burning off trees and brush from the plot. Then, the land is prepared and exposed to the rains for two or three months until crop cover is established. Crops come then in place and the plot is left again with the soil exposed until natural vegetation is re-established. The potential for soil erosion is especially high during the months prior and subsequent to the crop establishment as the soil is exposed to intensive tropical rainfalls (Reigning, 1992 and Howeler et al., 1981). This is particularly critical in cassava cropping.

Coffee is planted on the best soils of the farm. In preference, it is planted in new soils of recently cleared land or preceded by rotations of high-input crops, such as beans and vegetables, in order to increase the fertility of the soil. Coffee has been an important agent in preventing a major degradation of the soil resource base. Coffee tree's bushy, root and canopy characteristics have impeded, to some extent, greater losses of soil in the area[60].

Cassava is commonly cropped once in poor soils and twice in richer soils. Thereafter, the field

[59] CIAT IPRA had relatively better results when organised field days in which farmers could observe and discuss trials in other farmers' fields. Trials exhibit recommended cultural practices addressed to overcome local soil problems. In the case of live barriers, farmers opted for sugarcane and fodder pastures.

[60] Some studies carried out by the CIAT's Soil Conservation Program show that beans can also contribute to control soil erosion. Erosion is minimal when a single bean harvest is done, since its root system belays soil and, helped by chicken manure, covers 100 percent of the area.

is left in fallow at least two years to recover fertility. Cassava can be intercropped with beans, but the soil must be good enough for beans to grow. *Algodona*, the local cassava variety, yields well on nutrient poor soils. Consequently, cassava is cropped sole in poorer soils and, as the plant is slow to establish a canopy surface over the soil surface, it often results in high levels of soil erosion, particularly on steep slopes. Howeler and Cadavid (1981) concluded that with the best set of conservation practices, cassava could drop from 40-50 ton ha^{-1} $year^{-1}$ down to about 9 ton ha^{-1} $year^{-1}$. According to their results, the cropping of cassava in successive rotation would run out the 15-25 cm thin soil cover. Other crops show less critic levels of soil loss (around 40 percent less).[61]

Maize and beans can be monocropped up to three times in a row before fallow. When a particular field comes from fallow, farmers take advantage of the renewed fertility, cropping annual crops two or three times before planting a perennial crop such as coffee or plantain. Figure 6.5 shows some of most customary rotations in Cabuyal.

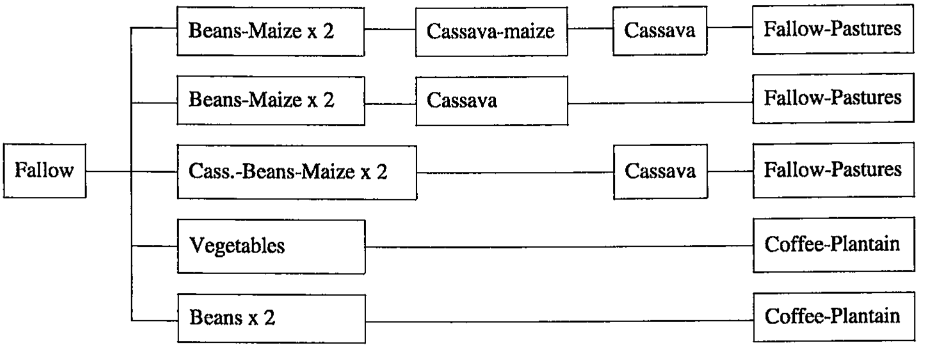


Figure 6.5 Sample of crop rotations in Cabuyal

6.4 Labour

Farm activities are labour intensive rather than capital intensive due to the low cost of labour and the scarcity of alternative income generating activities in the region. Labour accounts for up to 60 percent and 50 percent of coffee and cassava production costs, respectively. The poorest farmers of the region contribute significantly to the supply of labour in Cabuyal. The cost of the labour in Cabuyal, no including lunch, was Col.$4,000 a day (US$4.2 a day) in 1996. Labour wages are lower in the watershed highlands (up to 25 percent less a day) due to scarcer economic opportunities. The payment for labour is increased twice in the year: once in January to account for annual inflation and once in March during the main coffee harvest. Labour is most abundant in summer (June-August), when there are fewer farming activities. During this period, weeds dry easier and most farm activities revolve around seed-bed building.

[61] In another study, Muller (1992) established that live fences and fertiliser reduce in more than 70 percent the soil losses due to cassava. However, the economic applicability of these practices is low according to Estrada (1993). With half of the cost of fertiliser recommended, the farmer could rent another hectare of land to produce 9 tons of cassava.

6.5 Infrastructure

Physical infrastructure is poor in Cabuyal (Luijten, 1999; Ashby, 1995; Ostertag, 1994). Only a small number of farms adjacent to an unpaved road that goes along the region have access to transport means and electricity. Telephone lines are virtually nonexistent. These conditions limit the efficient fulfilment of marketing activities. Market information is poor in the area. Farmers usually do not have knowledge of product prices in the nearest city markets such as Cali and Popayán. The chief sources of market information are neighbours and rural traders. Farmers with bad access to roads, opt to sell their produce to rural assemblers at lower prices.

Transport

There is only one paved road (the Panamerican highway), which crosses the narrowest part of the region (see Figure 6.2)[62]. Unpaved roads connect the south with the north part of the watershed. Some segments of these roads become impassable during the rainy seasons. Pick-up vehicles are common means of transport. A one-way ticket within the watershed amounts at US $0.40, one-third more expensive than the cost of a pound of rice.

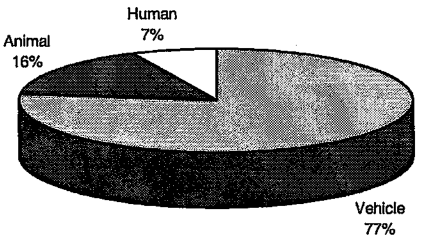


Figure 6.6 Transport means
n=120 farmers. Source: Market survey, 1994.

Figure 6.6 shows that horses and other animals are also important means of transport, particularly in isolated zones of the watershed or during the rainy season. Buses and pick-ups cover routes to outside places on market's days (with Popayán on Monday/Friday and with Santander on Wednesday/Sunday).

Markets

Local markets are Siberia, Pescador[63], Mondomo and Tunía. Middle size markets are Piendamó and Santander (including Agustina) that serve as assembling centers for larger markets such as Popayán and Cali. Farmers lacking of transport means or quality produce take the product to local markets of Siberia and Pescador. Products are assembled and graded and then taken to middle size markets where are bought by local consumers or transported to the main market centres such as Popayán, Cali and Bogotá.

[62] At the end of this study, a road communicating Siberia and Pescador (upper part of the medium agro-ecological zone) had been paved in the watershed.
[63] Laguna and Quingos (half-way between Pescador and Siberia) host also some starch processing plants.

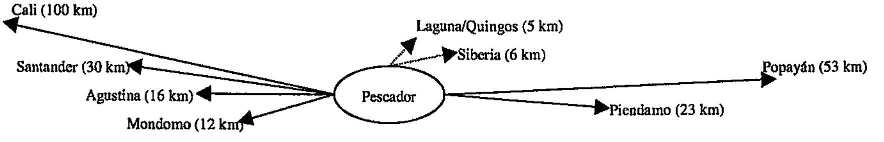


Figure 6.7 Distances to markets in Cabuyal

Figure 6.7 shows the approximate distances between Pescador and local, middle and big market centers. Normal lines denote paved roads and dotted lines denote unpaved roads.

Banks

Two banks serve Cabuyal peasant farmers. The *Banco Cafetero* (the Coffe Bank), whose services are directed to coffee growers, is the financial arm of FNC. The Agrarian bank is a state-owned institution that gives credit to a wider portfolio of agricultural activities. Both banks are located in Santander, 30 km from Pescador. A branch of the Agrarian Bank located in the watershed was assaulted and blown up by guerrillas several years ago.

Warehouses

Apart from the private warehouses of wholesalers in Santander and Piendamo, there are no public or farmer-owned storage facilities. Neither there is availability of assembling depots where classification and grading of products could be done at a large scale.

Agro-industry

There are two main traditional small-scale rural agroindustries: "rallanderia" (cassava starch processing plants) and trapiches (sugar cane processing plants that produce 'panela' or whole-sugar bricks). Starch processing plants are discussed elsewhere.

6.6 Marketing

Agricultural marketing in the Cabuyal watershed is at an early stage of development. Factors such as underdeveloped infrastructure, the large number of separate farm production units and unclear agricultural policy frameworks complicate marketing activities in the region. These factors create unfavourable conditions for marketing channel actors though independent operators, such as intermediaries, seem to have an advantage in adapting better their operations to such conditions than formal marketing institutions.

The intermediary

The intermediary emerges as a prominent actor in most of the marketing channels due to the poor infrastructure and lack of financial sources, storage, equipment and processing expertise in Cabuyal. In particular, intermediaries are flexible to adapt to or benefit from:

- the lack of post-harvest expertise in processing and grading that conducts reiteratively to poor produce quality.
- the lack of storage capacity that compels farmers to sell small quantities of produce as it is being harvested in order to avoid losses and quality deterioration.
- the farmers' daily urgency to obtain money to meet immediate needs
- the inadequate access to roads and transport means

- the low prices usually prevailing just after harvest

Usually, the intermediary is, or has been, a farmer and may own a small truck. He buys any kind of produce quality (first, second and third grades) either on-farm (such as vegetables, maize, cassava and plantain) providing sometimes the packaging or at the market place (such as coffee and beans). He sorts, grades and distributes products to different consumer segments; disseminates information on prices and future demands. He habitually makes small pre-harvest advances and discounts the credit from the cash payment. Nevertheless, the credit market is limited and interest rates are high. Although there is some bargain when discussing discounts associated with produce quality and any money advances, the price is normally imposed by the intermediary. Although intermediaries complain about low quality produce, they do not make much effort in instructing peasants on proper processing, sorting and grading since quality dissimilarities is a reason to stay in business.

The dominance of the intermediary in the Cabuyal agricultural marketing channels is reinforced by the services they give:

- buying small amounts of any quality of produce
- paying in cash or at most within a week
- making pre-harvest advances with not collateral.

These services, especially credit and flexibility with assorted produce, fit easily to the Cabuyal farmers who habitually lack capital and interest in grading. The intermediaries work informally, do not pay tax and use these services to ensure supply from rural peasants. Hence, marketing institutions, such as cooperatives, sometimes find it difficult to compete with intermediaries if they do not offer credit, good prices and are flexible with produce quality.

Notwithstanding all these considerations, farmers express considerable dissatisfaction with the intermediary.

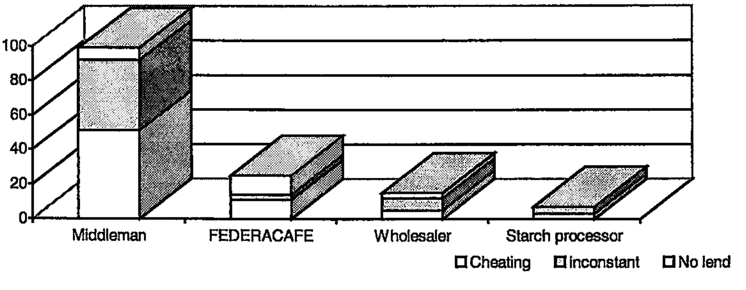


Figure 6.8 Reasons for changing buyer (number of responses)

Figure 6.8 illustrates that farmers show greater discontent with small intermediaries. Cheating in weight and price and unstable characteristic of the commercial relationship are the main reasons for this discontent. Farmers consider that these agents take advantage of the circumstances to abuse them in relation to the price paid and the cost of credit.

Marketing institutions

The marketing institutions that are found in the Cabuyal agricultural marketing channels include FNC, COAPRACAUCA, starch processing plants, CORPOTUNIA, ECONORCA, IDEMA and SEMILLAS

PESCADOR[64] (Ashby, 1985; Ostertag, 1994; Ravnborg and Ashby, 1996)[65]. These institutions concern the main cash crops of the region (coffee, cassava and beans). With the exception of COAPRACAUCA, CORPOTUNIA and SEMILLAS PESCADOR, these institutions behave like administrative vertical marketing systems[66] where contracts with farmers are informal and sporadic. Similar contracts are also seen between farmers and rural assemblers for the production of highly perishable products such as vegetables.

The national federation of coffee growers (FNC) is as a private non-profit association of coffee producers established in 1927. The Federation is responsible for the management of a national coffee fund, for provision of technical assistance and credit to growers, for the control of domestic and export marketing, and for advice on the setting of certain rates of taxation and prices for the coffee industry. Its supreme authority is the National Congress of Coffee Growers where the national government is permanently represented. Departmental Committees provide education, technical assistance and social services in all coffee producing regions. In the study region, FNC is represented by the Cooperative of Coffee Growers of Santander (Cafinorte) and the Cooperative of Coffee Growers of Piendamó (Coopiendamó). The participation of these cooperatives in the Cabuyal coffee market is described in the following section. Depressed international coffee prices forced FNC to promote crop diversification in marginal coffee producing regions such as Cabuyal, where coffee bean quality is poor in order to reduce coffee supply. The promotion included intensification of production of beans, plantain and other staples; subsidies to encourage the change from coffee to other crops; and the elimination of input subsidies.

FNC has stringent quality standards for purchases but payments are regularly on the same date of the transaction. Coffee beans must be dry and clean, with maximum 5.5 percent of 'pasilla' (dissimilar beans) and 3 percent of 'flojo' (half-dried beans). Few coffee growers in Cabuyal can comply with these standards. At the time of this study, Cafinorte and Coopiendamó were offering prices lower than those of private coffee exporters. Consequently, the coffee cooperatives were procuring 10 percent or less of the total coffee production of the zone in 1995 compared with 70 percent in 1993. Wholesalers and private exporters paid higher prices and were more flexible with quality.

COAPRACAUCA is a cooperative created in 1983 with the objective of assembling enough volumes of starch to supply the national agroindustry and to offer attractive prices to producers thanks to direct contracts with the food industry[67]. By 1995, the cooperative was composed by starch processors (33 members) and cassava growers (25 members)[68]. Payments are due 8-15 days after the starch is received. COAPRACAUCA commercialises around ten percent of the starch of the region (600 ton a year) and has stayed at this level for the last years. The cooperative has not been able to exceed this level due to lack of capital. Many of its members operate informally and lack the collateral required by banks. COAPRACAUCA trades the starch with the agro-industry in Cali (baker coops and Maizena), Bogotá (baker coops and distributing wholesalers), and

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[64] Other institutions include supporting institutions such as FIDAR, FUNDAEC and CETEC. FIDAR has had a role in promoting the development of small agro-industries in the region. FUNDAEC and CETEC played an important role on credit assistance to bean growers during the 'bean boom'. However, their presence in Cabuyal was significantly lessened after many credits defaulted when bean prices collapsed.

[65] Ravnborg and Ashby (1996) and CIAT (1993) give a detailed listing of other type of organisations and their functions.

[66] See Chapter 2 for the definition of administrative systems and other VMS type schemes.

[67] COAPRACAUCA made also bean purchases during the 'bean boom' in 1991-1993.

[68] The interest of cassava growers to be members of a starch cooperative such as COAPRACAUCA is twofold. First, growers can apply for production credits. Second, COAPRACAUCA is an appropriate forum for deal making.

Pereira and Medellín (Delmaiz, Alimex and baker coops).

Starch processing plants or 'rallanderias'[69] are small-scale enterprises committed to the production of cassava starch. There are around 190 plants in Cabuyal and nearby areas, which are normally run by families. Although there is some mechanisation in the starch extracting process, the equipment and techniques employed are rather rudimentary. Cassava starch is primarily sold to the pastry industry[70] for the production of bread and local snack foods (*pandeyuca*, *almohabana* and salty donuts); and to the animal feed and glue production industry. Fermentation, the most important processing stage in starch production, is a key factor in starch quality. Twenty days is the minimal duration of fermentation. Shorter fermentation periods are associated with lower starch qualities. Three different starch qualities are distinguished. The first starch quality is used in *pandeyuca* baking and is worth around Col.$1,200 a kg. The second and third starch qualities are employed in the elaboration of *almohabanas*, salty donuts and *buñuelos*, and it is 20-25 percent cheaper[71]. The agro-industry sustains that Cabuyal starch could render higher quality, and therefore higher economic returns, with a more adequate processing.

Starch processors rule the cassava marketing channel in Cabuyal. They are key agents in injecting finance in the zone. They tie the supply of cassava by granting pre-harvest loans to the growers that involve implicit interest rates that easily doubles the bank rates. These loans represent the farmer's compromise of sale and acceptance of the terms of price and discounts related to the provision of packing sacks, transport and credit. Payment is due within two weeks. Starch processors indicate to farmers the most convenient date of harvest and collect the produce at the farm. Starch processors are tough buyers whose main concern is to ensure supply. They are careless of farming practices as long as these do not affect output volume and starch content. Rather, they promote monocropping to boost cassava productivity per unit area and cassava varieties that adapt very efficiently to nutrient depleted soils and yield higher contents of starch.

CORPOTUNIA is a NGO created in 1986 by the Carvajal Foundation, a non-profit organisation with headquarters in Cali. CORPOTUNIA is based in Tunía (15 km from Pescador) and aims at improving the life standard of rural communities in the northern part of Cauca by bettering agricultural trade channels for products such as beans am hog. It also offers training in post-harvest, handicrafts and agricultural/livestock production. In particular, CORPOTUNIA played a major role in the commercialisation of beans during the 'bean boom' in 1991-1993. CORPOTUNIA established an alternative marketing channel by linking bean growers with reliable buyers in Cali, such as supermarket chains and grocery shops, and coordinated the assembling and transport of the produce. Some of these buyers were grocery shop cooperatives also supported by the Carvajal Foundation in poor neighbourhoods, for the purpose of reducing the cost of living.

As a result of direct contracts, farmers received a premium price (from 10 to 15 percent higher than in intermediary marketing channels). CORPOTUNIA also coordinated the obtaining of production inputs such as fertilisers, seeds and pesticides, which were reflected in lower costs due to economies of scale. CORPOTUNIA charged farmers a reasonable commission for its services. CORPOTUNIA's services, however, declined significantly since 1993 and now are limited to a small number of bean producers due to constraints in capital and other resources (Roa, 2001)

The Trading Enterprise of North Cauca (ECONORCA) was a small cooperative established by COAPRACAUCA, other small cooperatives, JAC (the Cabuyal Community Action Group) and the Caldono town hall. ECONORCA operated in Pescador from 1993-1997 and its operations involved

[69] Starch processing plants take this name from grating the cassava, one of the processing stages to obtain starch.

[70] Starch is traded to the agro-industry in Cali (baker coops and Maizena), Bogotá (wholesalers and baker coops), and Pereira and Medellín (Delmaiz, Alimex and baker coops).

[71] *Afrecho*, a starch processing residue, is sometimes sold to the animal feed industry if it meets certain sanitation standards.

the assembling of commodities (mainly beans) for Santander's and Cali's markets and the supply of basic staples to local farmers at affordable prices. ECONORCA bought beans from members and non-members and payments were due within one or two weeks. Credit and production inputs were not offered. ECONORCA closed operations because the business went unprofitable (Roa, 2001). Economic margins were insufficient to pay a higher price for not fully graded beans while running in fixed costs such as personnel, energy, telephone, transportation, etc.

IDEMA, the Colombian Institute for agricultural and livestock marketing, became active in the region in early 1993 as a result of a request from CORPOTUNIA and other local entities. IDEMA established a buy point in Pescador in order to secure part of the bean production during the 'bean boom'. IDEMA fixed a floor price at about 7 percent higher that the market price and propelled a competence that benefited bean farmers until mid-1993. Payments were due 2-3 weeks after the product was receipt. In mid-1993 the Colombian government decided to import beans from Ecuador in order to lower the prices of this staple. This action depressed bean prices and bean production in the region. Instead of opting to improve the distribution channels towards other bean consumer markets, the government opted to discourage bean production and sacrifice the economic development of the region that was, until then, Colombia's second largest bean producing region. IDEMA closed down operations shortly after the coffee boom was over.

SEMILLAS PESCADOR (PESCADOR SEEDS) is a micro-enterprise promoted by CIAT IPRA and created in the early 1990s by seven farmers for the production and trade of *Caucayá* bean seeds. The group of farmers carefully trash, clean, dry, grade, fumigate, pack the bean seeds in 5 kg bags and sell them to other farmers and local institutions (such as FNC). These farmers were trained by CIAT in seed production and by the Carvajal Foundation in management and accounting. Part of the capital was also obtained from the Carvajal Foundation. SEMILLAS PESCADOR only buys seeds to members and commercialise around of 30 ton per semester, around 30 percent of the bean seed commercialised in the region (Roa, 2001).

6.7 Marketing channels

Coffee, cassava and beans are the main cash crops in the region. The general characteristics of trade and distribution channels of small-farm products in Cabuyal vary to a large extent. Irrespective of this, the intermediary dominates most of the marketing channels. Marketing intermediaries can be divided into assembling traders, collecting wholesalers and distributing wholesalers. Assemblers can be subdivided in rural and external assemblers. Rural assemblers are usually local farmers who collect produce from the farm units (at the farm gate or at the market place) to sell to wholesalers in nearby markets (Santander and Popayán) and, less frequently, to big markets in Cali and Popayán. External assemblers are foreign intermediaries who collect produce from the farm units to sell to wholesalers in Cali. In small markets, wholesalers carry the commodities to larger towns such as Cali and Popayán or sell to distributing wholesalers, who in turn sell to retailers or to the end consumer.

In the rural areas, rural assemblers (small grocery shops, market stalls and street vendors) are the most common middlemen. Rural assemblers or even consumers might buy directly from farmers. Street vendors are located on sidewalks outside wholesaler and coffee depots. They buy the produce either from farmers who bring small amounts of assorted grains and roots or from farmers who want to avoid time-consuming transactions. Their profit is not the margin of each small transaction but the large volumes traded in one day. Once the produce is cleaned and assorted, middlemen resell the product to wholesalers. If the produce is of moderate or better quality, farmers turn to wholesalers or to the coffee cooperative, in the case of coffee. At the market place in rural areas is common to find assemblers, wholesalers, retailers and consumers alike. Consumers can find large differences in price depending on the agent they are dealing with.

Traders complain about the unwillingness of farmers to clean, sort and grade the produce. Explanations for this are first, there is no culture or training in post-harvesting; second, traded quantities are often too small to justify the work; third, current prices discourage the effort required in selecting uniform lots. Nevertheless, farmers were not much enthusiastic when institutions such as CORPOTUNIA and IDEMA demanded cleaner and graded produce in exchange for higher prices. Whether this is due to lack of expertise or cultural factors is hard to determine. The market characteristics of five products are discussed below.

Coffee

After harvest, coffee is processed on-farm. The initial (wet) processing is undertaken mostly on the farm while rousting plants undertake the curing of the coffee beans (hulling and grading). On-farm processing comprises 'depulping', fermenting, washing and drying. Coffee is 'depulped', washed four times, left one day in fermentation and dried. According to local traders, Cabuyal farmers are good coffee growers, but bad post-harvesters. Cabuyal farmers improperly perform both washing and drying operations. At difference of non-marginal coffee areas in Colombia, such as the Caldas coffee region, Cabuyal growers do not posses the minimum equipment required for the processing of coffee up to the parchment stage. Bad washing is mainly due to lack of expertise and inadequate water tanks. Improper drying is due to absence of drying facilities such as silos. Coffee is commonly dried under the sunlight instead. Bad weather and occupation on other farm activities hamper an optimal drying process, which results in what is called half-dried coffee ('flojo').

Inadequate drying is the key reason for price discounts. Once dried, coffee beans are stored to wait for higher prices. When improperly dry, stored beans get mouldy ('cardenillo'), which is penalised with further price discounts. Other reasons for price discounts are assorted grain sizes ('pasilla' and 'ripio'), green coffee (washed but not dried coffee) and 'brocado' coffee (affected by 'broca'). For 'pasilla', 'ripio' and 'brocado' coffee, price discounts are related to the proportion of non-uniform grains in a sample. For green coffee, price discounts can be 50 percent or more for inadequate dried beans. Depending on quality and prevalent market prices, coffee beans are sold either at one of the countrywide buying points of the FNC, coffee cooperatives or to other intermediaries. Figure 6.9 shows that intermediaries buy over 90 percent of the farm coffee sales in Cabuyal, indicating the limited importance of FNC as a direct coffee buyer.

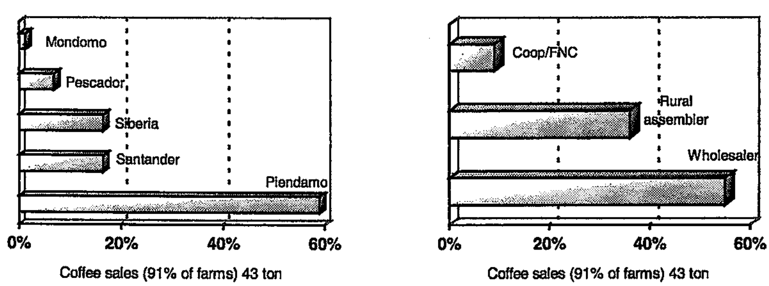


Figure 6.9 Coffee sales by market and market agent from surveyed plots
Source: Market survey, 1994

Assorted and poor quality beans ranging from 'ripio', 'brocado' to 'flojo' are sold to small middleman and street vendors. These traders assemble small lots of coffee and clean and grade the beans according to quality before reselling to wholesalers. Wholesalers buy medium quality and half-dried 'flojo' coffee beans but reject very poor lots. Wholesalers finish the drying process of humid coffee, grade coffee beans and transport and sell the best coffee to FNC, coffee cooperatives and private exporters[72]. FNC buys only coffee beans that comply with at least 92 percent of cleanness and 11 percent of humidity[73]. The Federation buys the coffee at a fixed minimum price at any of its national buying points. The coffee is then bulked and transported to depots or mills in Cali, if it comes from Santander, or in Popayán, if it comes from Piendamó. It is cured and taken for export to Buenaventura, the main Colombian export port on the Pacific coast, where it is stored and shipped or milled just before export. Medium (up to 20 percent of dissimilar beans) and lower coffee qualities are sold to roasting and milling plants for domestic consumption.

Figure 6.9 shows that Piendamó is the main coffee market place of Cabuyal farmers, with about 60 percent of sales. This coffee is of medium or high quality and is mainly bought by wholesalers and FNC. The remaining coffee is taken to Santander and Siberia (16 percent each) or sold in nearest villages such as Pescador (7 percent) and Mondomo (1 percent). This coffee is of inferior quality and is sold mainly to small intermediaries. Figure 6.10 shows the marketing channels of coffee in Cabuyal.

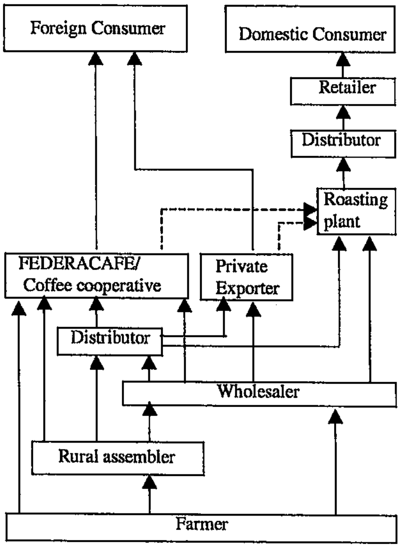


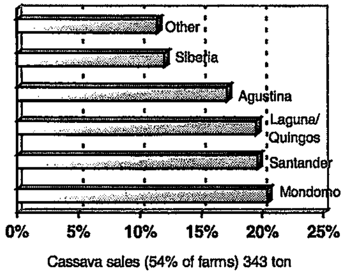
Figure 6.10 The coffee marketing channels

Cassava

Cassava does not have a strict maturation period (between the 16th and the 20th month after planting). Thereby, harvesting can be delayed to reap the benefits from eventual higher prices

[72] At the time of this study, an important part of coffee production was being smuggled for some traders to Ecuador, where prices were more attractive than FNC's depressed prices.
[73] In 1996, a coffee-farmer movement achieved changes on the purchasing policy. FNC started buying less premium qualities of coffee with minor 'broca' attacks in the bean.

outside the main harvest season[74]. Cabuyal small-scale farmers commit the cassava production to starch processors through pre-harvest loans. Figure 6.11 shows that 96 percent of farmers deal with starch processors and 4 percent with rural assemblers. This illustrates the dominant role of starch processors in the cassava marketing channel.[75]



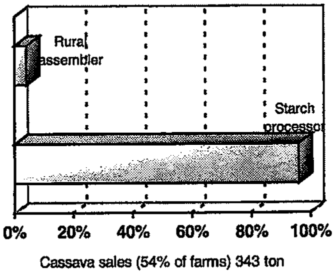


Figure 6.11 Cassava sales by market and market agent from surveyed plots
Source: Market survey, 1994

Due to its perishability, cassava is harvested once an agreement with a buyer has been reached and the cassava is transported to the starch plant in the same day. Cassava is up-rooted and graded. The trader provides the sacks and the farmer is responsible for packing and transporting the cassava to the limit of the farm where the trader takes it to any of the 190 starch plants of the region. Figure 6.11 also shows that Cabuyal farmers sell similarly to starch plants in Mondomo, Santander and Laguna/Quingos (around 20 percent each) and Agustina (17 percent).

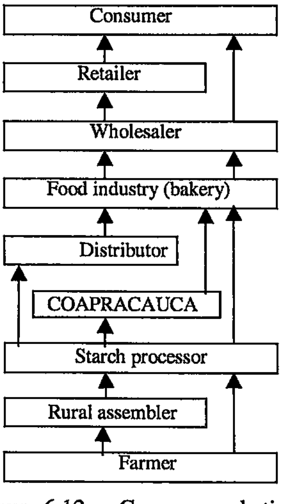


Figure 6.12 Cassava marketing channels

[74] Regardless, this strategy is too risky because of renewed sprouting and the consequent loss of starch in the roots (cassava is said to get watered or 'aguachenta').

[75] Infrequently, farmers either in bad economic conditions or extremely bad access to road, sell to rural assemblers the crop on the field (*vender en mata*). The trader harvests the field and recognises a lower price.

90 to 95 percent of the 42,000-45,000 ton of cassava produced in Cabuyal and nearby areas is utilised in starch production (Ostertag, 1994), which yields around 8,000 ton of cassava starch[76]. COAPRACAUCA commercialises around 10 percent of this production. Small amounts of cassava sold to rural assemblers are used for fresh consumption. Figure 6.12 shows the cassava marketing channels.

Beans

The volume of beans traded in Cabuyal is not evenlly distributed within the year. In the first semester, the traded amount of beans doubles that of the second semester. This is due to the farmer's requirement to generate income to cover land preparation and other costs for coffee planting in the second semester. As with coffee, bean prices are determined by grading and sorting levels. Price discounts are applied to assorted grain sizes and green produce. Bean prices are punished with discounts if a sample contains stones, dust, harvest residues and dissimilar sizes and forms. 'Dirty' produce is returned for home consumption.

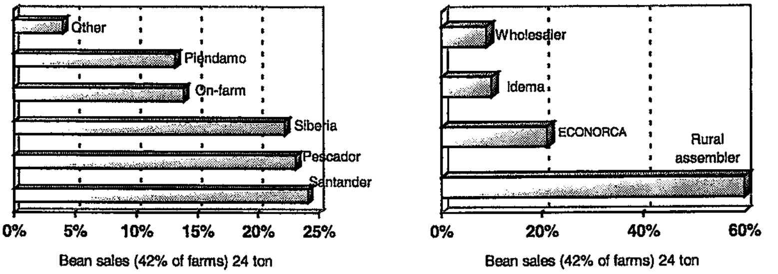


Figure 6.13 Bean sales by market and market agent from surveyed plots
Source: Market survey, 1994

Figure 6.13 shows that beans are preferably sold in Santander (24 percent of farmers) or in any of the middle watershed local markets. Fourteen percent of the farmers sell beans on-farm. Figure 6.13 also shows that the small intermediary, with 60 percent of sales, is the main beans' buyer in the watershed. 21 percent of farmers reported sales to cooperatives (i.e. ECONORCA). Once assembled by traders, beans are taken subsequently to public markets and assembly centres in Cali and Popayán. Figure 6.14 illustrates the marketing channels of beans.

[76] The production ratio cassava:starch is 5 ton of cassava per 1 ton of starch (highland cassava varieties may yield higher amounts).

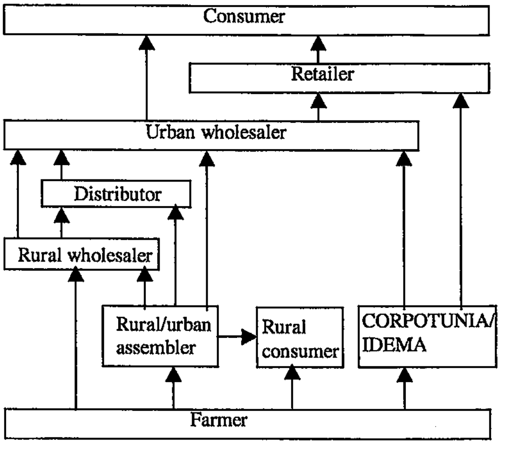


Figure 6.14 The bean marketing channels

Maize

Maize is mainly used for animal feed and self-consumption. It is cropped sole in small plots or intercropped with beans and/or cassava. When sold (around 40 percent of the volume produced), it could be either green and unshelled or dry and shelled.

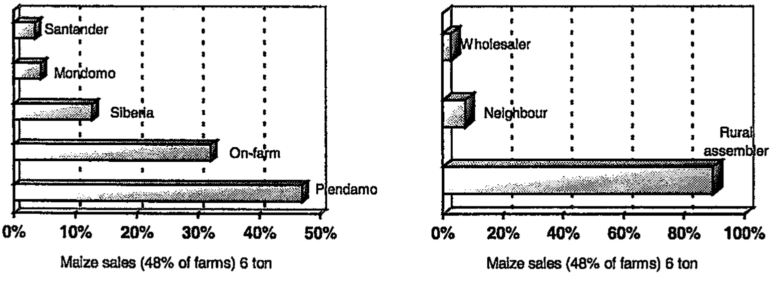


Figure 6.15 Maize sales by market and market agent from surveyed plots
Source: Market survey, 1994

Figure 6.15 shows that 32 percent of sales are on-farm, commonly to neighbours (mainly green maize). 47 percent of sales are taken to Piendamó where it is sold or exchanged for staples. Rural assemblers (mainly street vendors), with 90 percent of sales, are the principal buying agent. Figure 6.16 illustrates the maize marketing channels.

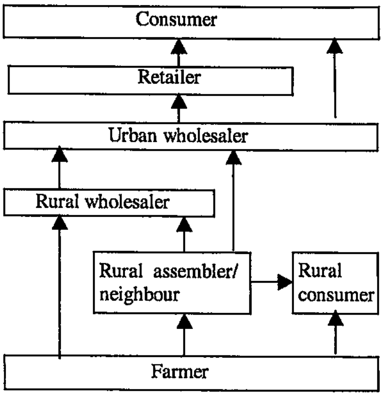
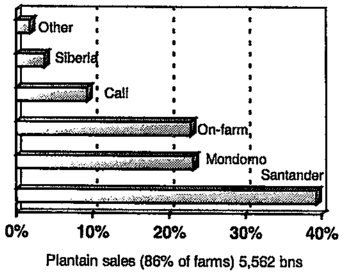


Figure 6.16 The maize and plantain marketing channels

Plantain

Plantain, the coffee's nurse crop, is sold either on-farm (23 percent of farmers) or in Santander and Mondomo, and a minimum part is exchanged for primary products in local markets, as illustrated in Figure 6.17. Small intermediaries are practically the only market agents for Cabuyal plantain. Figure 6.16 shows that plantain marketing channels are similar to those of maize.



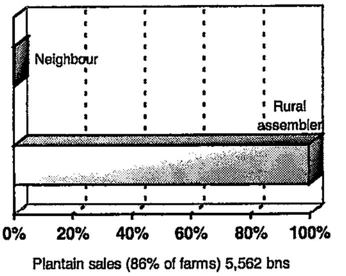


Figure 6.17 Plantain sales (in % of sold bunches) by market and market agent from surveyed plots.
Source: Market survey, 1994.

6.8 Financing

In Colombia, financial services for small-scale farmers and rural marketers and processors are inadequate. The reason for this is twofold. Firstly, private banks are not very eager to finance high-risk perishable small-farm products. Secondly, small-scale farmers and marketers operate in informal markets and often lack collateral to back loans.

As noted earlier, there are two financial institutions serving rural areas, namely *Caja Agraria* (Agrarian Bank) and *Banco Cafetero* (Coffee Bank). Farmers wishing loans from these banks need to go to Santander (30 km from Pescador) and meet the bank requirements. Most small-scale farmers cannot provide supporting documents on land title[77] or, otherwise, find the bank procedures time consuming and costly. Consequently, the business activities of all marketing agents from producer to processors are very limited due to lack of finance. Despite this, intermediaries operate relatively efficiently because they are numerous and very flexible, lending small amounts of money to equally numerous farmers.

In the Cabuyal Rive watershed, informal credit is important because it finances the daily needs of the farmer and the purchase of crop inputs. Mainly local market agents (intermediaries and starch processors) offer informal loans as short-term pre-harvest advances. Traders lend according to the crop area and farmers' previous performance. Loans are in the form of cash or inputs (e.g. chicken manure, the most common fertiliser). Advances are given for different reasons. They may be small amounts of Col. $10,000 (US $10) on the day of the market to buy food or may be higher amounts of Col. $150,000-200,000 (US $150-200) to buy crop inputs. There are neither signed documents (the farmer's word is accepted) nor collateral, but the farmer's commitment to selll the production to the moneylender. Debt is discounted from the harvest payment implicitly through a lower crop price. The real interests of these loans, estimated at 40-60 percent annually (Hernandez, FIDAR, pers. comm.), are considerably higher than bank interest of 30 percent. Traders consider this service important, because it assures supply. They state that 'the trader who does not lend, does not buy'.

Self-financing is an important way of financing farm activities. Resources can be obtained from previous harvests (coffee and other cash crops) or from the family's off-farm activities. Intercropping short-duration annual crops with perennials or semi-perennial crops is another way of self-financing. It permits the farmer to recover great part of his initial costs. A minor income source comes from cattle and poultry activities.

6.9 Risk avoidance

Farmers reduce market and agronomic risks by diversifying crops in space and time. This practice, however, depends to a large extent on the rainy season, though cassava and vegetables offer particular advantages. While local cassava varieties are very well adapted to dry conditions vegetables can be grown throughout the year using water irrigation.

Other risk avoidance strategies are intercropping and sharecropping. The farmer attempts to reduce production costs by intercropping cash crops. Moreover, inter-crops such as maize and plantain provide mulch and organic fertilisation for the remaining crop, thereby decreasing costs. Sharecropping is another activity practised by very poor farmers in association with other farmers and rural assemblers. The farmer puts the land and the labour and the partner puts the capital. The harvest is divided into equal parts. Sharecropping is intended to spread cash investment and risk of harvest losses through time and across different locations.

6.10 Sampling in the Cabuyal Watershed

6.10.1 The survey

In order to analyse soil sustainability in Cabuyal, information on farm soil management and marketing was required. In a preliminary step, a census of the region, carried out by the CIAT Hillsides Program in 1993 (CIAT, 1993b), was analysed.

The census was undertaken in November 1993 and covered the 22 villages that comprise the

[77] Many do not have a legal title of property because of an unfinished succession.

watershed. In this census, CIPASLA personnel collected information on such matters as home characteristics, land use, natural resources status, agricultural production difficulties, marketing, etc. The diagnosis had participatory components, to ensure the involvement of the community in the process. The diagnosis comprised review of the following aspects:

a. Biophysical: weather, land, water, vegetation, geomorphology, flora and fauna, etc.
b. Socio-economical: land use, land tenure, infrastructure, population, family welfare, marketing, agro-industry, employment, housing and health.
c. Administrative: institutional presence and development plans.

Understandably, the Cabuyal census did not cover all the aspects that could serve the purpose of this study. This study demands a more in-plot focused appraisal of soil management vis-à-vis the marketing channel in use. To generate this information, a survey was undertaken in the Cabuyal watershed. The data to be collected will allow estimating the extent to which farmer's attitude towards the soil resource (degree of adoption) is being affected by his varying approach to the market (market systems).

Appendix B presents the questionnaire used in the survey, which is composed of two parts. Part one of the survey comprises sections one to seven, which review soil conservation management. In section one, the farmer and the village are identified. Section two determines the ethnic origin of the farmer. Section tree records the farm size. The two most important plots according to the farmer are characterised in section four. The reason for the importance of the plot is also queried. Sections five and six distinguish some plot characteristics and the soil conservation practices observed. Soil practices are grouped in seven categories: soil conditioning, water management, soil preparation, sowing, fertilising, weeding and harvesting. Section six-b details the types of (live) barriers and distances. Section six-c inquiries on conservation practices on other places of the farm. The last part of section six reviews investments made or planned in the farm and long-term horizon attitudes of the farmer. Lastly, section seven reviews farmer's reasons for working the land. Altogether sections five to six-b provide the basis for the appraisal of the soil sustainability variable.

Part two of the survey includes sections eight to eleven, which examines the commercialisation of the products and the access to marketing services and institutions. Section eight quantifies the amount produced and marketed of each crop, whereas section nine identifies the buyers of the produce. Part b of section nine evaluates the commercial stability of the farmer and the buyer. Distances from the farm to customary market centers are appraised in section ten. Section ten also asks for customary sources for price information, marketing attitudes (such as bargaining, orientation to the market, etc.), risk aversion attitudes and a farmer's assessment on his access to marketing services. Finally, section eleven identifies institutional links and the services provided by those institutions.

6.10.2 The sampling method

Farm households in the Cabuyal watershed are dissimilar in terms of land use and market access. The medium geographic zone is twice as densely populated as the high zone. This implies greater pressure on the land, consequences in land use and increased risks in soil sustainability. Access to market also varies among villages in Cabuyal. Some villages are either near or have good access to town markets, while others are either located in hilly areas with difficult access or communicated by bridle paths, which become impassable in the rainy season. These farm dissimilarities in the pressure on the land and market access were taken into account for the selection of the sampling technique.

This study made use of stratified sampling techniques in the data collection. The watershed's population was divided into homogeneous strata. Some data tests and discussions with local experts highlight two criteria for stratification:

1. Population density
The pressure of population on the land varies throughout the Cabuyal watershed. It is higher in the medium and low zones of the watershed, and lower in the high zone. Population pressure is important in the general attitude of the farmer towards the soil resource. Literature points at that more predatory attitudes towards the natural resource are observed in highly populated areas (Barkin, 1994; Gabelnick et al., 1997). Furthermore, density involves indirectly the size of the farm. Smaller farms are located in denser areas and vice versa (CIAT, 1993c). Villages were classified in high and low density (greater or lower that 1.4 habitants/ha, respectively).

2. Market access
Market access is defined as the accessibility of the farmer to the local market centres in terms of the village farms' availability of passable roads and distance to town markets. Some villages only have access to the nearest markets by bridle paths and become isolated in rainy months. This hinders the marketing of the produce and limits farmer access to basic input supplies and market services. Market access of each village was classified as good or bad according to the above criteria. Characteristics such as type of road, distances to roads and main market centres, and topography were considered in this evaluation.

Table 6.3 shows the classification of the 22 villages into the resultant four strata and the number of farms in each village.

Table 6.3 Market access and population density in Cabuyal

Good market access						Bad market access					
High population density			Low population density			High population density			Low population density		
Vereda	Zone	N	Vereda	*Zone*	N	Vereda	*Zone*	N	Vereda	*Zone*	N
Panamericana	M	41	Palermo	L	51	Socorro	L	78	Caimito	L	34
Ventanas	M	65	Cabuyal	L	59	La Isla	L	20	La Laguna	M	86
Pescador	M	50				Porvenir	M	48	Sta Barbara	M	65
C. Pescador	M	54				Los Quingos	M	81	Cidral	H	64
Campiña	M	37				Primavera	H	20	Buenavista	H	45
La Llanada	L	53				Cruc. Rosario	H	91	El Oriente	H	11
Potrerillo	M	54				La Esperanza	H	28			
Sub-total		354			110			366			305

Agro-ecological zone: H=High, M=Medium, L=Low.

The Cabuyal Census (CIAT, 1993c) reported a population of 1,135 farms, 60 percent of them with bad market access and 40 percent (most in the medium agro-ecological zone) with good access. 63 percent of the farms are located in denser areas, whereas 37 percent of the farms (mostly in the highlands) are located on lowly dense areas of the watershed. A random sample of 10 percent was obtained from each stratum, for a total of 120 farms. Table 6.4 shows the number of farms selected per village and strata. The sampled farms were randomly drawn by means of the 'SAS random procedure' (SAS, 1993), excluding farms with comparatively large sizes. Appendix B discusses the operative details of the survey.

Table 6.4 Stratified sampling by market access and population density

Good market access						Bad market access					
High population density			Low population density			High population density			Low population density		
Vereda	*Zone*	*N*	*Vereda*	*Zone*	*N*	Vereda	*Zone*	*N*	Vereda	*Zone*	*N*
Panamericana	M	2	Palermo	L	7	Socorro	L	7	Caimito	L	2
Ventanas	M	11	Cabuyal	L	7	La Isla	L	4	La Laguna	M	10
Pescador	M	4				Porvenir	M	4	Sta Barbara	M	6
C. Pescador	M	7				Los Quingos	M	6	Cidral	H	7
Campiña	M	6				Primavera	H	3	Buenavista	H	6
La Llanada	L	3				Cruc. Rosario	H	8	El Oriente	H	1
Potrerillo	M	6				La Esperanza	H	3			
Sub-total		39			14			35			32

Agro-ecological zone: H=High, M=Medium, L=Low.

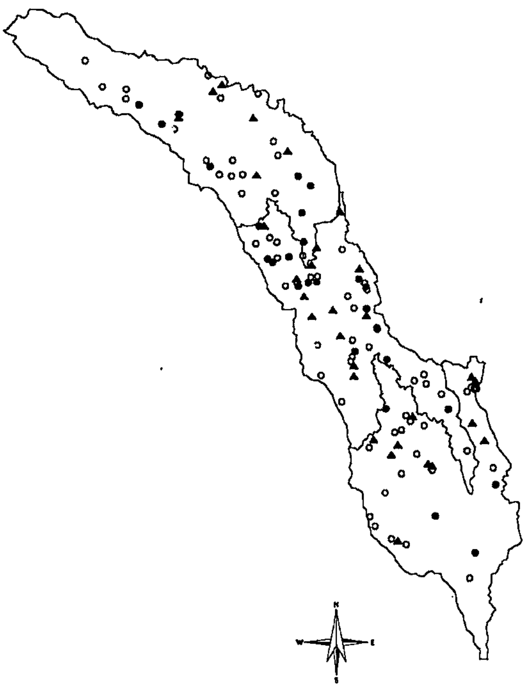


Figure 6.18 Distribution of interviewees in the Cabuyal watershed

The surveyed farms were geo-referred by means of Geographical Position System (GPS) tools to enable links to the CIAT Geographical Information System (GIS) databases. Figure 6.18 illustrates the distribution of the interviewees along the three agro-ecological zones of the Cabuyal watershed. In the figure, farms are denoted by ●, ○ or ▲ to distinguish high, medium and low levels of *well-being*[78].

6.10.3 Other Appraisals

Additional primary data was collected in order to meet the requirements of technical coefficients of the LP model. This involved data collection on production, living and credit costs, consumption and trade patterns and preferences for new market opportunities. In these appraisals, farmers, traders, local experts and technicians were interviewed. This involved both personal and group interviews and the use of participatory methodologies, with the assistance of the personnel of the CIAT IPRA Program. Table 6.5 describes the appraisals undertaken.

Table 6.5 Further Appraisals

Subject	No. of interviews	Topics	Date	Executed by
Production and living costs	Three participatory workshops (45 farmers)	Production and living costs by farm type	June-July 1995	CIAT IPRA and author
Production costs Farms' objectives	30 key farmers	Labour, land and capital requirements for 34 activities. Farm objectives.	July-August 1995	Author
Terms of trade	15 key traders (nearby markets)	Market channels, type of arrangements, loans, interest rates	October 1995	Author
Consumption patterns	10 key farmers	basic diets and costs	December 1995	Author
Market opportunities	Four participatory oriented workshops (80 farmers)	Identification of potential sustainable technologies	April-May 1996	CIAT IPRA/Hillsides and author

6.11 Discussion

Cabuyal small households are constrained by underdeveloped infrastructures (e.g., communication, banking, legal and education) and lack of organisation in marketing channels, on the one hand, and by scarce factors of production (especially capital) on the other. These conditions hinder market access and daily sustenance. Marketing problems such as high price fluctuations, lack of credit service and infrastructure (roads, energy), high input prices and unavailable marketing channels, were identified by farmers as the main region's problems after pests, diseases and crop failures (CIAT, 1993c). Farmers mentioned the promotion of farmer organisations to establish cooperatives and warehouses, and the establishment of financial institutions as possible solutions to those problems.

Undoubtedly, intermediaries play an important gap-filling role in the Cabuyal watershed where market infrastructures are poor and producers are financially weak and lack of marketing and post-harvesting expertise. Intermediaries have an advantage in adapting to heterogeneous

[78] The farmer *well-being*[78] level is an index developed by CIAT IPRA attempted to reveal differences among small-scale farmers based on local criteria (Ravnborg, 1994). Besides income, the index takes into account local criteria such as capacity to employ, crop diversity, non-agricultural source of income and housing quality.

markets and provide marketing services to rural small households hardly attainable otherwise. Nonetheless, farmers are not satisfied with intermediaries.

The contribution of the intermediary to Cabuyal marketing channels is important should remain. Perhaps what it is needed is to diminish the high dependence of small farmers from these agents by stimulating the emergence of vertical marketing channels that extend the range of marketing activities and increases producers' competence. Those marketing channels must provide the services in need in Cabuyal such as input, credit, post-harvest training and transport while contributing to price stabilisation. In particular, more integrated marketing channels would be required for Cabuyal small-farm households that want to:

- cut acute price fluctuations, gain commercial and income stability
- open sales, currently confined to local oversupplied markets, to other market outlets
- switch to quality and high-value crop production systems
- bring part of the value-added process to the rural community

The maintenance of the alternative marketing channels help to abate the dependence from intermediaries while strengthening the bargaining capacity of the small household.

The development of marketing channels in Cabuyal can be assisted by the government through regulatory action and support services addressed to improve the working environment of marketing activities and institutions involved in the area. Cooperatives, agribusiness and other marketing institutions facing taxes and high operatives costs such as transport, storage, financing and market intelligence are often in disadvantage with intermediaries who operate more skilfully in marketing channels lacking infrastructure and are less affected by inconsistent agricultural policies.

7 A NEW METHOD FOR MEASURING THE ADOPTION OF SUSTAINABLE AGRICULTURAL PRACTICES: AN APPLICATION TO THE CABUYAL WATERSHED

7.1 Introduction

Chapter 3 focused the study of farm sustainability on the management of the soil, as soil conservation problems are the most critical environmental issues in the tropical hillside farms. Similarly, Chapter 6 argued that in the Cabuyal watershed, as in many other tropical hillsides, farmers face erosion and loss of soil fertility as the most limiting factors (IGAC, 1976; CIAT, 1996; Reigning, 1992). Several features of the environment make the natural ecology vulnerable to soil erosion (Ashby, 1985; Howeler, 1981): intensive rainfall, erosive traditional cultivation practices and cultivation on steep slope land.

This chapter devotes its attention to the measurement of farm soil sustainability. In this connection, a methodology is proposed to identify, rank and quantify the adoption of sustainable agricultural practices (ASAP) in Cabuyal. This methodology, it is believed, contributes substantially to the empirical appraisal of soil sustainability.

In order to put the appraisal of soil sustainability in context, several approaches from earlier works are reviewed in section two. From this review it is concluded that the variables used to represent ASAP are either too general regarding the actual adoption process (e.g. adoption/non-adoption), but straightforward enough to undertake in field-to-field studies, or detailed (e.g. degree of sustainability) but very data demanding and more suitable for 'single-farm' studies. Based on these findings, section three proposes a method that measures and quantifies, with fair detail, ASAP and is straightforward to apply on a field-to-field basis. The proposed method leads to the elucidation of three dimensions showing the degree of soil sustainability, which facilitates the application of quantitative analysis methods.

Section four presents an application of the proposed method through a preliminary characterisation of soil sustainability in Cabuyal with respect to 'market access' and 'population pressure' strata. This preliminary analysis is complemented in sections five and six by a cluster analysis attempting to identify soil management typologies in Cabuyal. Lastly, section seven discusses the main findings of the chapter.

7.2 Review of the literature

The quantification of the concept of sustainability has been a challenge in recent years. Despite several attempts, there is not a blueprint for its assessment. It is unlikely that a single approach, regardless of the concept of sustainability or the problem under consideration, will ever be found (Harrington, 1992; Ervin et al., 1982). In some approaches to measuring sustainability, or the adoption of sustainable agricultural practices, *state variables* and/or *control variables* are quantified. The former variables describe the quality of the environment or specific resources (e.g. soil depth remaining after erosion) and the latter directly influence the level of a state variable (e.g. tillage practice).

The approaches to the measurement of ASAP can also be categorised in discrete and continuous measurements (Harrington, 1992; Ervin et al., 1982). The former approach describes sustainability as a dichotomous process: a system is said to be either sustainable or not. Measuring sustainability comes down to ascertaining which of these two stages prevails. The second approach describes sustainability as a continuous process where it is possible to entertain different degrees of sustainability. Describing sustainability as a continuous process of adoption of sustainable farm practices opens the way to comparisons between systems and enables answers to questions such as: is a certain farm production system more or less sustainable than an alternative farm production system?

In the following review, approaches used for the appraisal of sustainability range from discrete variables, which describe whether or not a producer is an adopter of soil sustainable agricultural practices, to continuous variables that represent soil nutrient balances.

The dichotomous approach

According to this approach, sustainability is represented by whether a producer is an adopter or a non-adopter of sustainable agricultural practices (Harper et al., 1990; D'Souza et al., 1993; Mbaga, 1998). The dichotomous approach is, perhaps, the most widely used approach to the measurement of sustainability in cross-sectional studies because its use is simple and straightforward. The choice of a dichotomous approach to sustainability implies the use of non-parametric methods such as maximum likelihood, Probit/Normit or Logit models when model estimation is pursued[79]. The sustainability variable is measured according to whether or not the use of a minimum number of sustainable practices is used (e.g. at least 60 percent of previously defined practices), in conjunction with a minimum number of inappropriate (from the sustainability's viewpoint) practices that are reduced or not used during a period of time. These minimum numbers are arbitrarily selected.

D'Souza and co-workers defend the dichotomous approach as a proxy for ASAP arguing that it is debatable that a continuous variable would be preferable to a dichotomous variable as there may not be such thing as degree of sustainability: an operation could be either sustainable or not sustainable. Nevertheless, they recognise that if data were available to represent sustainability as continuous, it could lead to improved results.

The number of practices index

Through this approach, farmer's decision on ASAP is measured by summing up the number of conservation practices implemented at the farm plot. As the previous approach, the resulting variable has discrete characteristics. Some empirical works have adjusted the variable by taking into account farm applicability of each conservation practice (Hansen et al., 1987). An assessment of the applicability of conservation practices may be obtained either from expert's judgements or farmer's judgements. However, some authors recommend the use of expert's judgements (Ervin et al., 1982).

Trends in output and yields (TOY)

This method analyses sustainability in terms of trends in production and/or yields using aggregate data. If crop yields decline over time, it would imply a possible degradation of the resources devoted to the production of that crop. A clear drawback of this approximation to ASAP is that problems of sustainability can be present even when there is a rising trend in output and yields (Harrington, 1992). A trend may be due to other factors, such as changes in the quantity or quality of inputs used, or in the mix of enterprises selected by farmers.

Trends in per Capita Production (TCP)

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[79] These estimation techniques estimate the probability of a factor in explaining the adoption decision. The differences between these techniques lies on the type of probability distribution assumed. For instance, *Logit* is based on a cumulative logistic distribution while *Probit* is based on a cumulative normal distribution. The Logit formulation is often preferred because of its convenient mathematical properties and desirable S-shape, which resembles the adoption process.

This approach is based on the concept that a system is sustainable over a defined period if outputs do not decrease when inputs are not increased (Monteith, 1992). With input levels held constant, per capita production (C) is a function of yields (Y), harvested area (A), and population density (P), where yield changes are driven by 'sustainability' factors (resource quality), not by varying input levels or land use shifts. Thus:

$$C = Y\frac{A}{P} \tag{7.1}$$

By differentiating with respect to time, percentages changes become additive in the following manner:

$$\frac{\partial C}{\partial t}C = \frac{\partial Y}{\partial t}Y + \frac{\partial A}{\partial t}A - \frac{\partial P}{\partial t}P \tag{7.2}$$

Declining trends in per capita production (negative $\frac{\partial C}{\partial t}C$) are used to identify sustainability problems (net benefits vary in direct proportion to gross benefits because inputs are held constant in time). This approach is, however, data demanding and its use is focused mainly on enterprise-specific analysis. Furthermore, the feasibility of this approach hinges on whether input levels are held constant as in control trials. Then, its application on cross-sectional farm studies is limited.

Total Factor Productivity (TFP)

This approach measures the sustainability of a system as the ratio of output and inputs (Harrington et al., 1990; Lynam and Herdt, 1988; Cardwell, 1982; Byerlee and Siddiq, 1989). Thus,

$$TFP = \frac{O}{I} \tag{7.3}$$

where O = total value of all outputs
I = total value of all inputs

A sustainable system would feature a constant or a positive trend in TFP. A drawback of this approximation to ASAP is its ambiguity. A declining trend in TFP might be due to resource degradation or to declining product prices and higher input prices.

TFP revisited

There are several revisited versions of TFP. Samuelson and Nordhaus (1985) use the following:

$$TFP = Q - SL(L) - SK(K) \tag{7.4}$$

where Q = output growth rate (percentage per year);
L = labour input growth rate (percentage per year);
K = capital input growth rate (percentage per year);
SL = labour factor share (constant);
SK = capital factor share (constant);

This revision defines TFP as a residual after accounting for the effects of increased input levels on output. As presented, it confounds the positive effects of technological changes and the negative effects on resource degradation. Similarly to the original TFP approach, TFP revisited is used in enterprise-specific analyses and tends to be extremely data-intensive and rather expensive since it implies large sample of measurement of the outputs and input in farms, several times during each year. Sometimes, it requires the combination of both time series and micro-level data from farm surveys and on-farm and on-station experiments.

Nutrient flow/balance

In the past, different authors have focused on nutrient flows (Pieri, 1989; van Keulen, 1992; van der Pol, 1992; Smaling, 1993; Duivenbooden, 1992). This approach consists in assigning monetary value to the difference between the amount of plant nutrients exported from cultivated fields and those added or imported (van der Pol, 1992). The word 'nutrient' in this approach is largely confined to the three macro-nutrients nitrogen (N), phosphorus (P) and potassium (K). Thus, the nutrient balance is given by

$$NUTRIENT\ BALANCE = INPUT - OUTPUT \tag{7.5}$$

Output processes include extraction by crops, losses due to leaching, losses due to erosion, and losses due to volatilisation and denitrification. *Input* processes include nutrients input via application of chemical fertilisers, organic manuring, restitution of crop residues, biological nitrogen fixation, atmospheric deposition of nutrients by rain and dust, enrichment by alteration and dissolution of soil minerals, plus a few additional minor sources. Smaling et al.'s Nutrient Monitoring (NUTMON) is a decision support model developed for monitoring the soil nutrient balance of sub-Saharan African countries. This approach presents the advantage over others, of considering soil erosion as another output of the system. Van der Pol (1992) used nutrient balance approach but adding an economic valuation of the balance. The advantage of the nutrient balance approach is that it allows assigning a money value to the depleted nutrients based on the cost of purchasing an equivalent amount of chemical fertilisers. The disadvantage is that the detail required in assessing the applied and depleted nutrients limits the method only for single-farm case studies, when time and budget are constraints.

The land investment approach

This approach considers investment in conservation as investment in land improvement (i.e. investment in capital) (Carlson et al., 1993; Norris and Batie, 1987; Saliba and Bromley, 1986). Under this assumption, the investment theory can be applied. Survey evidence (Magleby et al., 1884) indicates that farmers adopt land conservation primarily because it is profitable. Similarly, structures such as terraces, physical barriers, or practices such as composting help to conserve water and fertility, thereby reducing irrigation and fertilisation costs[80]. Land improvement investments can be designed to improve soil drainage, facilitate cropping and irrigation, maintain or enhance soil productivity through conservation activities, or provide facilities and structures for specialised agricultural activities.

Carlson et al. (1993), for instance, present the following model. Assuming that farmers maximise the present discounted value (PDV) of future net returns (Nielsen, 1989), a simple linear approximation of the investment function can be formulated. Although the model is closer to the stock-oriented than to the flow-oriented models in literature, it explicitly incorporates expectations of future net returns, and policy factors hypothesised to influence the land

[80] This fact may suggest that farmers in the long term are profit maximisers. Therefore, the investment approach could be reinforced by a neoclassical framework, say, by the profit maximisation function theory (Alfons Lansink & Erno Kuiper, pers. Comm.).

improvement investment decisions.

More specifically, the model is

$$I = f(Y^e, r^e, P, K_{-1}, G) \tag{7.6}$$

where
I = Land improvement investments[81];
Y^e = Expected income in the current period;
r^e = Expected long-term interest rate;
P = Price of the land improvements relative to the price of the land;
K_{-1} = Value of last period's capital stock;
G = Government incentive policy (subsidy, tax exemptions);

The land investment approach requires detailed data of total capital expenditures, annual operation and maintenance expenses for conservation practices. These data is often difficult to collect and prone to imprecision on field-to-field basis especially in studies in the tropics.

Soil loss

Soil loss has been used as an approach to measure soil sustainability. To assess soil erosion, wide use has been made of the *Universal Soil Loss Equation* (*USLE*) (Wischmeir and Smith, 1978). Although developed to measure soil loss in US standard grain plots, USLE has been frequently applied in the tropics (Hudson, 1971; Reigning, 1992; El-Swaify and Dangler, 1976). Saliba and Bromley (1986) tested this approach as a measure of soil erosion control effort in a logit model applied to a farm survey. The most recent update is the revised USLE (*RUSLE*):

$$A = R * K * L * S * C * P \tag{7.7}$$

where,
A = Average annual soil loss (ton ha^{-1} year^{-1}),
R = Erosivity index (rainfall and rainfall intensity),
K = Soil erodibility factor (soil properties),
L = Length of slope,
S = Gradient of slope,
C = Vegetation or crop factor,
P = Land management (conservation practices) factor.

This approach requires the set up of field trials appropriately equipped with soil collecting canals that allow regular measurements of soil loss.

The conservation effort

The conservation effort is an alternative method to the land investment approach. When data on total capital expenditures and annual operation and maintenance expenses for conservation practices are not available or difficult to be collected, land investment can be seen as a conservation effort (Ervin et al., 1982). A proxy for effort could be based on a physical measure of the farm erosion rate (tons per ha per year) estimated with the USLE (Wischmeier and Smith, 1978). The approach adopted defines effort as the difference between the estimated farm erosion rate without conservation practices ($USLE_0$) and that rate reflecting sample information on practices used ($USLE_f$):

[81] Investment in land improvement measurement is suggested here to consider costs of labour and capital in soil conservation practices (terracing, composting, live fences, etc.), inputs costs, as well as costs of opportunity of fallow lands, reforestation, etc.

$$EFFORT = USLE_0 - USLE_f \quad (7.8)$$

Ervin affirms that "this measure corresponds well with its theoretical counterpart. That is, larger differences should be highly correlated with larger expenditures on erosion control. For example, terraces on steeper sloped land will reduce erosion a larger absolute amount than terraces on less sloping land, but will also usually cost more due to shorter intervals." A clear disadvantage of this approach is the lack of earlier information on farm erosion without conservation practices ($USLE_0$). It would imply a rough estimation of this value by asking to the farmer previous farm characteristics.

The previous literature review shows that there are different degrees of complexity for the appraisal of sustainability. The appraisal approaches range from proxies that determine whether farmers use soil sustainable practices to careful and detailed criteria to estimate the inversion in land improvement or the magnitude of nutrients exported or soil lost. Some variables describe the condition of the resource, while others distinguish the practices that conduct to soil sustainability (Figure 7.1). Some of these approaches are data intensive whereas others are more straightforward.

	State	*Control*
Specific	Soil loss, Conservation effort	Dichotomous
Comprehensive	Nutrient flow	TOY, TCP, TFP, TFP revised, Number of practices index, Land investment

TOY = Trends in Output and Yields; TCP = Trends in per Capita Production;
TFP = Total Factor Productivity

Figure 7.1 Classification of sustainability variables

Several conclusions can be drawn. If the goal is soil conservation and if interest is centred on the determining the level of adoption, then the measurement of the number of conservation practices implemented will suffice. However, if the ultimate goal is erosion reduction (e.g. the goal of a conservation policy), then the variable should reflect the degree of erosion control by each practice and the extent to which it is applied over the farm. The next section discusses the approach to appraise sustainability that best suits the purpose of this study.

7.3 A proposal for measuring ASAP

Based on the evidence from the previous literature review as well as on the review of sustainability adoption studies undertaken in Chapter 3, it is noted that ASAP has been commonly measured by:

1. nominal approaches that indicate whether a producer is an adopter or a non-adopter of soil sustainable agricultural practices; and
2. continuous variables that attempt to reflect the degree of (un)sustainability (e.g., level of erosion or soil nutrient losses).

The first approach is uncomplicated to undertake and very flexible in field-to-field studies, but ignores the degree in which the conservation adoption is actually made by farmers. This means that in-between movements towards sustainable farming are largely ignored. This misses large a part of the insight of the adoption process and limits the use of quantitative analysis aiming at the detection of cause-effect relationships. The second approach is more precise in the appreciation of the degree of sustainability but more complex to implement (e.g., may involve periodical measurements over the time) and more suitable to 'single-farm' rather than to field-to-field-studies. Thus, it appears more preferable to use a sustainability variable that integrates the attractive features of both approaches. That is, a variable that measures the degree of sustainability actually made by the farmer and, at the same time, defined in a simple way so it can be appraised straightforward and efficiently on field-to-field basis.

In our approach, soil sustainability is operationalised as the number of adopted sustainable agricultural practices weighted by their relevance to address the soil conservation problem at hand. In this way, the more pertinent the sustainable practices are, the greater the degree of soil sustainability observed by the farmer. The strength of the proposed operational measure lies on its applicability to farm survey appraisal while making possible to entertain different degrees of adoption behaviour. The operational measure permits to contrast, for example, possible differences in the adoption behaviour of groups of farmers of a given region. The weakness of the proposed operational measure is that it does not provide detailed information on the technical aspects of the conservation practices implemented. The measure, for example, does not indicate the level of recovery or decline in soil or soil nutrients. As such, its use in enterprise-specific analyses is limited. Another limitation of the proposed measure is that it is more pertinent to farmers from the same region where the conservation practices and their relevance to local problems are common.

The section turns now its attention to developing a method for the assessment of soil sustainability. The method consists in grouping and quantifying adopted sustainable agricultural practices in order to obtain a few number of basic sustainability dimensions. The basic sustainability dimensions attempt to measure farmer's soil sustainability behaviour. Figure 7.2 shows the steps of the proposed method.

1. Identification:
   Identify soil conservation practices and group them in categories

2. Ranking:
   Rank practices within each category according to soil sustainability efficacy and zone applicability; and assign the rank scores to each farmer

3. Non-linear principal components analysis:
   Scale optimally each ordered category to quantify the ranking and extract basic (orthogonal) dimensions by means of principal components analysis (PCA)

Figure 7.2 A method for measuring ASAP

In the first step of the method, sustainable agricultural practices in Cabuyal are grouped in different categories according to farm activity. Then, within each category, practices are subject to a ranking of soil effectiveness. The ranking is subsequently applied to each farm on the basis of the practices adopted. In the third step, non-linear principal components analysis is applied to attain metric behaviour to all farms' rankings and extract few major dimensions. The new dimensions of ASAP must be independent to guarantee separate views of soil sustainability when incorporated as response variables in the econometric model in Chapter 8.

Step 1. Identifying and grouping soil conservation practices

Farmers in Cabuyal have been seen as adopting measures, primarily addressed to reduce the negative impact of soil erosion and the losses of water, nutrients, and organic matter associated with it. Soil conservation measures in Cabuyal comprise practices intended to guard the soil from the impact of raindrops (e.g. plant cover, mulching); practices that reduce surface run-off and increase water infiltration (e.g. live barriers, interception drains); practices intended to maintain soil fertility (e.g. animal manure); and practices that have low negative impact on the physics of the soil (e.g. minimum tillage). Table 7.1 shows the conservation practices that Cabuyal farmers often adopt to overcome soil degradation problems. The practices are grouped into seven categories according to farm activities and soil effect: soil conditioning, soil preparation, sowing, fertilisation, weeding, harvesting, run-off control, and other practices.

Table 7.1 Soil practices in the Cabuyal watershed

Soil Conditioning	Soil Preparation	Sowing	Fertilisation	Weeding	Harvesting[1]	Run-off control	Other
Terracing live barriers (pastures, sugar cane, etc.) live cover, live mulch others	slash-and-burn/cover liming oxen traction machinery traction manual: iron-stick manual: digging holes	contour planting iron-stick sowing stream sowing planted	residues (mulch) cattle manure chicken manure composting chemicals none	machete hoe, shovel eyebrow weeding herbicide	Root harvest Grain harvest Picking	waterways intercep-tion drains	Crop rotation

1= root harvest is seen in cassava and beans; grain picking is seen in coffee and beans.

Step 2. Ranking soil conservation practices

A ranking was assigned to each category of conservation practices, based on USLE equivalency tables (e.g. P factors; Wischmeir & Smith, 1978) and CIAT's soil scientist judgements. Nonetheless, this ranking involves, to a large extent, subjective assignments based on the local characteristics of the soil and the local relevance of the practices. The different soil practices within each category (individual or a combination of several practices) were ranked according to their expected soil conservation effect on the plot system. High values were assigned to those practices that best control soil degradation problems and require more effort, i.e. those that stop run-off (e.g. live barriers) and those that require high capital investments and care (e.g. compost devices)[82]. Table 7.2 shows the scores assigned to the soil practices[83].

[82] Ties among practices were averaged as customary in ranking procedures. For example, the top four of the sixteen soil conditioning practices were ranked equally. Therefore, an average value of 14.5 [i.e. (16+15+14+13)/4] was assigned to each.

Table 7.2 Ranking of soil conservation practices in Cabuyal[1] (experts' judgements)

Soil[2] conditioning	Soil preparation	Sowing[3]	Fertilisation	Weeding	Harvesting	Run-off control
Elephant grass[4]: 14.5	digging holes new field: 9	Transplanting: 3	residues+chicken manure+compost+ chemicals: 15.5	Machete: 4.5	Picking: 6	waterways: 2.5
King grass[5]: 14.5	digging holes+iron pike: 8	stream-sowing: 1.5	residues+chicken manure+cow-dung+chemicals: 15.5	eyebrow weeding: 4.5	picking+ grain harvest: 5	interception drains: 2.5
Mulch: 14.5	digging holes in stubbly field: 7	stick planting: 1.5	residues+chicken manure+chemicals: 10.5	shovel+eye brow: 2.5	grain harvest: 4	none: 1
Iraca: 14.5	iron stick: 6		residues+compost+ chemicals: 10.5	machete+hoe: 2.5	Root harvest+ Picking: 3	
Citronella[6]/ Lemmon[7]: 11	slash-and-cover: 4		chicken manure+ compost+chemicals: 10.5	hoe: 1	grain+root harvest: 1.5	
Sisal[8]: 11	slash-and-burn: 4		chicken manure+ compost: 10.5		root harvest: 1.5	
Axonopus Micay: 11	oxen traction new field: 4		residues+compost: 10.5			
Telembi[6]/ Imperial: 7.5	liming: 2		chicken manure+ residues: 10.5			
Arachis Pintoi: 7.5	oxen traction in stubbly field: 1		compost: 10.5			
Centrosema acutifolium: 7.5			residues: 10.5			
Brachiaria decumbes: 7.5			cow-dung: 4.5			
Sugar cane: 4.5			chicken manure: 4.5			
Trichanthera gigante: 4.5			chicken manure+ chemicals: 4.5			
Pine-apple: 2.5			residues+chemicals: 4.5			
Inga Densiflora: 2.5			chemicals: 2			
None: 1			none: 1			

1=higher values mean more effectiveness. 2=terracing was no found in the sampled farms. 3=strip-cropping was found in all plots, and therefore, was not included. 4=*Pennisetum purpureum Schm.* 5=*Saccarum sinese Roxb.* 6=*Cymbopogon nardus.* 7=*Cymbopogon citratus.* 8=*Agave spp.* 9=*Axonopus scoparius*

The system of ranks was subsequently applied to each farm (120 farms in total) on the basis of whether or not it was using one or more practices in the seven categories. Consequently, seven ordinal variables are obtained, each corresponding to a soil conservation category. Although a quantification of ASAP has been obtained, the ordinal nature of these variables sets limitations on

[83] Note that some categories in Table 7.2 include a combination of conservation practices to represent the cases where farmers adopt more than one practice per category. This results in mutually exclusive conservation practices within each category (i.e. only one score per conservation practice).

the type of statistical techniques that can be used for comparison analysis. First, it would be inaccurate to argue, for instance, that a farmer who digs holes (ranked 8) is twice more sustainable than another farmer who prepares his fields with oxen traction (ranked 4). Second, the number of categories makes analysis difficult. There might be a relationship among categories implying some degree of redundancy. The final step of the method removes these limitations by transforming the ordinal categories into metric categories and obtaining few essential dimensions.

Step 3. Nonlinear principal components analysis

ASAP may be built up on few essential dimensions. These dimensions might be identified by means of *principal components analysis*, which consists of finding relationships among given metric attributes and representing these relationships in a few independent components (dimensions). This enables describing the structure or pattern in the relationships between the attributes that would be difficult to discern in their original richness and complexity. The new dimensions explain a proportion of the original variance and assign scores to each observation (object scores) with a zero mean and unit variance.

Principal components analysis assumes, however, that all variables in the analysis are measured at the numerical level and that relationships between pairs of variables are linear. *Nonlinear principal components analysis* (Gifi, 1990) extends this methodology so principal component analysis can be performed on any mix of nominal, ordinal and numerical variables. The procedure transforms categorical variables into metric variables, looks for nonlinear relationships between the variables and reduces the relationships to few components. Nonlinear principal components analysis makes use of *optimal scaling* (Kruskal and Shepard, 1974; Young et al., 1978; Winsberg et al., 1983) to detect nonlinear relationships between categorical variables and transform them into metric variables. Optimal scaling is a technique used to quantitatively transform categorical attributes in order to meet continuity requirements of other statistical techniques such as principal components[84].

Nonlinear principal components analysis was carried out by using the SPSS procedure PRINCALS (SPSS, 1990). Figure 7.3 shows that three dimensions (sustainability dimensions) were obtained out of the soil conservation categories[85].

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[84] Optimal scaling was developed by social statisticians in the '70s and implemented in the '90s by software packages such as SAS and SPSS. Optimal scaling applies nonlinear transformations to the variables by means of *alternating least squares* (ALS) (Young, 1981), to optimise properties of the transformed variables' covariance or correlation matrix. ALS nonlinearly transforms variables, improving their fit to a principal component model. This technique is often described as a form of quantification of qualitative data. As almost every multivariate technique, optimal scaling can be understood as a technique very useful to reveal patterns of association of variables, which otherwise would remain hidden.

[85] Two criteria were applied to determine the most optimal number of components: the *latent root criterion* and the *scree test criterion* (Hair et al., 1995). The latent root criterion selects components having significant latent roots or eigenvalues (greater than 1). The scree test criterion plots latent roots against the number of components and the shape of the resulting curve is used to evaluate the cutoff point.

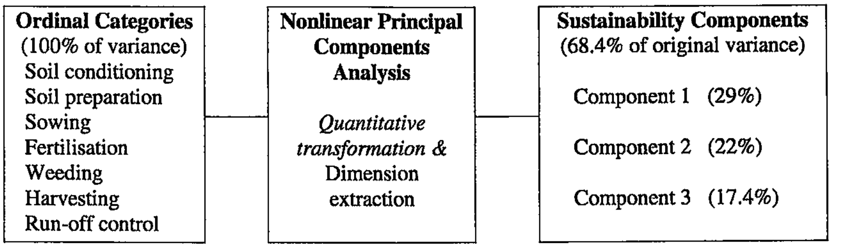

Figure 7.3 The Nonlinear Principal Components procedure

The sustainability dimensions account for significant proportion of the original variance (68.4 percent). A matrix of component loading coefficients, used to express each standardised variable in terms of the dimensions, is shown in Table 7.3. Dimension loadings range from -1 to 1 to indicate the weight of each variable with respect to each dimension. Dimensions with large coefficients (in absolute value) in relation to a variable are closely related to the variable. The dimension loadings were orthogonally rotated to permit independence among the dimensions and clearer interpretation. Table 7.3 displays in bold loadings greater than 0.5 in absolute value. Sowing shows no meaningful contribution to the explained variance.

Table 7.3 Dimension loadings

	Dimension 1	Dimension 2	Dimension 3
Conditioning	-0.016	**0.714**	-0.071
Preparation	**0.884**	-0.070	0.073
Sowing	0.220	-0.010	0.005
Fertilisation	-0.180	**0.680**	0.033
Weeding	0.390	**0.571**	-0.148
Harvesting	**0.908**	-0.028	-0.053
Run-off control	0.047	0.116	**0.991**

The dimension loadings in Table 7.3 show patterns clearly associated with practices that have certain effects on the soil. *Dimension one* refers to practices of farm activities associated with crop and production process. They include practices, such as manual/oxen preparation, slash-and-burn and root/grain harvesting, which are related to soil conservation practices in soil preparation and crop harvesting. These practices have physical disturbance effects on the soil. Oxen traction, for example, cause greater perturbation to the soil physics than manual land preparation. On the other hand, root harvesting generates topsoil removal leaving the soil susceptible to erosion, whereas fruit picking exerts low impact on the soil. Soil perturbation affects the decomposition rate and therefore the loss of organic matter. Organic matter is one of the most important factors for a production system. It determines, to a large extent recycling of nutrients, physical structural stability of the soil and biological activities of micro and macro-fauna (microorganism, earthworms, etc.). The less disturbed the soil physics is, the greater the soil sustainability will be. Dimension one is labelled *soil-disturbance control* (*sc*).

Dimension two comprises (structural) practices not related to the crop production process but to practices intended to provide protection to the topsoil. They include conditioning, covering and fertilisation practices that supply the soil of cover and better conditioning. They embrace live barriers, live mulch (e.g. grass) and dead mulch from weeding and crop residuals. Fertilisation provides, besides fertility management, appropriate conditions for the growth of soil protective covering (Hudson, 1981). Live barriers stop soil loss and therefore nutrient leaching. A good cover provides protective mulch from raindrops, decreases soil run-off, increases the input of organic residues, stabilises the temperature of the soil, and reduces the decomposition rate. Dimension two is labelled *soil protection* (*sp*).

Lastly, *dimension three* was merely associated with drainage practices. These practices comprise the constructions of waterways and interception drains that lead away any concentration of surface water and avoid field's leaching of soil and nutrients. This dimension is labelled *run-off control* (*rc*).

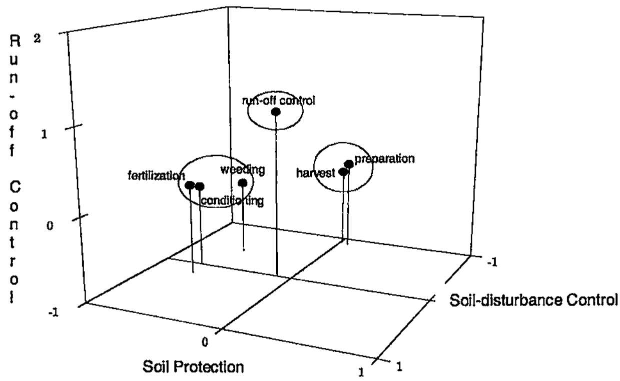

Figure 7.4 Soil sustainability dimensions

The previous four-step method has guided the elucidation of three basic soil sustainability dimensions of ASAP in Cabuyal. The three dimensions, named 'soil-disturbance control', 'soil protection' and 'run-off control', address correspondent types of soil conservation issues. Whereas the first sustainability dimension is related to the crop and its production system and linked to low-impact farming, the other two dimensions are unrelated to the crop but linked to physical measures that equip the soil with shelter from erosive rain that leads to soil loss and nutrient leaching. Soil-disturbance control refers to mechanical impact of preparation and harvest activities (such as minimum tillage) on the field soil. Soil protection refers to overall cover of the field ground with mulch, leaves and other physical barriers as a protection from erosive rainfalls. While run-off control, the third sustainability dimension, is related to physical practices made at the margins of the field in order to carry the water flow away. Figure 7.4 distinguishes the three soil sustainability dimensions in relation to the six soil conservation categories.

Given the fact that they are essential dimensions of the soil sustainable measures practised in the Cabuyal farming systems, each sustainability dimension identified has great importance in measuring soil sustainability. However, soil-protective measures intended to safeguard the topsoil from erosive raindrops seem to be particularly meaningful as rainfall erodibility has been identified a major cause of loss of soil and the nutrient matter associated with it in Cabuyal

(Reining, 1992).

7.4 A descriptive analysis of the soil sustainability dimensions of ASAP

In order to demonstrate the usefulness of the developed measure for ASAP, a descriptive analysis of the Cabuyal sample of farmers is made on the basis of the three sustainability dimensions extracted (soil-disturbance control, soil protection and run-off control) per 'market access' and 'population pressure' strata.

In Table 7.4, farms with good market access show positive average values in the adoption of soil-disturbance control and soil protection practices. This suggests that farm households with good accessibility to local market centres tend to adopt soil conservation measures addressed to mitigate impacts on the soil structure from preparation and harvest activities and provide shelter from erosive rain that leads to soil loss and nutrient leaching.

Table 7.4 Average ASAP values per sampled stratum

	Good market access	Bad market access	Total Pop. pressure
High population pressure			
Soil-disturbance control	0.06	0.12	0.09
Soil protection	0.36	-0.16	0.11
Run-off control	0.0	0.06	0.03
Low population pressure			
Soil-disturbance control	0.05	-0.22	-0.14
Soil protection	-0.23	-0.13	-0.16
Run-off control	-0.18	0.02	-0.04
Total market access			
Soil-disturbance control	0.06	-0.05	
Soil protection	0.19	-0.15	
Run-off control	-0.05	0.04	

Soil-disturbance control, soil protection and run-off control have zero mean and (max, min) values of (1.1,-2), (2.5, -1.7) and (1, -2), respectively.

In contrast, bad market access is associated with negative values of soil-disturbance control and soil protection practices. This suggests that deficient access to the market not only disrupts marketing activities but also hinders farmer access to extension and knowledge on the implementation of soil conservation practices.

Table 7.4 shows that the adoption of run-off control practices is associated with poor market access. This appears contradictory in face to the findings of the other type of soil practices. Considering the possibility that run-off control practices could be linked with the topographic characteristics of the farm, average values were also computed for each agro-ecological zone.

Table 7.5 Average ASAP values per agro-ecological zone

Soil sustainability dimension	Agro-ecological zone		
	High	Medium	Low
Soil-disturbance control	-0.1	0.0	0.0
Soil protection	0.2	0.1	-0.4
Run-off control	0.1	0.0	-0.1

Table 7.5 shows that, in fact, the adoption of run-off control practices shows positive values in the high agro-ecological zone where slopes are steeper. This suggests that drains and interception canals are more often adopted in farms located on steep slopes of the highlands, where access to market centres is usually bad.

Table 7.4 also shows that the adoption of soil-disturbance control, soil protection and run-off control practices are more plausible to occur in highly populated areas. This finding may imply that farm labour, more easily available in highly populated areas, is an important factor for setting up and maintaining labour-intensive soil conservation practices. Readiness of labour is particularly critical for the implementation and maintenance of labour-intensive physical structures such as terraces, live barriers and waterways.

7.5 Soil management typologies in Cabuyal

The finding that ASAP in Cabuyal is built up on three soil sustainability dimensions suggests that watershed farmers might be adopting different strategies towards sustainable soil management. In other words, it suggests the existence of typologies of soil management resulting from the way farmers combine soil-disturbance control, soil protection and run-off control practices. These soil management typologies may reveal differences in soil conservation behaviour adopted by the farmers.

To further demonstrate the usefulness of the measure for ASAP, this section devotes to the identification of soil management typologies based on the soil sustainability dimensions. Cluster analysis (SAS, 1999) was applied to the 120 surveyed farms, which led to the identification of 5 farm household clusters[86]. Clusters 1 to 5, composed of 32, 28, 26, 17 and 17 small farm households, respectively, account for 64 percent of the variance[87]. Figure 7.5 illustrates the average soil sustainability dimensions of each cluster.

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[86] The selection of the most optimal number of clusters was guided by the *scree test criterion* (Hair et al., 1995), where the cluster's R^2 contributions is plotted against the number of clusters and the shape of the resulting curve is used to evaluate the cutoff point.

[87] In practice, 100 percent of the variance would be explained by 120 clusters, one cluster per farm household.

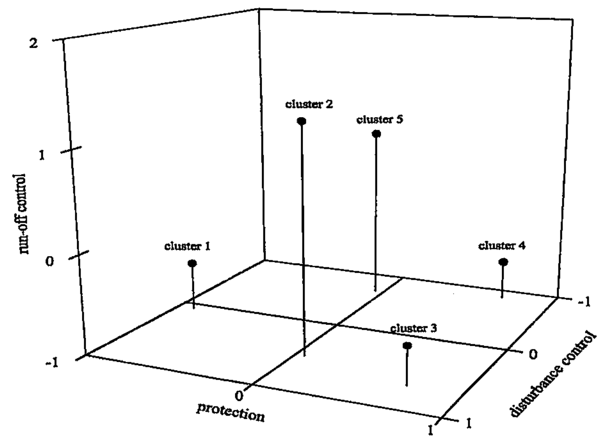

Figure 7.5 Farm household clusters according to soil management

In Figure 7.6, the soil sustainability dimensions do not show intermediate values but rather extreme (i.e. close to 1 or –1) or non-significant values (i.e. zero). This means that the clusters can be represented as five soil management typologies, where farm households adopt (Yes) or not adopt (No) a given category of soil sustainable practices (Table 7.6).

Table 7.6 Cabuyal soil management typologies

Soil sustainability dimension	Typology				
	1	2	3	4	5
Soil-disturbance control	—	Yes	Yes	No	No
Soil protection	No	—	Yes	Yes	—
Run-off control	No	Yes	No	No	Yes

Table 7.6 shows five well-differentiated soil management typologies. Small farm households in typology 1 are characterised for non-adoption of soil conservation practices. Typology 2 includes small farms that practice low-tillage to control soil disturbance and set up interception drains to control soil run-off. Typology 3 corresponds to farm households that control soil disturbance and protect the topsoil with mulch cover from rainfall but do not practice run-off control. Small farm households in typology 4 adopt topsoil protection practices but do not take measures against soil disturbance and soil nutrient run-off. Finally, typology 5 involves farm households that follow practices to prevent soil nutrient leaching but do not control soil disturbance.

Thereby, the soil management typologies of the Cabuyal watershed can be described as:
1. Non-adopters.
2. Adopters of soil disturbance and run-off control practices.
3. Adopters of soil disturbance-control and protection practices but ignoring run-off.
4. Adopters of soil protection practices but ignoring soil disturbance and run-off.
5. Adopters of soil run-off control practices but ignoring soil disturbance.

7.6 Description of the soil management typologies

This section provides a characterisation of the farmers in the soil management typologies in order to gain further insight into soil management in Cabuyal. In the review of the factors associated with soil conservation adoption in Chapter 3, institutional (e.g. marketing and government), personal-social (e.g farmer's education and awareness of soil degradation problems), economic (e.g. farm income and labour) and physical (e.g. soil erodibility) factors were identified to play a role in affecting such an adoption. Variables that represent these factors were estimated from the study survey and crossed with the soil management typologies. Table 7.7 presents factor average values as low (denoted by '-' or '+'), intermediate (denoted by '--' or '++') or high (denoted by '---' or '+++') with respect to zero, their mean value. Blanks correspond to non-significant values (i.e. close to zero).

Table 7.7 Factor indicators per soil management typology

Factor[2]	Typology[1]				
	1	2	3	4	5
Institutional					
Access to marketing services, GOs/NGOs	-	--	+	+++	-
Market nearness and road access	+		++		---
Entrepreneurship	-			++	+
Commercial orientation and VI[3]	++	+		-	---
Non links with cooperatives			+	-	-
Personal-social					
Educated and farm-committed mestizos		-	-	++	
Risk prone and innovativeness	-	-		++	-
Aware poor-resource farmers	-		++	+	+
Economic					
Wealthy farmers	-	-		+	
Coffee growers	+	+	++	--	--
Long-term planners	--	+	+	+	--
Farm labour shortage		---	+	++	
Owners with debt concerns				--	++
Physical					
Low soil erosion potential		--		++	-
Second farm plot with the longest slope	-	-	--	+	
Deepest soils of the highest zone	--	+	+	-	++

1='+'/'-' signs stand for positive/negative associations, respectively; 2=A description of these factors is provided in Section 8.5; 3=Vertical Integration to the market.

Table 7.8 provides further information on crops and market integration for each soil management typology.

Table 7.8 Crops and market integration of soil management typologies (%)

	Typology				
	1	2	3	4	5
Crops					
Coffee[1]	78	68	77	35	33
Cassava	0	0	0	6	56
Beans	0	0	4	18 [3]	0
Intercrops[2]	22	32	19	41	11
Total	100	100	100	100	100
Vertical integration					
Coffee cooperative	16	4	4	0	0
Bean cooperative	3	0	0	12	0
Cassava starch processor	9	14	8	29	50
Total	28	18	12	41	50

1=Coffee is often intercropped with plantains and other fruit trees.
2=Intercrops include combinations of coffee, cassava, beans, and other local crops.
3=Beans is slightly the most predominant crop in this cluster, if adding bean intercrops.

Non-adopters

Table 7.7 shows that the 'non-adopters' type comprises poorer farmers with short planning time frames, who have preference for coffee cropping (Table 7.8). Although farms tend to have good access to market centres, with some farmers selling to coffee cooperatives, access to institutional services such as credit, inputs and extension is poor. These farmers are not entrepreneurs and tend to shy away from risk and innovation. The non-adoption of soil conservation practices is most often seen in the smallest farms with shallow soil layers of the low agro-ecological zone of the watershed.

Adopters of soil disturbance and run-off control practices

This type of adopters involves poorer coffee growers with longer planning time frames. Farm households tend to have larger than average family sizes, having therefore enough farm labour for the implementation of soil conservation measures. Farmers are ethnic Indians and neither innovative nor risk takers. They show some commercial orientation but have bad access to marketing services and institutions. The adoption of soil-disturbance and run-off control conservation practices seems to be more frequent in the steepest lands of the medium and high agro-ecological zones.

Adopters of soil disturbance-control and protection practices but ignoring run-off

This type of adopters embraces Indian-ethnic resource-poor coffee growers with long-planning horizons and high awareness of soil erosion problems. These farmers have good access to markets and market institutions and to the services provided by them. About 27 percent of these farmers benefited from subsidies for coffee pest management. The adoption of conservation practices addressed to control soil disturbance and topsoil erosion is mainly observed in the most important field on the farm.

Adopters of soil protection practices but ignoring soil disturbance and run-off

The adopters of this important type of soil conservation practices are most influenced by institutional, personal, economic and physical factors. They include wealthy and educated non-Indian farmers committed to the farm who have diversified crops led by beans and coffee, followed by cassava and intercrops (Table 7.8). The commercial orientation of these growers is reflected in contractual arrangements with starch processors and bean cooperatives alike[88]. These farmers own farms of above average size but lack enough farm labour. They seem to be entrepreneurs, very innovative trying new farming practices, who do not shy away from risky situations and have long-term planning attitudes. They tend to have good access to institutions and marketing services, hold credits from these institutions and one-third of them have been granted subsidies for coffee pest management. The adoption of topsoil protective practices tends to be more frequent in gentle slopes and low degradable croplands of the medium agro-ecological zone of the watershed.

Adopters of soil run-off control practices but ignoring soil disturbance

The adopters of run-off control practices comprise growers with non-diversified cropping patterns that rely heavily on cassava (Table 7.8). They tend to have very short planning horizons, are very concerned about debts and show little risk and innovative attitudes. Apart from commercial links with starch processors, these farmers do not seem to have much contact with the market. Access to institutions and, thereby, to marketing services seems very poor. The adoption of sole run-off control measures is more habitual in steep lands of the highest agro-ecological zone of the watershed.

The foregoing analysis of the adoption typologies has enabled a better understanding of soil management in Cabuyal. Some findings are noteworthy:

First, the analysis shows that good access to marketing services and institutions seems to be associated with adoption of soil sustainable practices. Nevertheless, good access to markets seems insufficient to stimulate such an adoption when farmers lack marketing services, entrepreneurship, long-term planning and farm labour, as seen in the 'non-adopters' typology (type 1).

Second, from the standpoint of soil conservation in Cabuyal, the adoption of soil protection practices (types 3 and 4) are probably the most important. Topsoil protection is crucial as rain erosion is extremely critical in Cabuyal as the topsoil is often left exposed to rainfall after crop planting and after harvesting. Ease of access to market centres, good access to marketing services and entrepreneurship were found common characteristics for the adoption of topsoil protection measures. Notably, these marketing factors seem to positively affect coffee growers (type 3) as much as non-coffee growers (type 4). Other important characteristics for the adoption of topsoil protection include long-term planning, innovativeness, better education and awareness of soil degradation problems. These economic and personal characteristics seem to be more relevant for the adoption of topsoil protection practices than physical land characteristics such as slope and potential erodibility.

Third, adopters of only topsoil protection practices (type 4) seem to follow land use systems more in line with soil sustainability. Land-use by this type of adopters shows more balanced polycultural systems such as intercropping whose output meets farm earnings through crop commercialisation (e.g. beans, coffee and cassava) and farm household's food needs (e.g. beans, cassava, maize and plantain). In this context, this type of land-use seem to support beneficial cultural practices such as crop diversity and rotation, which diminishes economic risks resulting from market instability and soil fertility breakdown.

Fourth, the adoption of run-off control practices alone does not seem to be affected by marketing and economic factors. The adoption of these types of structural practices seems to be influenced by physical characteristics such as soil erodibility as it is seen on lands in steeper areas of the high agro-ecological zone of Cabuyal. This suggests that local institutions have almost no

[88] Market integration to both bean cooperatives and starch processors explains the negative sign of "Commercial orientation and VI" in this typology.

impact on the promotion of run-off control practices. These physical measures seem to be adopted as a result of the farmer's own initiative.

Fifth, simultaneous adoption of soil protection and run-off practices did not take place in any of the soil management typologies. This would indicate that, when providing mulch, live barriers and other type of topsoil protecting practices, farmers believe that these are also an effective solution for soil run-off. Or, the other way round, farmers may believe that the construction of waterways at the plot borders suffice for the control of topsoil erosion. This suggests the need for strengthening extension to explain the differences between topsoil erosion caused by rainfall and nutrient run-off erosion caused by surface water streaming down the field. Farmers must be shown that soil run-off and the resulting leaching of soil and nutrients are better controlled by waterways and interception drains.

7.7 Discussion

This chapter developed a general method to measure ASAP. The method involves ranking of soil conservation practices, metrical transformation of the ranks and obtaining basic sustainability dimensions. The method bridges the gap between existing measures, which either classify adopters versus non-adopters of soil sustainable practices or measure the use of sustainable practices in great detail. Also the proposed method is easily applicable in quantitative research.

As illustration, the method was applied to 120 farms of the Cabuyal watershed. It led to the identification of three dimensions (*soil-disturbance control*, *soil protection* and *run-off control*). The procedure probed to be straightforward to apply on field-to-field empirical studies and very useful for the visualisation of soil sustainability as a multidimensional concept entailing various aspects of the adoption of soil conservation practices

In order to demonstrate the proficiency of the measurement of ASAP, descriptive quantitative analyses were carried out. First of all, cross-table analysis of the soil sustainability dimensions was undertaken to detect associations with 'market access' and 'population pressure'. Secondly, cluster analysis was applied to the soil sustainability indicators with the purpose of identifying soil management typologies in Cabuyal. The analysis enabled the identification of five types of soil management, which were characterised by means of institutional, economic, physical and personal-social factors. The results show the flexibility of the proposed measure of ASAP for the application of quantitative methods, which has enabled an insight into the soil conservation adoption process.

8 AN ECONOMETRIC ANALYSIS OF THE IMPACT OF MARKETING FACTORS ON THE ADOPTION OF SUSTAINABLE AGRICULTURAL PRACTICES

8.1 Introduction

In this chapter, the conceptual model introduced concisely in Chapter 5 is elaborated and applied to the case study data. The model attempts to explain the adoption of soil sustainability practices by farm households on the basis of marketing factors as well as other aspects such as personal-social, physical and economic factors. In particular, the model attempts to test that marketing factors have a direct influence on the adoption of sustainable practices (ASAP).

To pursue this assessment, both, the dependent variable(s) that represents ASAP and the explanatory variables that affect such an adoption, need first to be identified and quantified. The identification and quantification of ASAP was carried out by means of the method developed in Chapter 7. The explanatory variables are identified by a methodology, whose steps are outlined in Figure 8.1. These steps are worked out in more detail in the following sections of this chapter.

The conceptual model is presented as an integrated approach of the factors that may affect ASAP (Section 8.2)
Explanatory factors are discussed and reduced to basic components (Sections 8.3 & 8.5)
PC regression analysis Sustainability dimensions = f (basic explanatory components) (Section 8.5.2)

Figure 8.1 Steps in the methodology for the cause-effect assessment of ASAP

The first step of the methodology consists of an elaboration of the conceptual model introduced in Chapter 5. In the second step, the independent variables representing the explanatory factors are discussed. Hypotheses about the relationship between dependent and explanatory variables are presented. Thereafter, the explanatory variables are reduced to basic independent explanatory components by means of principal components. This reduction aims at discarding correlation among explanatory variables and eventually easing interpretation of model parameters. In the last step of the methodology, the soil sustainability dimensions of ASAP are regressed on the independent components by means *of Principal Component Regression (PCR).* The chapter ends discussing the estimation results and the main findings.

8.2 Conceptual model of factors affecting ASAP

Chapter 3 undertook a review of econometric models used to evaluate the effect of factors on farmer's decisions to practice sustainable measures. The conceptual model proposed in this study is based upon this review of earlier studies. The model, shown in Figure 8.2, is an integrated perspective of the factors, whose influence on ASAP has been tested. The model attempts to explain ASAP as the result of the influence of institutional (including marketing), personal-social, physical and economic factors. Personal factors might alert the farmer on erosion problems. Physical deterioration levels may guide the farmer on the type of practice(s) to adopt. Further, economic factors may either facilitate or restrain the adoption decision. Marketing and other institutional factors may be an incentive or intensify positive attitudes towards soil conservation. In Figure 8.2, positive and negative signs indicate the expected effects of the various factors on the ASAP. The arguments supporting these expected effects are provided in Section 8.3.

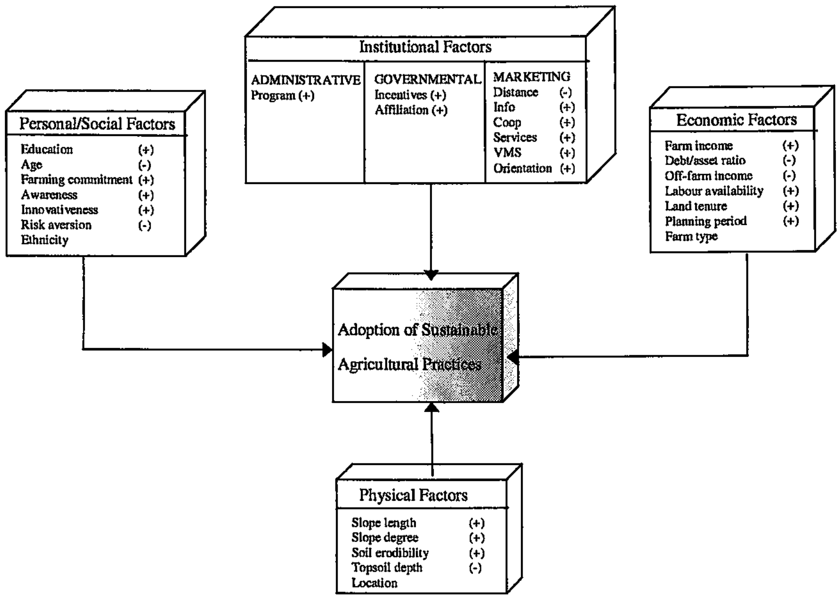

Figure 8.2 A conceptual model of adoption of sustainable agricultural practices (+,- indicate the direction of the factor influence on ASAP)

The conceptual model of ASAP formulated in Chapter 5 was as follows:

ASAP = f (Physical fact., Pers-Soc fact., Economic fact., Institutional fact.) + random error (8.1)

Substituting ASAP by its three soil sustainability dimensions deduced in Chapter 7 (sc, sp and rc)[89], and the explanatory factors by the variables shown in Figure 8.2, thus:

(sc) = f (Physical fact., Pers-Social fact., Economic fact., Institutional fact.) + random error
(sp) = f (Physical fact., Pers-Social fact., Economic fact., Institutional fact.) + random error (8.2)
(rc) = f (Physical fact., Pers-Social fact., Economic fact., Institutional fact.) + random error

where sc = the soil sustainability dimension "soil-disturbance control" with mean zero;

[89] The three sustainability components sc, sp and rc are independent and standardised with zero mean and unit variance.

sp	= the soil sustainability dimension "soil protection" with mean zero;
rc	= the soil sustainability dimension "run-off control" with mean zero;
Physical factors	= slope length, slope gradient, soil erodibility, topsoil depth and location;
Personal-soc. factors	= education, age, commitment to farming, awareness, innovativeness, risk aversion and ethnicity;
Economic factors	= farm income, debt concerns, off-farm employment, on-farm labour, land tenure, planning periods and farm type; and
Institutional factors	= subsidy, affiliation, market distance, price information, cooperative links, market services, market integration and market orientation.

The first equation analyses the effect of various factors on the adoption of *soil-disturbance* control practices. Soil-disturbance control practices refer to sustainable measures adopted during farm activities associated with the crop production process. Practices such as low tillage are applied to ensure low disturbance to the soil physics. The second equation centres on the adoption of *soil protection* practices such as mulching, fertilisation and minimum weeding. In contrast to soil-disturbance, soil protection is not related to the crop production process but to appropriate conditioning of the topsoil to impact from erosive raindrops. Lastly, the third equation focuses on the adoption of practices that exert *run-off control*. They include waterways and drains that divert water flows out of the farm plot to prevent water erosion and soil nutrient depletion.

The next section discusses the explanatory variables and the underlying hypotheses with regards to their effects on ASAP. Their use in analysing sustainability in the Cabuyal agriculture is also discussed.

8.3 The hypotheses to explain ASAP

In the review of empirical studies on the adoption of sustainable practices, Chapter 3 identified six general approaches: diffusionist, rationality, personal, physical, institutional and integrated approaches. The empirical works that represent these six approaches include works from the following authors: NCFM, 1952; Blase, 1960; Carlson et al., 1977; Pampel and Van Es, 1977; Taylor et al., 1978; Earle et al, 1979; Novak and Korshing, 1979; Hoover and Wiitala, 1980; Ervin et al., 1982; Hamal and Anderson, 1982; D'Souza et al. 1983; Dhanakumar and Perumal, 1986; Eplin and Tice, 1986; Norris and Batie,1987; Lynne et al.,1988; Gould et al, 1989; Debertini and Sjarkowi, 1989 (in: Bonnard, 1995); Coughenour and Chamala, 1989; Sinden and King, 1990; Wollenberg, 1991; Van Kooten, 1993; Featherstone and Goodwin, 1993; D'Souza et al., 1993; Lopez-Pereira et al.,1994; Carcamo et al.,1994; Anderson and Thampapillai, 1990 and Mbaga, 1998. Based on these works, the conceptual model introduced in this study (Figure 8.2) takes on board personal-social, physical, economic, and institutional variables as explanatory factors of ASAP. The main focus, however, is on institutional factors (i.e. marketing systems and macro-environmental factors). The criteria for the selection of the variables to represent these factors include:

- main findings of earlier works, emphasising the variables that showed to be significant in explaining soil conservation adoption;
- judgements of local experts such as local leaders, extensionists, and social and technical scientific staff of local-based institutions;
- other variables envisaged from secondary information, from a pilot survey and from ideas

gathered through informal chats with farmers.

1. Institutional factors

Institutional factors are the main concern of this study. In particular, it is analysed which role marketing and other institutional macro-environmental factors play in affecting farmers' decisions to use soil conservation practices. Institutional factors are divided into three categories: marketing, governmental and administrative factors.

Marketing factors

Focus is made on those marketing factors that reflect the (type of) relationship between the farmer and marketing institutions. These factors are used to evaluate hypotheses of whether farmers with closer marketing institutional links are more likely to have access to appropriate knowledge and practice soil sustainable agriculture. These marketing factors include variables such as distance to markets, source of price information, access to market services, cooperative membership, marketing arrangements and market orientation.

H1. The farther the farm from market centres, the less likely the adoption of soil sustainable practices.

Distance to market centres defines, to some extent, the farm's degree of vicinity and accessibility to institutions and services available in those centres. Difficult access hinders the marketing of the produce and creates problems in obtaining basic input supplies and market services. Better access to crop inputs, technical assistance and 'green' knowledge not only diminish marketing costs but also facilitate sound farm management and soil sustainability. In developing countries, farmers physically need to go to the market centres to obtain services as other means of communication (telephone, radio) are seldom in rural areas. An illustration of this could be observed in Cabuyal. Farmers properly communicating with the seed distribution centre were the primary adopters of live barriers made of pasture (*Pennisetum purpureum* and other pastures).

Three indicators were used to represent distance: average transport time, cost per transported unit and access type. An average time of travel to the local market centres was obtained for each farm from the CIAT Geographical Information System (GIS) databases. Transport time shows higher variability in measuring distance than the other two indicators. Time accounts for the delay caused by topographic obstacles and the type of road or path that connects two geographical points. Cost per transport unit of weight was another indicator of the distance to market centres. This cost was not fully available, since some farms are inaccessible by motor transportation. Access to markets in terms of village's availability of passable roads and distance to town markets was further considered. This indicator, used in the study sampling, classifies good access from bad access based on physical characteristics such as type of road, distances to main roads and market centres and topography. This indicator is particularly sensitive describing farms in villages practically inaccessible in the rainy season.

H2. Farmers better informed of market news are more likely to adjust the timing of the cropping and to optimise the use of their soil resource.

Resources are not likely to be allocated in the best way when access to market intelligence (such as information on the movement of prices that reflects supply and demand movements) is poor. A better informed farmer is more able to switch his crop mix in reaction to market changes. Timely adjustment of his resources will allow him to practice sustainable food production. Price information is defined in regard to the relevance of the source used for market news. Farmers using multiple and objective information sources such as radio, television, telephone, town-market news, newspapers are likely to be better and promptly informed than those farmers using few and subjective sources of information such as a neighbour or a rural assembler.

H3. Farmers are more likely to adopt environmentally sound farm management systems if they have proper access to institutional services.

Good access to market services such as credit, inputs and extension strengthen farmers' positives attitudes toward the use of the natural resource. Appropriate gathering of inputs and of information on pertinent production and (post-)harvest techniques minimises waste and promotes optimal production behaviour. Three variables evaluate this aspect. A first variable captures farmer' own judgement of the quality of his access to market services such as credit, inputs, transport, and technical assistance. A second variable defines the number of market services that the farmer receives from local institutions. A third variable identifies whether the supplier of the service is a cooperative[90].

H4. Farmers that market their produce under vertical marketing type systems, based on long-term relationship, care more about the use of soil conservation measures.

Farmers that look for VMS relationships to gain commercial stability, to reduce average market risks or to improve access to market, are long-term horizon farmers who care more about the conservation in time of the productive resource. In the case of buyers going for low prices, the VMS relationship will likely stimulate farmers to neglect soil conservation measures. Such type of VMS is probably not very stable, since the buyer will always search for the lowest price supplier and, as a result, does not like to be tied up in a long-term relationship.

Farmers were asked whether the main product of the plot was sold either under contractual arrangements or conventionally to any other trader on the harvest day. In the Cabuyal watershed, administrative VMS rather than contractual VMS arrangements are observed as contracts are on informal and eventual basis. Two types of administrative VMS arrangements, marketing cooperatives (for coffee and beans) and starch processors (for cassava), are distinguished. Two dummy variables account for these two types of VMS arrangements. Starch processors rule the cassava market channel and have great influence on farmer's behaviour. They ensure supply by providing short-term pre-harvest advances (in cash or inputs). The implicit interest rates easily doubles the bank rates. Starch processors impose the price and, frequently, the harvest time[91]. In contrast to marketing cooperatives, starch processors are hard buyers whose main concern is to keep on business. They are unconcerned of what soil practices contracted farmers employ, and rather they promote monocropping to boost cassava productivity per unit area and cassava varieties that are very efficient on nutrient depleted soils (Ashby, 1985). Consequently, higher adoption of sustainable soil practices is expected from farmers commercially engaged with marketing cooperatives, while lower adoption of these practices is expected from farmers commercially engaged with private starch processors.

[90] Users of cooperative services are not always cooperative members.

[91] Starch processors promoted the adoption of bitter varieties in the region, not only because of their high yield well on poor soils (i.e. efficient at extracting scarce essential nutrients from the soil), but because their high contents of starch.

H5. Farmers with entrepreneurial skills will care for appropriate production systems.
A farmer with entrepreneurial skills is one who commercialises most of the farm output, has an interest in accounting on crop's profitability, searches for changing wants and needs in the market, cultivates new promising products and crop varieties, and searches for better production systems. An entrepreneur pursues to continuously create superior value for current and future customers (Narver and Slater, 1990). An entrepreneurial farmer is therefore a long-term planner and would be concerned for adequate practices that sustain the productivity of the soil resource in the time. Market orientation is an important characteristic of entrepreneurship. Narver and Slater argue that market orientation is founded on three components, named customer orientation, competitor orientation and inter-functional coordination[92]. While extensive measures of market orientation are available (e.g. Kohli et al., 1993), this characteristic is measured concisely by an index that measures farmer's attitude towards understanding and assessing buyers' demand. Furthermore, commercial orientation was used as an index that accounts for the percentage of farm produce sold.

Governmental factors
The governmental factors comprise the variables that are included in current national policies such extension, subsidies, tax exemptions and institutional assistance. Although official support programs might have an evident impact on soil conservation, their contribution to adoption may vary with the type of conservation practice.

H6. Affiliation to technical institutions increases farmer chances of practising sustainable production methods.
Affiliation examines farmers' links to organisations in terms of technical assistance on a field-by-field basis, extension, etc. Farmers with good communication to technical institutions can obtain knowledge on appropriate farming practices, pest control, and on the control measures to overcome soil erosion and other problems. Farmer links to technical institutions were divided in two groups according to whether the institution was private or not in order to check out possible differences in roles. Variable *GO* (yes/not) accounts for farmer links to governmental technical organisations, while variable *NGO* accounts for farmer links to non-governmental organisations. A third variable expresses whether the farmer has links to any type of institution. In the Cabuyal watershed, the national federation of coffee growers (FNC) granted subsidies for pest management[93] and diversification practices to coffee growers. The subsidies were intended to reduce economic risks or coffee supply. Henceforth, a binary variable expressing whether farmers received such a subsidy was also defined.

Administrative factors
The studied farmers might be attached to administrative regions. For example, county's watershed district can be under an organised voluntary *program* for purposes of soil conservation planning. Farmers residing in such an area may likely reflect increased awareness and commitment to soil sustainability compared to farmers located in other district having no voluntary program. The

[92] Narver and Slater (1990) define customer orientation as "the sufficient understanding of the buyer's value chain [...]"; competitor orientation as "the ongoing assessment of the value of the business offerings and capabilities relative to those of the competition"; and inter-functional coordination as the fact that "information on buyers and competitors is shared throughout the business, decisions are made inter-functionally and all functions contribute to the creation of buyer value".
[93] Pest control subsidies were mainly addressed to control rust in coffee leaves (known locally as *roya*, a fungus that affects coffee bean production).

study area is fully covered by the *Cipasla* consortium's[94] several projects, so the specification of an administrative variable was unnecessary[95].

2. Personal-social Factors

Personal-social factors are related to personal characteristics, such as age, education, and to attitudinal attributes, such as farming commitment, awareness, innovativeness and risk aversion, that define farmers' attitudes towards the manner he uses farm resources and is receptive to conservation technologies. Personal-social factors reflect the willingness of farmers to adopt sustainable agricultural practices and their capacity for the proper application and maintenance of such practices.

H7. Education level is positively related to the use of conservation measures, which prevent soil erosion.

Better-educated farmers will acquire and process more information on problems of soil erosion and on the possible use of instruments to prevent soil erosion (e.g., Carlson, 1977, Mbaga, 1998). These farmers are expected to be associated with greater knowledge about conservation measures, understanding the consequences of erosion and higher management expertise.

H8. Age is negatively associated with the adoption of soil sustainable technologies.

Younger farmers are expected to have a longer-planning horizon (longer payoff period) than older farmers (e.g., Gould et al., 1989). Older farmers tend to be more attached to traditional practices and more reluctant to new soil conservation measures. Conversely, younger farmers are more eager to gain knowledge and experience from new technologies. Hence, it is likely that young farmers are earlier adopters of soil sustainable agricultural technologies. It is also expected that younger farmers are better educated and, as such, this hypothesis is a corollary of H8. They are more conscious about the possible damage of soil erosion than old farmers, since their income relies upon the fertility of the land for a longer period of time to come.

H9. Commitment to farming is positively related to the adoption of soil conservation practices.

Farmers with greater commitment to farm economic activities would care more about the long-term productivity of the soil resource. Individuals who see the farm as his way of life and the source of his family livelihood are more committed to live in harmony with the natural surroundings. Farming commitment is to be derived from the farmer's reasons to be a farmer, such as being his own boss and income motivations (Kliebenstein et al. 1980).

H10. Farmers' awareness of soil erosion problems is positively associated with adoption of sustainable practices.

Aware farmers are more perceptive of the decreasing land productivity over time and on the susceptibility of fields located on hillsides to soil erosion. These aware farmers are likely to associate these factors with soil erosion and depletion and will look for preventive measures. Therefore, farmer's *awareness* of current soil degradation problems reflects concerns about soil resource and about the adoption of 'friendly' soil practices. Both, an indicator of soil degradation problems' concern (yes/no) and an indicator of willingness to take actions (yes/no), represent farmer's awareness of soil degradation problems.

[94] Cipasla is the consortium of governmental and non-governmental entities involved in research projects at the Ovejas watershed (see Chapter 6).

[95] Nonetheless, it is possible that the consortium's influence vary to some extent on households located in areas where such projects or programs have limited impact. Other variables, however, such as distance and farm location, account for this possibility.

H11. Innovativeness is directly related to adoption of soil sustainable practices.
Innovative farmers like to be informed of new technologies and try new production methods. These types of farmers are likely to furnish themselves with knowledge of soil erosion and seek for measures to reduce its impact on farm production. The most important elements of innovativeness in Cabuyal are related to the farmers' participation in organised field days in which they can observe and discuss trials in other farmers' fields. Trials often exhibit recommended cultural practices addressed to overcome local soil degradation problems. A binary variable, denominated *innovativeness*, indicates whether farmers show interest in attending these community actions and peer groups and/or in trying demonstrated practices.

H12. Risk-averse farmers are less willing to adopt soil conservation practices.
Farmers who avoid risk may be hesitant to sacrifice short-run returns for the uncertain benefits of conservation practices[96]. These farmers will be reluctant to invest in technologies which are costly and which benefit is not immediate. Kramer (1983) argues that farmers with a high aversion to risk will follow production practices that are associated with more secure income and lower costs. Although this description is generally accepted in the literature on adoption of soil conservation technology, it could also be otherwise. Risk-averse farmers might be expected to adopt practices to avoid the chance of a long-term productivity decline, whereas risk takers might not adopt these practices with the belief that new technology will be developed to substitute for topsoil. Nevertheless, most empirical works subvert such a theory (e.g., McSeeney et al., 1983; Ervin and Ervin, 1982; Carcamo, 1994; Mbaga, 1998). In Cabuyal, risky situations are related to vegetable production, grow of new crops and being in debt. Three risk-aversion indicators were constructed from a series of questions about the farmer's preferences for avoiding risky situations[97].

H13. Ethnic origin has an impact on the adoption of soil conservation practices.
Ethnic roots are associated with cultural values that affect views and attitudes to nature and, in particular, to the soil resource (Lutz and Young, 1992). In Cabuyal can be observed discrepancy in conservation attitudes among ethnic groups. *Paeces*, *Guambianos*, *Caucanos*, *Nariñenses* constitute the Cabuyal racial groups. The first two groups are Indigenous communities, whereas the remaining groups are non-Indigenous communities (*mestizos*), often inmigrants from other regions. Immigrants are expected to make a lower conservation effort compared with native farmers. Indigenous, in particular *Paeces*, practice low-intensive crop production. For *Paeces*, *la pacha mama* (the mother land) has a spiritual meaning. They are a close ethnic group that cultivates low-input crops basically for self-consumption.

3. Economic Factors

Economic factors such as income, family labour, off-farm employment, debt levels and land tenure, are expected to play a role in determining the willingness to adopt sustainable agricultural practices. These factors may either facilitate or constrain farmers' dispositions towards conservation.

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[96] Risk aversion, depending of the context, could be also classified as an economic factor. In this study, it is defined as an attitudinal characteristic.

[97] The methods to measure risk aversion in studies on the adoption of soil sustainable practices vary to a large extent in the literature. This is because risk attitudes are not observable and not easily measured in cross-sectional studies. This implies the use of proximate measures such an index of farmer's attitudes to risky situations as observed in Ervin et al. (1982) and Mbaga (1998) works.

H14. Higher levels of economic returns are positively associated with adoption of conservation practices.

Wealthier farmers are more likely to adopt soil conservation practices since financial constraints to adoption are less for farmers with larger profits[98]. Ideally, net farm income would be the appropriate measure but difficult to assess in field-by-field studies. As this measure was not available, the total area of *cropland* operated (owned and leased) was used as substitute (Pampel et al. 1977; Ervin et al. 1982). Cropland size is often shown to be highly associated with higher economic returns (Carlson, 1977; Earle et al., 1979; Mbaga, 1998). There are reasons to consider that large croplands tend to be more sustainably managed than small croplands. First, the size of the cropland is often correlated with the physical conditions of the land. In the Andean tropics, small farms are commonly located on steep and fragile lands, whereas big farms are located on valleys of fertile croplands. Second, larger farms tend to have easier access to institutional credit than small ones, whose access may be limited to the informal market where interest rates tend to be higher due to either market imperfections, high retailing costs or the high risk of defaults. This fact puts pressure on small farmers to invest in activities with short pay-off periods, which is not conducive to the adoption of environmentally benign practices that characteristically produce more lasting but fewer immediate benefits (Lutz & Young, 1992). Third, larger farms have greater availability of area and resources to implement soil conservation measures (Norris et al., 1987; Laing et al., 1992).

The farmer *well-being*[99] level, an available index from a previous study in the zone (Ravnborg, 1994), was used as another proxy for farm economic returns. The well-being index attempts to reveal differences among small-scale farmers based on local criteria. Besides income, the index takes into account local criteria such as capacity to employ, crop diversity, non-agricultural source of income and housing quality. Farmers were classified according to three well-being levels: high, medium and low.

H15. High debt levels negatively affect soil erosion control decisions.

High debt service loads (e.g. land mortgages, crop credits) create concern and may force farmers to apply unsustainable soil management such as erosive crop mixes. Farmers may also not be able to invest in conservation practices, especially in costly physical structures. A debt/asset ratio will properly indicate debt concerns. However, this figure is difficult to obtain from the farmer. Instead, a *debt-concern* dummy variable indicates whether farmers are concerned with in-cash or in-kind debts. A farmer is concerned if he has high-interest loans from middlemen, is behind in instalments or owes money to a food-shop.

H16. Off-farm employment affects negatively the adoption of sustainable agricultural practices.

Off-farm employment reduces household labour available for farming activities hampering decisions to adopt soil conservation practices. Off-farm activities may imply less on-farm labour and time available to set up and maintain labour-intensive sustainable practice. This variable is estimated as the percentage of family members working off-farm[100].

H17. Availability of farm labour facilitates farmer willingness to adopt soil conservation

[98] Although theory and evidence support a positive relationship between income and sustainability, there are other opinions regarding this relationship. Other authors think that higher income can result in further deterioration of the natural resource.

[99] Initially, this index was referred to as "*wealth*" index, but later termed "*well-being*" since this later has less materialistic focus and is more associated with the broader notion of quality of life.

[100] Other authors use a days-off/day-on ratio.

measures.

This hypothesis arises as a corollary of the previous hypothesis. Conservation measures, which involve construction of physical structures such as terraces, waterways and composting pits, are labour intensive. More farm labour at hand is a decisive factor in the adoption decision process as labour shortage is a major impediment for the implementation and maintaining of these conservation measures[101]. Labour per unit area may be a suitable indicator of farm labour but likely to be highly correlated with cropland area. Instead, the number of economically qualified on-farm labourers was selected.

H18. Land tenure has a positive effect on adoption of sustainable agricultural practices.

Landowners are shown to be more willing to invest in soil conservation practices than farmers who do not own the land (e.g. Featherstone and Goodwin, 1993). Non-owner farmers may be unwilling to invest in soil conservation due to lack of long-term commitment or responsibility on the land. Non-owners will be thinking short-term and focused on meeting daily needs, which restricts their investments in land care. Conversely, full ownership of the land increases the sense of responsibility due to a long-term planning horizon and concern about the soil quality of the farm. Therefore, a greater use of soil conservation technologies is expected among the households cultivating own land[102].

H19. Farmers with a long-term commitment and longer planning periods are more likely to be adopters of soil conservation measures

Since conservation practices often require short-run expenditures for long-run productivity benefits, lower discount rates and longer *planning periods* make conservation investments more attractive. Discount rates and planning periods are not easily measured in personal surveys. Operator age is discarded as a proxy as it is already assumed as a personal characteristic. Four proxies were taking into account to measure influences on planning period length. A binary variable indicates whether or not farmers expect to transfer their farms to a child. A second binary variable expresses farmer's opinion about keeping or selling the farm. Finally, two indexes of past and future investments in farm improvement complete the set of planning-period variables.

H20. Adoption of soil sustainable practices varies according to the predominant crop in the farm.

Certain farms have production systems that may differ in the emphasis allocated to short-term or long-term considerations[103]. The importance of this variable arises from the fact that in Cabuyal, cassava farms have production systems that are more oriented to short-run profits. These farmers might have higher discount rates and shorter planning periods compared to bean and, particularly, coffee farms. Coffee farmers, in contrast, possess a higher degree of farm commitment and a longer planning horizon. Hence, these types of farms are expected to perceive the long-term benefit of soil management and devote more efforts in the adoption of soil sustainable practices.

4. Physical Factors

Physical characteristics set boundaries to households in terms of resource quality and physical conditions. These characteristics determine the levels of soil degradability and agricultural output that may be associated with the land. Physical factors, such as erodibility, topsoil layer depth and

[101] The author thanks Helle Ravnborg for suggesting the inclusion of this variable.

[102] Bank credit is often linked to land tenure. Land rights and credit are inter-linked: the higher the degree of security of tenure, the greater the credit worthiness of the farmer and therefore the better the access to credit (Feder and Onchan, 1987).

[103] Other authors used other farm types such as 'grain farms' (Ervin and Ervin, 1982) and 'cash crops' (Mbaga, 1998).

farm location, guide farmers on soil types and erosion susceptibility and are used to determine actions to improve or maintain land productivity over the farm unit (Rahm and Huffman, 1984; Caswell and Zilberman, 1985).

H21. Higher levels of soil erodibility are positively related with adoption of soil conservation measures.

Soil erodibility indicates the extent to which soil degradation problems are likely and the need to adopt sustainable measures (Ervin and Ervin, 1982; Gould et al., 1989). Those households having farms in areas prone to soil erosion, such as steep slopes, are expected to recognise the risks of topsoil soil loss more easily than households located on gentle slopes and lowlands. The degree of potential erosion may influence farmers to use a particular type of soil conservation measure. However, farmers may opt for inappropriate remedial actions (e.g. fallow instead live barriers). Ideally, an index of 'natural' soil erosion potential could be calculated as the product of the soil erodibility (K), slope length without terraces (L), and slope percentage (S) variables (see Smith's USLE equation in section 5.5). Not all USLE variables, though, were available at the time of this study. Instead, a rating of the erosion potentiality of each field -high, medium and low- was used. Complementary to erosion potentiality, *slope length* and *slope gradient* measurements were also considered. Thus, adoption of sustainable agricultural practices is expected on steeper and larger fields.

H22. Shallow topsoil layers are associated with adoption of soil conservation practices.

The erodibility of the soil (e.g. slope gradient) is not the only indicator of the need for soil conservation measures. In informal discussions, Cabuyal farmers identified *depth of topsoil layer* as another guiding indicator of the need for soil conservation measures and, as such, this hypothesis is a special case of hypothesis H22. The depth of the field's topsoil layer, which farmers can estimate when ploughing, leads farmers to judge the use or not of soil conservation measures. The deeper the topsoil layer, the lower the need for soil conservation practices.

H23. The adoption of soil conservation factors is affected by location-specific factors such as agro-ecological conditions.

Agro-ecological farm location provides on-site characteristics such as soil type, altitude, climate and rainfall differences among zones. Farming systems are susceptible as well to agro-ecological variations. Farm location determines what practices are more sustainable and optimal in one area than in other. Three agro-ecological zones are commonly distinguished in Cabuyal, namely high, medium and low.

Farmers' plot prioritisation is also a location-specificity factor when deciding on adoption of soil conservation practices. Cabuyal farmers, as most of Andean farmers, show marked preference for one of their plots, which is generally the most productive, main source of income, the most fertile, the closest to the house and the best managed. Therefore, adoption is likely to be more commonly observed in this plot.

This section has developed a number of hypotheses related to the factors identified in Figure 8.2 to affect ASAP. Also measures of these variables in the Cabuyal area have been discussed. Some of these variables are highly demanding in data, difficult to collect or prone to imprecision in the study area. When this was the case, approximations have been proposed instead. Table 8.1 summarises the variables selected to represent the explanatory factors.

Table 8.1 Description of the explanatory variables

		Variable	Indicators	Description
I	G	Affiliation	4	Number of GOs that farmer has contact with.
N	O			Number of NGOs that farmer has contact with.
S	V			Links to any type of institution.
T				1 if farmer receives subsidy; 0 otherwise.
I	M	Market distance	2	Distance in minutes from the plot to the market.
T	A			1 if road access is good; 0 otherwise.
U	R	Price information	1	1 if objective price information sources; 0 otherwise.
T	K	Market services	3	Number of services provided by institutions.
I	E			Farmer's marking on access to market services (%).
O	T			1 if service provided by a cooperative; 0 otherwise.
N	I	Marketing integration	2	1 if farmer is VI[2] to the market; 0 otherwise.
A	N			1 arrangements with starch processors; 0 otherwise.
L	G	Market orientation	2	Percentage of sold product.
				1=poor, 2=intermedium, 3=high market orientation.
P		Education	1	Education in years
E		Age	1	Age in years
R		Farming commitment	1	1 reasons related to income motivations; 0 otherwise.
S		Awareness of soil	2	1 if farmer is aware of soil problems; 0 otherwise.
-		problems		1 if farmer plans to control the problem; 0 otherwise.
S		Innovativeness	1	1 if farmer visits experimental farms; 0 otherwise.
O		Risk aversion	3	1 if farmer dislikes market-risky crops; 0 otherwise.
C				1 if farmer does not test new crops; 0 otherwise.
				1 if farmer is averse to credits; 0 otherwise.
		Ethnic group	1	1=other, 2=Nariño, 3=Cauca, 4=Guambia, 5=Paez.
E		Farm income	2	1=high, 2=medium, 3=low well-being level.
C				Cropland measured in plazas[2].
O		Debt concerns	1	1 if farmer has debt concerns; 0 otherwise.
N		Off-farm employment	1	Percentage of family members working off-farm.
O		On-farm labour	2	On-farm labour (economically available).
M				Persons per cropland area (persons/plaza)[2].
I		Land tenure	2	1 if farmer owns the plot; 0 otherwise.
C				1 if farmer has formal credit; 0 otherwise.
		Planning periods	4	1 if farm will be transferred to a child; 0 otherwise.
				1 farmer is not planning to sell the farm; 0 otherwise.
				Farm improvements in the last 5 years.
				Planned farm improvements within 5 years.
		Farm type	3	A dummy for coffee, cassava and bean farms.
P		Slope length	1	Plot length in meters.
H		Slope gradient	1	Ten levels of gradient, from gentle to extreme.
Y		Soil erodibility	1	1=low, 2=mild, 3=high.
S		Topsoil depth	1	Measured in cm.
Y		Location	2	1=high, 2=medium, 3=low agro-ecological zone.
C				1 if plot is the most important of the farm; 0 otherwise.

1: 1 plaza=0.64 ha; 2: VI= Vertically Integrated

8.4 Model estimation: lessons from the past

When reviewing the empirical studies on ASAP, in Chapter 3, it was noted that many of them defined ASAP as a dichotomous variable (adoption or no-adoption of sustainable practices) for reasons of simplicity. The pros and cons of that specification have been discussed in Chapter 7.

Also the choice of a dichotomous approach to sustainability, however, rules out the use of parametric estimation techniques such as Ordinary Least Squares (OLS) and forces the use of non-parametric methods such as maximum likelihood, Probit, Tobit or Logit models when model estimation is pursued[104]. Consequently, some disappointing results, in terms of model fit and significance, are likely to occur as it is noted below.

Table 8.2 shows the results of three authoritative works (Ervin and Ervin, 1982; D'Souza et al., 1993 and Mbaga, 1998), which belong to the 'integrated model' approach discussed in Chapter 3. The authors employed multiple regression, Logit and Poisson methods to explain ASAP.

Table 8.2 Previous results of ASAP models

Variables	Ervin et. al., 1982	D'Souza et al., 1993	Mbaga, 1998
Dependent variable	No. of practices	Adopter/Non-adopter	No. of practices
Independent variables			
Age	n.a.	-***	n.a.
Education	+*	+***	+
Perception	+*	n.a.	+***
Conservation Attitudes	+	n.a.	n.a.
Farm orientation	+	n.a.	n.a.
Risk aversion	-*	n.a.	n.a.
Erosion potential	-*	+*[1]	n.a.
Off-farm employment	-	-**	-**
Hired labour	n.a.	-	+***[2]
Transfer to child	+	n.a.	n.a.
Total cropland	+	n.a.	n.a.
Debt concern	+	+	n.a.
Cash grain farm	-*	n.a.	n.a.
Government programs	+	-	+***
Farm location	-	n.a.	-
Sample size (farms)	92	600	162
Estimation technique	Multiple regression	Logit regression	Poisson regression
R^2	0.31[3]	0.10	0.17

*, **, *** represent .10, .05 and .01 levels of significance, respectively; 1=contamination of ground water was used instead of erosion potential; 2=farm labour was used instead of hired labour; 3=other R^2s with different dependent variables were 0.25 and 0.26.

In the results of these models some features can be distinguished. Firstly, few of the hypothesised variables appear to be significant, although signs (+ or -, in Table 8.2) in most of the times are correct. Secondly, although these models belong to the 'integrated approach' (Chapter 3), R-squares are rather low indicating poor model fit to the data. Some elements might be the cause for unsatisfactory fit. Reasons for the unsatisfactory fit might be:

a. The definition of ASAP as a dichotomous (adoption/non-adoption) or nominal (number of practices adopted) variable misses large a part of the insight of the adoption process and obscures the detection of cause-effect relationships and the explicative power of the model.

[104] As noted earlier, the differences between these techniques lies on the type of probability distribution assumed to estimate the probability of a factor in explaining ASAP. For instance, *Logit* is based on a cumulative logistic distribution while *Probit* is based on a cumulative normal distribution.

b. The use of estimation techniques such as *Logit* and *Poisson* to deal with discrete dependent variables implies relaxed assumptions with respect to variable distribution with the consequent loss of explanatory power. As a result, the model adjustment to the data (R^2) is often low.
c. Correlation among explanatory variables (e.g., between age and education) can lead to multicollinearity problems, which result in difficult disentangling of the separate effects of explanatory variables and low parameter significance (Maddala, 1992).

All these elements have been taken into account here for the conceptual formulation and empirical estimation of the present study model. First, an 'integrated model' approach, that considers institutional, personal-social, physical and economic factors, has been adopted in order to guarantee full model specification. In this way, the model will be more consistent and the effect of marketing factors more reliably estimated. Second, ASAP has been measured as the degree of farm soil sustainability by means of a method developed in Chapter 7. The method consisted of grouping and quantifying a great number of adopted sustainable agricultural practices in order to obtain a few number of basic sustainability dimensions. The sustainability dimensions are interval scaled and as dependent variable they are normally distributed[105], which enables the use of multivariate parametric techniques such as multiple regression for the estimation of the factors affecting sustainability adoption.

With regards to multicollinearity, it is plausible that some degree of correlation among explanatory variables occurs as the number of variables is high and all attempt to explain ASAP. For example, higher levels of income are possibly related with larger croplands and greater credit worthiness. Farmer's education is likely to be associated with younger farmers and innovative behaviour. An effective way to solve this problem is through principal component regression. The following section discusses this estimation procedure.

8.5 The principal component regression of ASAP

An estimation technique to deal with difficulties in parameter interpretation and inter-correlation, when there are many explanatory variables, is *Principal Component Regression (PCR)* (Maddala, 1992). The estimation procedure starts with a very general model with many independent variables. In a first step (Section 8.5.1) key independent components are extracted from each explanatory factor category in order to explain a fair proportion of the original variance[106]. Since the extracted components are independent, multicollinearity is in this way eliminated within categories[107]. In a second step (Section 8.5.2), regression is pursued on ASAP and the explanatory components. Tests of multicollinearity are undertaken to evaluate possible correlation between explanatory components across different factor categories. Following the component extraction procedure is discussed for each factor.

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[105] As per definition, optimal scaled variables are normal standard with zero mean and unit variance.
[106] Principal component analysis (PCA) was independently applied to personal-social, economic, institutional and physical factor categories. Nonlinear transformation was used in discrete variables to induce quantitative behaviour.
[107] The extraction of components was limited to each factor category in order to ease the evaluation of the hypotheses proposed and the contribution of each factor (including marketing factors) to the overall model fit.

8.5.1 Extraction of the explanatory components

As in Chapter 7, the selection of the most optimal number of components for each explanatory factor category was guided by the *latent root criterion* (components with latent roots greater than 1) and the *scree test criterion* (the cutoff point of a curve of latent roots versus number of components) (Hair et al., 1995).

Institutional components

The criteria applied for the determination of components led to the extraction of five components for institutional factors. The five components account for 60.8 percent out of the total variance in institutional factors. Table 8.3 shows in bold component loadings greater than 0.50 in absolute value[108].

Table 8.3 Institutional component loadings

	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5
Subsidy	**0.53**	0.21	0.04	0.14	0.27
GO	**0.71**	-0.31	0.16	-0.04	0.03
NGO	**0.75**	-0.17	-0.01	-0.31	0.04
Distance	-0.33	**-0.75**	0.04	0.29	0.01
Road access	0.32	**0.80**	-0.29	-0.10	-0.12
Market orientation	0.20	0.20	**0.68**	-0.23	-0.10
Price information	0.19	-0.31	**-0.69**	0.38	0.36
Commercial orientation	0.06	0.03	0.27	**0.67**	-0.13
Cooperative	0.32	-0.08	0.08	-0.14	**-0.90**
Vertical integration	0.43	0.25	-0.15	**0.51**	0.07
Sales to starch processors	0.06	-0.35	-0.10	**-0.56**	0.11
Access to institutional services	**0.62**	-0.07	0.06	0.11	0.08
Links to any institutions	**0.79**	-0.39	0.05	0-07	0.19

Component loadings larger than 0.50 in absolute value are reported in bold

Component loadings in Table 8.3 shows that component one is related to farmers with good access to marketing services and good links to governmental and non-governmental institutions. Good institutional proximity enables these farmers to get FNC subsidies addressed to pest management and crop diversification. The second component depicts farmers settled on farms with comparatively good roads and market centres access. The third component is associated with farmers with market orientation who apply accounting, search for market taste changes and look for alternative information sources for the latest prices and other market news. They are modernist and information-intensive entrepreneurs who care for effective ways of production and sources of price information. Component four characterises farmers who commercialise most of their produce and market it under contractual arrangements excluding those with starch processors. Finally, farmers who have not links at all with cooperatives constitute the fifth institutional component.

Henceforth, the institutional factors in Cabuyal can, to a large extent, be described in terms of five independent components, namely 'good access to marketing services, GOs/NGOs', 'market

[108] Component loadings range from –1 to 1 to indicate the weight of each variable with respect to the component.

proximity and road access', 'entrepreneurship', 'commercial orientation and VI[109]' and 'non links with cooperatives'.

Personal-social components

For personal-social factors, three components or dimensions were extracted. The three components account for 48.6 percentage of the total variance. Table 8.4 displays in bold loadings equal or greater than 0.50 in absolute value.

Table 8.4 Personal-social component loadings

	Component 1	Component 2	Component 3
Education	**0.64**	0.09	0.13
Farming commitment	**0.50**	-0.10	-0.39
Ethnic[1]	**-0.72**	-0.22	0.09
Awareness of soil problems	0.04	0.03	**0.71**
Plans to control soil problems	**0.64**	-0.06	0.30
Risk aversion to high-value products	-0.09	**-0.70**	0.26
Risk aversion to crop opportunities	-0.13	**-0.61**	-0.23
Risk aversion to credit	0.11	0.07	**0.61**
Innovativeness	-0.04	**0.71**	0.16

Component loadings larger than 0.50 in absolute value are reported in bold.
1= low values represent *mestizo* farmers and high values represent indigenous farmers

Component one shows positive loadings with education, farming commitment and future investments in sustainable agricultural practices, and a negative relation with ethnic groups. This description points at non-Indigenous farmers with higher education, concerned about controlling soil degradation problems and oriented to farming more than to any other activity. Component two is negatively related to risk aversion and positively to innovativeness. This component describes innovative and risk prone farmers. Component three is positively related to awareness of the soil degradation problem and a risk aversion to credit. This personal-social component characterises resource-poor farmers who lack collateral and face soil degradation problems. It is noted that 'age' was the only variable that obtained a component loading below 0.5 reflecting low variability and lack of contribution to the three personal-social components.

Henceforth, the personal-social factors in Cabuyal can be described in terms of three independent components, namely 'educated and farm-committed mestizos', 'risk prone and innovativeness' and 'aware resource-poor farmers'.

Economic components

Principal component analysis reduced the economic factors to five main components that account for 57.5 percentage of the total variance. Table 8.5 displays in bold component loadings equal or greater than 0.5 in absolute value.

Table 8.5 Economic component loadings

[109] Vertical integration to the market.

	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5
Well-being level[1]	**-0.76**	0.14	-0.12	0.08	0.06
Cropland area	**0.66**	0.08	0.10	-0.14	-0.07
Debt concern	0.01	-0.23	0.30	0.19	**0.65**
Credit	**0.74**	-0.01	0.17	0.15	0.01
Off-farm employment	0.03	-0.00	-0.05	0.25	-0.06
On-farm labour	-0.05	0.01	0.11	**-0.92**	0.10
People per cropland	**-0.68**	-0.02	0.11	-0.30	-0.21
Land tenure	0.00	0.25	-0.22	-0.21	**0.74**
Transfer to child	-0.03	0.04	-0.46	**-0.55**	-0.13
Future farm reforms	0.14	0.06	**0.85**	-0.16	-0.03
Past farm reforms	0.14	-0.06	**0.80**	0.12	0.01
Coffee grower	-0.06	**0.87**	0.11	-0.18	-0.01
Cassava grower	-0.01	**-0.78**	0.02	-0.11	0.07
Bean grower	-0.18	**-0.77**	0.10	0.01	-0.11

Component loadings larger than 0.50 in absolute value are reported in bold
2= well-being levels 1:high, 2:medium, 3:low

The first economic component represents better-off farmers with good access to land and credit resources. The second component defines coffee growers with little cropland under cassava and beans. The third component depicts farmers concerned in making farm improvements. Possibly, these farmers have longer planning horizons and lower discount rates. The fourth component describes farmers with shortage of own labour and whose children have left or plan to leave the farm to work in activities different to agriculture. The last component characterises landowners who are very concerned about current financial debts. It can be noted that 'off-farm income' was the only variable that obtained a component loading below 0.5 reflecting low variability and lack of contribution to the economic components.

Henceforth, the economic factors in Cabuyal can be described in terms of five independent components, namely 'wealthy farmers', 'coffee growers', 'long-term planners', 'farm labour shortage' and 'owners with debt concerns'.

Physical components

Three components were identified for this last factor, which account for 65.5 of the variance. Table 8.6 displays in bold component loadings equal or greater than 0.5 in absolute value. The first component is strongly related to farm plots with soils not prone to erosion problems. These plots are characterised by relatively flat plots with low soil erosion potential. The next component describes the second farm plot characterised by long slopes. The last physical component comprises plots from the high agro-ecological zone of Cabuyal with depth topsoil layers. Thereby, the physical factors in Cabuyal can be described in terms of three independent components, namely 'low soil erosion potential', 'the second farm plot with the longest slope' and 'deepest soils of the highest agro-ecological zone'.

Table 8.6 Physical component loadings

	Component 1	Component 2	Component 3
Slope length	-0.10	**0.54**	-0.20
Slope gradient	**-0.82**	**0.20**	-0.29
Erodibility	**-0.89**	-0.08	0.18
Topsoil depth	0.16	0.21	**0.50**
Zone[2]	-0.09	0.38	**1.00**
Plot[3]	0.18	**0.88**	-0.24

Component loadings larger than 0.50 in absolute value are reported in bold.
2= 1:low, 2:medium, 3:high. 3= 1:main farm plot, 2:second farm plot.

The previous procedure has resulted in the reduction of the explanatory variables to sixteen primary components by means of PCA. The sixteen components explain a satisfactory proportion of the original variance and are independent within factor categories. Table 8.7 shows the final components and the proportion of the explained variance with respect to the original explanatory variables.

Table 8.7 Factor components

Factor component	Variability explained (%)
Institutional	61
Good access to marketing services, GOs/NGOs	
Market proximity and road access	
Entrepreneurship	
Commercial orientation and VI[1]	
Non links with cooperatives	
Personal-social	49
Educated and farm-committed mestizos	
Risk prone and innovativeness	
Aware resource-poor farmers	
Economic	58
Wealthy farmers	
Coffee growers	
Long-term planners	
Farm labour shortage	
Owners with debt concerns	
Physical	66
Low soil erosion potential	
The second farm plot with the longest slope	
Deepest soils of the highest agro-ecological zone	

1=Vertical Integration to the market

The next section presents the results of regressing ASAP on the explanatory components by means of ordinary least squares.

8.5.2 The model estimation results

The sixteen primary components identified can now be placed on the right-hand side of expressions 8.3, which will result in the principal component model to estimate. Thus:

$$
\begin{aligned}
(sc) &= f\ (\text{Physical comp., Pers-Social comp., Economic comp., Institutional comp.}) + \text{error} \\
(sp) &= f\ (\text{Physical comp., Pers-Social comp., Economic comp., Institutional comp.}) + \text{error} \qquad (8.3) \\
(rc) &= f\ (\text{Physical comp., Pers-Social comp., Economic comp., Institutional comp.}) + \text{error}
\end{aligned}
$$

where sd, sp, rc are defined as before and the factor components are defined as in Table 8.7.

Table 8.8 shows the results of ordinary least squares (OLS) estimation for the each of the three independent dimensions of ASAP. No intercept terms were specified as all dependent variables are standardised (i.e. mean is zero). Variable with levels of significance lower than or equal to 0.2 are displayed.

Table 8.8 Regression of ASAP's dimensions on explanatory components (and significance levels)[1]

	Explanatory component	Soil-disturb. ctrl		Soil protection		Run-off control	
P	Educated farm-committed mestizos	-.11	(.03)	-		-	
&	Risk prone and innovativeness	.07	(.20)	-		-	
S	Aware resource-poor farmers	-		.16	(.01)	-	
E	Wealthy farmers	-		-		-	
C	Coffee growers	.61	(.00)	-		-.09	(.19)
O	Long-term planners	.11	(.05)	.18	(.00)	-	
N	Farm-labour shortage	-.08	(.10)	-.08	(.20)	-.22	(.00)
	Owners with debt concerns	.07	(.15)	-		-	
I	Access to MS[2], GOs/NGOs	-.09	(.13)	.32	(.00)	-.09	(.20)
N	Market proximity and road access	-		.10	(.15)	-	
S	Entrepreneurship	-.12	(.02)	.16	(.01)	-	
T	Commercial orientation and VI[3]	.13	(.02)	-		-	
	Non links with cooperatives	-		-.16	(.01)	-	
P	Low soil erosion potential	-		-		-.11	(.08)
H	Second plot with the longest slope	-.09	(.07)	-		-.08	(.20)
Y	Deepest soils of the highest zone	-		.23	(.00)	-	
No. of observations		196		196		196	
R^2		.55		.31		.09	
Adj-R^2		.53		.28		.06	
F		23.2	(.00)	10.4	(.00)	3.6	(.00)

1=Explanatory components coefficients denoted by '-' are not significant at the 20 percent level;
2=Marketing Services; 2=Vertical market Integration

An overview of the results shows that the principal component model R^2s present very good fit levels compared to previous studies results, except the 'run-off control' model[110]. Similar R^2s and

[110] Higher levels of R^2s (0.75, 0.45 and 0.19, respectively), were obtained in another attempt to regressing the sustainability components on the original factor variables. However, a high degree of multicollinearity was detected in all models.

adjusted R^2s hold correct model specification. It is particularly notable that 'soil disturbance control', the sustainability dimension that explained most of the original variability, was explained best. The R^2 of 55 percent of this dimension was clearly superior to the R^2 of the other two. High F statistics guarantee significant explanation power in all models. Most of the explanatory components present the hypothesised effects on each sustainability dimension.

The model tests presented in Table 8.9 validate the assumptions of no presence of multicollinearity and heteroscedasticity demanded by the OLS. Firstly, the tests *Tolerance*[111] (TOL) and *Condition Index*[112] (CI), that diagnose whether there is correlation among the model regressors (Belstey and Welsch, 1980), shows TOL and CI values close to 1 rejecting the presence of multicollinearity in all models.

Table 8.9 Testing the model's assumptions

Tests	Equation 1	Equation 2	Equation 3
TOL	0.7–1	0.9–1	0.9–1
CI	1–2	1–1.4	1–1.3
BP-LM(H)[1]	1.8*	0.9*	0.2*

*=Non-significant at .05 level of significance.

Secondly, the test of Breush-Pagan[113], a Lagrange Multiplier (LM) type of test that evaluates whether the residuals are homoscedastic (i.e, if the residuals have a constant variance), show non-significant BP values. BP values 1.8, 0.9 and 0.2 are much lower than the critical values χ^2_{10}=3.9, χ^2_8=2.7 and χ^2_5=1.1, respectively, at the 5 percent level of significance to accept the null hypothesis of homoscedasticity. The following reviews the results for each equation.

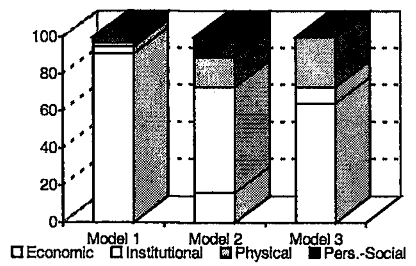

Figure 8.3 Contribution of explanatory factors to R^2 (%)

Soil-disturbance-control model

Figure 8.3 shows that economic factors explain over 90 percent of the explained variance of the adoption of soil-disturbance control practices. The remaining nine percent of the model

[111] TOL=1-R^2_j, where R^2_j is the R^2 resulting from the regression of the j-th regressor with the remaining regressors. TOL values close to 1 stand for no multicollinearity.

[112] CI=√[(max eigenvalue)/(eigenvalue X_j)], where X_j is any independent variable. CI values lower than 10 stand for no multicollinearity.

[113] BP=nR^2_{aux}, where R^2_{aux} is the R^2 resulting from the regression of the residuals with all independent variables. The Breush-Pagan (BP-LM(H)) test of heteroscedasticity is distributed χ^2_p under the null hypothesis of homoscedasticity.

explicative power is distributed between institutional (four percent), personal-social (three percent) and physical factors (two percent). 'Coffee growers' is the economic component that makes up the bulk of the explained percentage. This component has marketing aspects implicit due to several reasons. Coffee growers are market-oriented as virtually all coffee production is commercialised. Coffee growers are further linked to the market as coffee involves on-farm post-harvest processing. Inputs, credit, technical assistance and buying services are often available from coffee cooperatives (see Chapter 6).

Two out of five economic components were significant (Table 8.8). In coffee farms, growers tend to employ low soil-disturbing techniques in land preparation and harvesting. Coffee fields commonly have the best soil, the best fertility management and its land is manually prepared for transplanting the coffee plants. Similarly, farmers with long planning horizon take greater care of the practices that may have strong physical impact on the soil. These are careful farmers who mind the long-term productivity of the soil.

Marketing factors appear to be the second most important contributors to the adoption of soil-disturbance control practices, such as minimum tillage and low-impact harvest methods, directed to control soil disturbance. Further to the implicit role of marketing aspects in economic factors, two institutional components played significant roles in sustainable practice adoption. Farmers, who are commercially oriented and sell their products in VMS channels, adopt soil-disturbing control methods. These are farmers, with greater commercial stability, that find it profitable to practice sustainable farming methods. In contrast, entrepreneurs, as defined in this study, follow practices with disturbing effects on the soil. This relationship may indicate that modernist farmers, with market orientation characteristics, opt for practising intensive cultivation methods that result in soil disturbance. Conversely, traditional farmers, with poor managerial skills, use non-intensive cultivation methods.

Only one personal component is significant. Educated farm-committed *mestizo* farmers tend to practice soil-disturbing activities. This also means that Indian ethnic farmers with lower school education use more traditional farming systems in land preparation and harvesting than *mestizos*. These traditional methods have lower impact on the physics of the soil.

Only one physical characteristic was relatively important. The component indicated as 'second plot with the longest slope' shows that this type of plot receives stronger physical treatment in harvest and land preparation. This seems to confirm the common belief that the most important field of the farm receives better management. Furthermore, when the plot is long, it is much cost-effective to prepare the soil by using oxen traction than by manual means, which results in soil stress.

Other variables were non-significant at the 10 percent level. Nevertheless, their significance between 10 and 20 percent suggests that a weak relationship might exist between these explanatory variables and ASAP. Land ownership might augment farmers' interest in conserving the soil from physical degradation. Conversely, a shortage of farm-labour limits farmers from using soil disturbance-control practices. Lack of labour may force the use of mechanisation, especially for land preparation. With regards to institutional factors, links to GO and NGOs and better access to subsidies and institutional services seem to have a negative effect on the adoption of sound practices in land preparation and harvesting activities. This effect would imply that farmers receiving *FNC* subsidies for pest management and crop diversification are opting for cash crops with more intensive oxen-traction preparation and harvesting methods that significantly disturb the soil. Market proximity also appears not to exert a strong influence on the adoption of soil disturbance-control practices. The personal-social characteristic "risk proneness and innovativeness", seems to have a positive effect on soil disturbance control, suggesting that non-risk averse and innovative farmers are careful to avoid the types of practices that disturb the soil structure.

Soil-protection model

Table 8.8 and Figure 8.3 illustrate that marketing factors, with three components, were the most significant contributors (around 60 percent of total explained variance) to the adoption of physical barriers, such as live barriers and mulch, addressed to provide a soil protection from erosive raindrops. The remaining 40 percent of the variance in the model was explained similarly by one economic and one physical factor (16 percent each) and one personal-social factor (11 percent). The importance of marketing factors explaining adoption of soil protective practices is noteworthy, since rain erosion is one of the leading causes of total soil erosion in Cabuyal. Empirical evidence (Reining, 1992 and Howeler et al., 1981) shows that the potential for soil erosion is especially high when the soil is exposed to intensive tropical rainfall during the first months after crop planting and immediately after harvesting, until crop or bush cover is established.

Three institutional factors -access to market services, entrepreneurship and cooperative links- were highly significant in explaining adoption of soil protective measures such as mulch, live barriers, grass, weeds and other physical barriers that prevent the erosive impact of rainfalls. Good access to institutions and to marketing services has a significant direct effect on the adoption of soil protective practices. This effect would suggest that farmers receiving technical extension, market services and/or *FNC* subsidies obtain the appropriate instruction on soil covering measures.

Comparatively, farmers without links to cooperatives, in terms of trade and services, are negatively related to this adoption. This indicates that affiliation to cooperatives motivates farmers to care for the protection of the farm soil. Lastly, market oriented entrepreneurs, who like to be well informed, are positively related to investments in soil protective practices. These findings appear to validate the hypothesis that farmers with better proximity to market institutions and services feel encouraged to adopt sustainable practices that prevent the topsoil layer being lost. These farmers also seem to have long-term horizons with respect to the care of the productive natural resources.

Only one economic variable was important in the model. Being a long-term planner shows a positive and significant impact on the adoption of soil protection practices. This would imply that farmers with long-term views see the future benefit of investing in the protection of the topsoil. On the physical side, only farm location is highlighted as important physical factor in the adoption decision. Sustainable measures addressed to protect the topsoil from raindrop erosion are adopted in plots located at the highest agro-ecological zone characterised by deep topsoil layers. Soil protection, in this particular zone, is mainly provided by mulch cover and organic fertilisers rather than by live barriers. Only one personal-social characteristic, that is resource-poor farmers aware of soil degradation problems, exerts a positive effect on the adoption decision. This may indicate that farms lacking collateral for bank credit opt to implement less costly topsoil cover practices to protect soils highly susceptible to erosion problems.

Other variables -one marketing and one economic variable- showed low statistical significance. Appropriate road access and market proximity has a positive, but non-significant, effect on soil-protection adoption. If this effect holds, it suggests that better proximity to market centres, where market and extension services are available, may ease farmer's access to 'green' knowledge and reinforce decisions on long-term investments in soil protection. An economic factor, shortage of farm labour, shows also a negative, but non-significant, effect on the adoption of soil protection practices. Therefore, whether farm labour availability matters in the adoption of topsoil protection measures, such as live barriers, cannot be confirmed by the analysis.

Run-off-control model

Table 8.8 shows that one economic component, "farm-labour shortage", was significantly important explaining the adoption of practices addressed to divert surface water. Other four components (one economic, two physical and one institutional) showed a limited importance. Altogether these five components explained about ten percent of the total observed variation, with economic and physical factors accounting for 68 and 27 percent of this percentage, respectively (Figure 8.3).

Farm labour turned out to be the most important factor in the implementation of physical measures that control run-off of soil and soil nutrients. This indicates that households with more labour availability are better prepared to implement labour-intensive physical soil conservation technologies, while households with less labour availability may shy away from labour-intensive physical technologies.

The erosion potential of the plot, in terms of gradient and erodibility, showed a positive, though no highly significant, relation with the adoption of run-off control practices. If this relation were take into account, it would suggest that erosive proneness drives farmers to construct waterways that control nutrient leaching in farm plots. Other characteristics, such as marketing and physical variables, showed even a lower statistical significant contribution. If these contributions were considered, some conclusions could be drawn. Better access to institutions in Cabuyal appear no to stimulate the adoption of run-off control practices. As noted in Chapter 7, this is probably explained by the fact that these types of practices are more often adopted in the high agro-ecological zone where slopes are steeper. Drains and interception canals are required in farms located on steep slopes of the highlands, where access to market institutions is usually bad.

The adoption of run-off control practices also seems to be less frequently implemented on farms where coffee is the predominant crop. On the physical side, the model suggests that run-off control measures tend to be implemented on the main farm plot. Personal-social characteristics, on other hand, have apparently no effect at all on the adoption of run-off control measures.

8.6 Discussion of results

A model explaining the adoption of sustainable agricultural practices (ASAP) has been presented. The model attempts to include the factors identified in the sustainability theory to determine the adoption of soil sustainable practices. Although the focal point of the model (and of the study) rests on the potential effect of institutional factors (e.g. marketing factors) on ASAP, other factors that also contribute to such an adoption (economic, personal/social, physical) are taken into account. The model consisted of three equations with each equation related to the explanation of a correspondent aspect of ASAP. The first equation studies the determinants of the adoption of practices with low disturbance on the soil (e.g., low tillage and non-root harvest). From this perspective, soil sustainability is associated to the crop production process. The second equation studies the determinants of adoption of topsoil protective practices. In contrast to the previous equation, here soil sustainability is related to topsoil conditioning and erosion control regardless of the crop production. The third equation focuses on the adoption of soil run-off control practices, that is physical and structural practices, such as drains and waterways, that channel the water to the field limits to avoid the leaching of soil and nutrients.

Divergences of the effects of explanatory factors on ASAP

The results reveal that the influence of explanatory factors differs between the various aspects of ASAP.

Marketing factors were significantly contributors to the adoption of soil-disturbance and, particularly, to topsoil-protection practices but non-significant contributors to the adoption of run-off control practices.

Government factors, such as subsidies and links to institutions, were positively associated to topsoil protection practices but inversely associated with the use of soil-disturbance and run-off control practices. Economic factors showed overall the most significant and, relatively, more consistent influence on the several aspects of ASAP.

Economic factors showed a strong positive influence on the adoption of soil-disturbance control and topsoil-protection practices in the case of long-term attitudes and a negative (though no always significant) influence on the adoption of the three soil conservation categories in the case of shortage of farm labour.

Physical factors were, after economic and marketing factors, the third contributor to ASAP. Their influence also differs between the various aspects of ASAP. For instance, topsoil depth only influences the adoption of topsoil protection practices, whereas being the main plot of the farm only influences the adoption of soil-disturbance control practices.

The influence of personal/social factors was comparatively smaller and limited to the adoption of soil-disturbance control and topsoil-protection practices.

Implications for the validation of the hypothesis

Since the explanatory variables of the Principal Component Regression are linear combinations of the explanatory variables in the hypotheses of Section 8.3, the statistical analyses do not offer precise tests of these hypotheses. However, in most instances, there seems to be a strong, sometimes a very strong, commonality between an explanatory component and a variable specified as an explanatory variable in a hypothesis. In that case, tentative conclusions about the hypotheses can be made. In fact, this is the case for all hypotheses, excepting hypotheses H8 and H16, and a discussion about their validity seems pertinent. The effects of farmer's age (H8) and off-farm employment (H16) on ASAP could not be validated due to their low significance in all sustainability dimensions in the PCR analysis. The tentative conclusions on the hypotheses are reported in Table 8.10.

Table 8.10 Tentative conclusions about the validity of the hypotheses on ASAP (and significance levels of associated components)[1]

Hypotheses	Expected Effect	Soil disturbance control	Soil Protection	Run-off control
Marketing				
H1: Distance to market	-		Yes *	
H2: Information	+	No **	Yes ***	
H3: Access to services	+	No *	Yes ***	No *
H4: VMS	+	Yes ***		
H5: Entrepreneurship	+	No **	Yes ***	
Government				
H6: Links to institutions	+	No *	Yes ***	No *
Personal-social				
H7: Education	+	No **		
H8: Age	-			
H9: Farming commitment	+	No **		
H10: Awareness	+		Yes ***	
H11: Innovativeness	+	Yes *		
H12: Risk aversion	-	Yes *		
H13: Indigenous farmers	+	Yes **		
Economic				

H14: Income	+			
H15: Debts	-	No *		
H16: Off-farm employment	-			
H17: Farm labour	+	Yes *	Yes *	Yes ***
H18: Land tenure	+	Yes *		
H19: Long-term planning	+	Yes **	Yes ***	
H20: Coffee farms	+	Yes ***		No *
Physical				
H21: Soil erodibility	+	Yes **		Yes **
H22: Shallow topsoil	+		No ***	
H23: Agro-ecological location[3]	n.a.		Yes ***	
Main plot	+	Yes **		Yes *

1=Since ASAP is regressed on basic components extracted from the original variables specified in the hypotheses, a precise test of the hypotheses formulated in Section 8.3 is not possible (see text). *, **, *** represent .10-.20, .05 and .01 levels of significance of the component associated with the respective variable in a hypothesis.
2= Yes: validate the hypothesis, No: opposite effect, blank: no significant effect
3= Farm location is not about positive or negative effect, but about significance.

Marketing factors, proved to be important contributors for the general protection of the cropland soil. Firstly, this contribution was particularly important in the adoption of practices that provide soil cover from topsoil loss, one of the leading causes of soil erosion in the study region. Grass strips, mulch and other topsoil cover practices are key factors for soil conservation in Cabuyal, as they provide protection from erosive rains as shown by Reining (1991)[114] and Howeler et al. (1981). Secondly, the contribution of marketing factors was important in the adoption of sustainable practices addressed to control soil disturbance, such as minimum tillage and low-impact harvest. Table 8.10 shows that proper market information, better access to market services and entrepreneurship present the expected positive effect on adoption of topsoil protection practices, while they present an inverse effect in the adoption of soil-disturbance control practices. The positive effect of these marketing variables suggests that closer marketing institutional links improves access to appropriate knowledge on the market and on production systems and facilitates the timely adjustment and use of farm resources. The negative effect of the marketing variables on the adoption of soil-disturbance control practices might indicate that farmers with closer marketing institutional links practice intense cultivation methods that result in soil disturbance. VMS (and commercial orientation), in particular VMS having links with marketing cooperatives, presented the expected positive effect on soil-disturbance control practices. These reflect farmers more integrated to the markets with greater orientation to commercialisation and long-term perspective. Long-term perspective is translated not only in terms of a stable market relationship, but also in terms of care for the sustained use of the soil resource. These farmers foresee the long-term benefit of investing in soil conservation, are conscious of the negative effect of intensive farming systems and opt to invest in (structural) protecting measures as a way to conserve the topsoil and keep the long-term productivity to the land.

Government factors, such as subsidies and links to technical institutions, presented the expected positive effect on the adoption of topsoil protection practices but an inverse or

[114] Reining (1992) concluded that live covering protected best the soil against rain erosion in the Cabuyal watershed. In his study, contour strips of grass were the best cultural practices for soil conservation. Grass covering showed even better performance in economic and conservation terms than other practices such as minimum tillage.

non-significant effect on the use of soil-disturbance and run-off control practices. This might reflect a lack of emphasis of technical extension on soil-disturbance and run-off control practices. Farmers seem to misunderstand the use of topsoil protection practices to control nutrient run-off and the potential harm of nutrient leaching in less steep slopes.

Personal and social factors played comparatively a small role in the adoption of soil sustainable practices. Their effects were primarily limited to only one aspect of ASAP. Better education, farming commitment and non-indigenous characteristics present an opposite effect on the adoption of soil-disturbance control practices. These characteristics might refer to ethnic mestizos with higher school education that usually practice more intense cultivation techniques as compared to ethnic indigenous with lower school education. Awareness of soil problems presents a positive effect on the adoption of topsoil protection practices: when farmers perceive some degree of soil degradability opt to implement topsoil protective practices such as mulching, fertilisation and minimum weeding in order to cope with the problem. The finding of the limited role played by personal and social factors is consistent with Mbaga's results (1998). She concluded that personal attitudes to, and perception of, the soil erosion problem are not a necessary condition for using soil conservation practices.

Economic factors were the main contributors explaining the adoption of soil-disturbance and run-off control practices. The important role played by economic factors confirms similar findings of previous empirical works. Major economic variables such as long-term planning, being a coffee farm and availability of farm labour presented the expected positive effect on ASAP. Long-term planning, in particular, was a positive and significant influence on the adoption of soil-disturbance control and topsoil protection practices. Coffee farms are positively associated with adoption of soil-disturbance control practices, which also implies that cassava farms are negatively associated to such adoption. Being a coffee farm has implicit marketing aspects as coffee growing involves a large degree of processing and commercialisation. Availability of farm labour has a significant and positive influence on the adoption run-off practices. This suggests the importance of this production factor in the implementation of labour-intensive conservation practices such as the construction of waterways and interception drains. The hypothesis "income is a determinant of soil conservation adoption" cannot be validated on the basis of the analysis.

The contribution of *physical factors* to ASAP in Cabuyal was also important. They presented, in most of the cases, the expected effect on one or various aspects of ASAP. The location of the farm in higher agro-ecological zones was associated with the adoption of topsoil protection practices. Although it was expected that shallow topsoil layers implied greater need for conservation practices, these practices were often implemented in fields with deep topsoil layers. This is explained by the fact that topsoil conservation practices are frequently seen in the higher agro-ecological zone where soils are deeper. Soil erodibility is a significant physical characteristic for the adoption of soil-disturbance and run-off control practices. This may indicate that erosion proneness leads farmers to employ low-intense cultivation methods to diminish soil disturbance and implement waterways to reduce soil nutrient run-off. It also indicates that farmers seem to neglect the use of topsoil protection practices when soil erodibility is apparent. Being the main plot of the farm has a positive effect on the adoption of soil-disturbance and, to a lesser extent, run-off control practices. This suggests that the plot most preferred by the farmer receives better soil management.

All in all, economic and marketing factors are critical factors behind the adoption of soil sustainable practices. The finding that marketing factors are important in the adoption of soil sustainable practices validates this study's hypotheses and contributes to a better understanding of the adoption behaviour. Adopters of soil sustainable technology comprised long-term entrepreneurs integrated to the market with comparatively better access to institutions, marketing services and farm labour. Marketing factors, in particular, were the primary factors for the protection of the cropland topsoil. This latter fact is crucial for Cabuyal steep slopes, as fertility issues are particularly critical and soil losses and loss of precious topsoil (the nutrient layer) are the leading conservation difficulties in the region. The research findings support the central hypothesis that marketing does play an important role in promoting ASAP and, even more important, it specifically validates the hypothesis that VMS arrangements affects positively farmers and stimulate them towards more environmentally friendly production systems.

Implications for the Cabuyal watershed

The analysis of soil sustainability as a combination of various dimensions or aspects has led to some noteworthy findings. Firstly, education and managerial variables are the most important with respect to soil disturbance control. Secondly, marketing and managerial variables are the most important with respect to soil protection. Thirdly, farm labour and physical variables are the most important with respect to run-off control.

The finding that the various aspects of soil sustainability are distinctly influenced by these variables is vital for the formulation of policies aiming at soil conservation in Cabuyal. For example, if the interest lies in promoting low tillage and other low-disturbing soil conservation practices, policy makers must consider that the adoption of soil-disturbance control practices are influenced by economic factors (long-term planning, prevalent crop, labour availability), predominantly, and by marketing factors (commercial orientation and marketing integration). If the interest lies on curbing topsoil losses due to rain erosion, marketing factors (access to market/marketing services and technical institutions, entrepreneurship and links with cooperatives) are the most important determinants. Farmers with better market access are motivated to long-term horizon attitudes and apply greater care for the productivity of the natural resource. Lastly, if the interest lies in promoting control of soil nutrient run-off, decision makers should be aware of the fact that primarily economic factors (farm labour availability) and, to a lesser extent, physical factors (soil erodibility) are key determinants for adoption. More institutional work is needed to acquaint resource-users on the simplicity of the implementation of run-off control practices and about the risks of nutrient leaching in croplands on slopes not as steeper as those of higher agro-ecological zones.

The importance of marketing and institutional factors in explaining sustainable soil management adoption implies an opportunity for government action in supporting and promoting sustainable agriculture production systems. Government contribution to ASAP can be direct or indirect. Direct, by strengthening extension on the proper use of relevant soil conservation practices. Indirect, by creating opportunities for Cabuyal marketing channels, which promote soil sustainability, such as types of VMS.

Implications of the methodology

The econometric analysis contributed in three ways to the research on the adoption of sustainable soil practices. Firstly, a new method of measuring the adoption of sustainable soil practices, developed in Chapter 7, was used. This method identifies three sustainability dimensions, each representing a specific aspect of sustainable soil practices.

Secondly, in contrast to many other studies, the econometric analysis takes a holistic approach to the explanation of the adoption of soil sustainability. Apart from offering a complete spectrum of explanatory variables, this approach minimises the risk of estimation bias in determining the impact of explanatory variables on the adoption of soil sustainability.

Thirdly, the study demonstrated the usefulness of Principal Component Regression (Maddala, 1992) in estimating holistic models of soil sustainability. By reducing the great number of explanatory factors into a smaller number of *basic* variables, the problem of multicollinearity was minimised and the influence of *basic* variables could be established. However, this procedure prevented a precise test of the influence of the underlying 'real life' variables, proposed in the hypotheses.

The conceptual and empirical methodology developed and employed in this study proved to be straightforward and highly efficient. The methodology brought about theoretically consistent models with substantial explanatory power and significance. It proved to be a highly effective tool in revealing patterns of association which otherwise would have remained hidden. The methodology offers a sound alternative for the study of the, often complex, concept of sustainability.

9 THE COOPERA HOUSEHOLD MODEL

The preceding chapter presented an econometric analysis of the adoption of soil sustainability methods in the Cabuyal watershed in order to test the central hypothesis that marketing factors have a direct relationship to such an adoption. This econometric analysis revealed that marketing factors were important contributors to the general protection of the cropland soil in Cabuyal farms, and, in particular, to the adoption of physical barriers designed to provide protection to the soil from erosive rainfall. Chapters 9 and 10 seek to evaluate the effect of marketing interventions on soil sustainability and farm income. It should be noted that the accomplishment of farm soil sustainability does not need to be at the expense of farm income, but might contribute to its enhancement. In order to analyse this effect of marketing intervention, in this chapter a household linear programming model is developed. It will be applied on the Cabuyal river watershed region in Chapter 10.

The Cabuyal OPtimal Resource Allocation (named, conveniently, COOPERA) household model is a multiple goal linear programming model designed to capture the relationship between production, consumption and resource availability in a consistent way. It can provide insights into the consequences of marketing interventions on the soil sustainability and income as well as on the associated effects on resource allocation in small-farm households in Cabuyal[115].

This chapter is organised as follows. The first section discusses the relevance of linear programming household models for the study of the effect of marketing interventions on farm soil sustainability and income. The second section postulates the underlying assumptions of the COOPERA farm household model related to both the classical assumptions associated with farm households and the intrinsic assumptions of linear programming.

Section three describes the farm household while section four introduces the model's overall structure, thereby identifying farm household possibilities, objectives and restrictions. The farm household possibilities are reviewed in section five with respect to agricultural activities and product destinations. The specifications of the COOPERA farm household model are presented from section six onwards. Four model objectives are specified, namely, maximisation of discretionary income and on-farm employment, and minimisation of soil erosion and risks. The basic structure of the farm household model is completed in section seven by a description of the restrictions associated with land, labour and capital farm resources.

9.1 The purpose of farm household models

One of the greatest problems in agricultural policies for developing countries is the complex behavioural characteristic of rural households in semi-commercialised economies (Singh et al, 1986). Most rural households produce partly for the market and partly for their own consumption, while they also purchase some of their inputs (e.g. fertilisers) from and provide other inputs (e.g. labour) to the market. Therefore, agricultural policies and market changes will affect production, but also land use, commercialisation, consumption and labour supply decisions. The understanding of these relationships enable analysts to model the behaviour of farm households and monitor their responses to given interventions.

Singh et al. (1986) describe farm household models as models designed to capture the input-output relationships in a consistent way so that the results of the analysis can be applied theoretically to illuminate the consequences of policy interventions. The manner in which farm households respond to certain conditioning environments is a critical factor in determining the

[115] The model is an elaboration of an earlier version developed by Roebeling and Castaño (1995).

relative merits of potential interventions. That means it is essential to know what factors determine the level of farm production and the demand for farm inputs, what factors govern consumption and commercialisation, and how the behaviour of the household as a producer affects its behaviour as a consumer and supplier of labour, and vice versa. This makes necessary the quantification of the relationships between farm inputs (land, labour capital) and outputs (e.g. land use, yields, income), which constitute the backbone of a farm household programming model.

Although the household model is a useful tool to gain insight into the impact of potential interventions, it offers certain limitations. Given the fact that technical coefficients, describing input-output relationships, are estimations and that some assumptions need to be made to characterise potential interventions, the solutions of the household model constitute potential best solutions and do not indicate which solution will be chosen in reality. Farm household models are indeed useful exploration tools, but they offer no panacea to improvement of farm system sustainability on an overall system basis. Nevertheless, experience suggests that farm household models can approach the complexities of actual farm systems with an acceptable loss of realism (McCall and Kaplan, 1985; Harrington, 1992), and be of high relevance to draw conclusions and policy implications.

In the Cabuyal watershed, farmers perform agricultural activities under adverse market conditions. Credit is hardly accessible and markets are characterised by distortions in information and price formation. These conditions have a major influence on farmers' resource conservation decisions, and lead to an increasing reluctance to invest in soil conservation techniques (Hansen, 1996; Ashby, 1985). Changes in the marketing environment, through pricing and other instruments, can be expected to have a strong impact on production and incomes in agricultural households, and subsequently on the level of natural resource depletion. There could also be associated impacts on the use of labour, land and capital given the limited availability of these resources in the small farm household in Cabuyal.

The econometric analysis carried out in Chapter 8 attempted to measure the significance of marketing and various other factors on the adoption of farm soil sustainable practices. The LP analysis undertaken in this and next chapters attempts to provide answers to questions such as 'Will changes in the marketing environment, such as the introduction of direct contractual arrangements, increase households' income?' and 'What is the associated impact on farm resource conservation?'. Answers to these questions are possible by running the model under different market scenarios and different prioritisation of income and sustainability objectives. The results of this analysis should provide guidance on the possible trade-off of marketing aspects and the way farmers allocate resources when pursuing income maximisation and soil sustainability. Specifically, the results should indicate what marketing channel (CMC or VMS) enables a better management of the resources and a higher income level.

The findings of the analysis can be used in the formulation of possible policy strategies for marginalised hillside communities such as Cabuyal. A better understanding of the varying needs and constraints of the small farms can lead to possible implications for agricultural policy in terms of the role of marketing channels and sustainable development. The findings should also provide guidance on where to focus public support in order to achieve benefits and compatibilities between profitability and sustainability objectives.

9.2 Underlying assumptions

The assumptions made in the COOPERA household model are based on both, the classical assumptions postulated on agricultural households (Singh et al., 1986) and the intrinsic assumptions of linear programming (Hazell and Norton, 1986). First, in semi-commercial farms, some inputs to the production processes at the farm are purchased and some outputs are sold. Under these circumstances, and assuming markets for inputs and outputs, producer, consumer and labour supply decisions are not made simultaneously (Singh et al., 1986), although they are obviously connected because consumption cannot exceed production less inputs in market values. Production depends on farm gate prices, technological relationships between inputs and outputs as well as resource availability and market accessibility. This information is sufficient for the household to equate marginal revenue product to the wage. Therefore, the household can make production decisions independently of its consumption and labour-supply decision. This one-way relation, between production on the one hand and consumption and labour supply on the other hand, is known as the *profit effect* and results in the household model being *recursive* or *separable* (Krishna, 1964; Jorgenson and Lau, 1969; Singh et al., 1986; Delforce, 1994). The reverse is not true for household labour-supply, however, as it is not independent of production decisions. Labour supply depends on both prices and income and, although prices are fixed by assumption, income is determined by the household's profits from its on-farm and off-farm activities.

The recursive character of the model is crucial and is based on the assumption that households are price takers for every commodity, i.e. inputs and outputs, including labour, that are both produced and consumed by the household. For example, the amount of beans to be produced or the labour to be applied can be determined independently of the amount of beans to be consumed or the family labour to be used because beans and labour can be bought or hired at a fixed price. The only constraint on labour and commodity consumption arises from total household income. With prices fixed, the one-way relation comes from the production side of the model to the labour-supply side.

The assumption that any individual household is unable to influence the market price may often be the most plausible description of market behaviour (Singh et al., 1986). Other assumptions are related to product commercialisation. As the volume of production is small at the regional and national context, demand for farm products is perfectly elastic. Due to the *minifundia* characteristics of the farm households (3 ha in average), no economies of scale neither in production nor in purchase of inputs and consumption goods are assumed.

Second, there are assumptions about the nature of the production process, the resources, and activities implicit in linear programming (Hazell and Norton, 1986). These assumptions are:

1. *Optimisation.* The objective function is either maximised or minimised
2. *Fixedness.* At least one constraint has a nonzero right hand side coefficient.
3. *Finiteness.* There are a finite number of activities and constraints.
4. *Determinism.* All model coefficients are known constants (technical coefficients).
5. *Continuity.* Resources can be used and activities[116] produced in fractional quantities.
6. *Homogeneity.* All units of the same resource of activity are identical.
7. *Additivity.* The activities are additive, i.e., their total product is the sum of their individual products.
8. *Proportionality.* Gross margins and resource requirements per unit of activity are constant regardless of the level of activity. In other words, curves of the demand for products and the supply of inputs are perfectly elastic.

[116] In this study, activity is understood as an agricultural activity or *land use type* (LUT) (see Section 9.5).

The assumptions of additivity and proportionality, together, define linearity in activities, therefore giving rise to the name linear programming. Constant returns to scale is an associated result. In line with Hazell and Norton (p. 14; 1986), however, the COOPERA model relaxes, to a certain extent, some of the most stringent assumptions. The additivity assumption is relaxed by incorporating separately intercrops allowing joint, and not necessarily additive, production. The proportionality assumption is partly relaxed through dynamic multi-period specification, which enables varying market prices and yields and allows for capital growth throughout the time.

The model to be defined under the above considerations does not have to be a perfect view of reality, because institutional and social obstacles, not taken into account in the largely 'behaviour-free' model, might occur. Whether a solution is realised depends, amongst others, on the willingness of the members of the society, the degree of political consensus society can attain, and on external circumstances such as the development of world trade. In regards to the ignoring of general equilibrium effects, the COOPERA household model tries to relax this assumption for the labour market as the households' increasing demand for labour may well push wages upward. Distinguishing high and low labour demand according to crop seasons loosens the fixed wages assumption. However, this does not tackle the general equilibrium problem, since supply and demand (determined by the model) do not determine wages.

9.3 A description of the Cabuyal farm

The Cabuyal river watershed supports semi-commercial small farms, which are characterised by market, as well as subsistence, production. Most of the farms are located on acid soils of volcanic origin, characterised by poor fertility with slopes of a gradient greater than 12 percent. Farmers distinguish basically three types of soils: rich fertile black soils (*rich soils*), mixed red and black soils (*poor soils*) and red soils, in which the topsoil (black layer) has disappeared, leaving only the parent matter of red clay of balsatic origin (*eroded soils*). Table 9.1 presents an overview of a farm type in Cabuyal[117].

[117] The farm type selected corresponds to farm households with high 'well-being' level (Ravnborg, 1995; see also Chapter 5) as they entail farmers with higher commitment to farming their own land and more market orientation. Other 'well-being' levels (medium, low), which are predominantly farmers whose main occupation is day labouring, and who own only a small piece of land and had few resources, were ignored because of their limited role in crop production and trade.

Table 9.1 Characterisation of the Cabuyal farm

Farms (n)	95
Family size (pers.)	5.1
Altitude (m)	1,700-2,200
Soil type[1]	F, U
Farm size (plazas)	6.9
Total cropland (plazas)	5.5
Fertile/Poor/Eroded	2.2/3.2/0.1
Family labour (man month^{-1})	63.7
Hired wage rate (Col.$ day^{-1}) [2]	2,400.0
Off-farm labour (man.month^{-1})	6.0
Off-farm wage rate (Col.$ day^{-1}) [2]	1,920.0
Own capital (Col.$)[3]	930,380
Opportunity capital cost per year (%)	21
Bank interest rate per year (%)	32
Informal credit (% of input costs)	10
Inf. credit interest rate per year (%)	44

1 plaza = 0.64 ha and US $1=Col $950 in 1995
1: F=*Farallones: tipyc humitropept*, U=*Usenda: typic dystrandept.*[118]
2: wages are Col$ 500 higher during coffee harvest.
3: values based on the living cost workshop, corrected by sensitivity analysis and weighted by physical capital.
Source: CIAT GIS; Cabuyal census (CIAT, 1993c); Castaño et al. (1996); and Production cost and Terms of trade appraisals (1995).

Table 9.1 describes a farm characterised by mixed farming systems. The coffee-plantain inter-crop is a major agricultural activity in rich soils while cassava, pasture, beans and maize are cultivated in other soils. Appendix C shows the soil requirements for each crop. Bitter varieties of cassava (*Algodona*) yield well on poor soils, so it can be cropped in the poorest fields of the farm. Cassava can be intercropped with beans, but the soil must be good enough for beans to grow. The scenario analysis in Chapter 10 is focused on this farm type, which corresponds to a farm in the high agro-ecological zone of Cabuyal. The selection of this farm type obeyed several considerations. First, the selection of one farm type will enable an in-depth examination of the trade-off between income and soil sustainability under different market scenarios. Although there are certain differences between farms in the high, medium and low agro-ecological zones (e.g., in terms of cassava and maize varieties and labour availability), the inclusion of these farm types will likely not result in additional significant insight in terms of the objectives of the model analysis. Second, the high agro-ecological zone is the only area in Cabuyal suitable for blackberry farming (blackberry grows in altitudes over 1,400 m.a.s.l.), a new crop that will be introduced later in one of the model market scenarios.

Infrastructure is poor in Cabuyal. Most of the roads are unpaved where pick-up vans and horses are employed as the means of transport between the region's different sites. Transportation becomes very difficult during rainy season. Electricity is only available to farms close to the main road and there is only one bank exclusively serving coffee growers. Further description of the Cabuyal watershed farms is provided in Chapter 6. Other publications (Rubiano et. al, 1996; Castaño et. al, 1996) provide further geographic, demographic and agricultural information on the

[118] The description of *Farallones* and *Usenda* soils is provided in Chapter 6.

region and its agro-ecological zones.

9.4 Farm household model structure and time horizon

The COOPERA model is a typical household model that rests on classical household and LP assumptions. Figure 9.1 illustrates the structure of the COOPERA household model, thereby identifying the farm household's restrictions, possibilities and objectives. Farm household restrictions are given by the initial resource endowment. Resources available to the household include land, labour and capital as determined by the appraisal on production costs described in Chapter 6. Several market scenarios, that attempt to offer alternative marketing situations (i.e. CMC and VMS), are described in terms of output prices, traded quantities, price and yield risks, transaction costs, and interest rates. The market scenarios will be discussed in the next chapter. Farm household possibilities are given by on- and off-farm production activities. On-farm production activities are defined for crop and fallow activities, while off-farm production activities refer to off-farm employment possibilities for family labourers. Given the specified objective, the optimal allocation of resources determines output production, resource use as well as soil loss levels. Production is either destined to the market or used for on-farm consumption. The farm household can buy food and other products that are not produced at the farm. Goods as well as factors can be bought on the market at market prices, while family labour can also be hired out against the prevailing off-farm wage rate. The allocation of resources determines farm income as well as land (soil sustainability), labour (on-farm and off-farm) and capital (credit and own) uses.

The household model pursues four objectives: maximum *discretionary income*, minimum *soil erosion*, minimum *risk* and maximum *on-farm employment*. Discretionary income is defined as the sum of earnings from agricultural and non-agricultural sources net of production and capital costs, and household consumption expenditures. On-farm employment refers to the use of family labour in the execution of on-farm agricultural activities. Risk refers to the price and yields fluctuations that farmers face and makes incomes unstable from year to year. Finally, soil sustainability relates to the level of soil loss resulting from on-farm agricultural production. The objectives are maximised or minimised subject to the farm household resource constraints and accessibility given the household's production and marketing possibilities. The sequence of the objectives and the optimisation procedure is discussed later on.

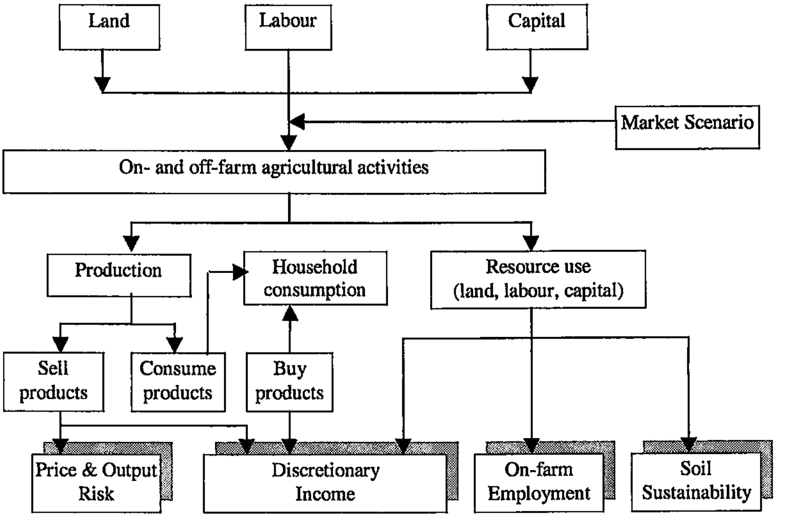

Figure 9.1 Structure of the COOPERA household model

Other objectives, such as *diversification*, *household consumption* and *yearly income distribution*, are indirectly pursued in form of model constraints. The model searches for insights between these different objectives, particularly with respect to farm income and soil sustainability.

Primary and secondary information was collected to set the model technical coefficients[119] (see Chapter 6). A sensitivity analysis enabled the adjustments of the coefficients to resemble as close as possible production possibilities of the Cabuyal farm households. Since cross-sectional data are used as well as institutional constraints specified, objectives are evaluated for a short-term horizon (two years). Lack of time series data and strong institutional assumptions discouraged a longer scope[120]. Each year was divided in two periods (semesters), the Cabuyal costumed cropping periods.

9.5 Farm household possibilities

Farm units in the Cabuyal region can opt for a range of land use types. In line with Fresco et al. (1992) and Schipper (1996), *land use type* is defined as "a specific kind of land use under stipulated biophysical and socio-economic conditions (current or future), seen as a subsystem of the farm." Fresco *et al.* noted that the definition highlights the "similarity between the concept land use system and the concepts activity, cropping system and livestock system". The land use types (LUTs) in the Cabuyal region include annual crops, such as cassava (16-month and 20-

[119] Technical coefficients are quantitative terms employed in the model to describe both input-output relationships (such as the quantity of labour resources required to produce a kg of maize) and resource availability (such as the amount of cropland procurable for agricultural production).

[120] A region can undergo numerous changes in the long term (e.g. investments in infrastructure, technological changes, new institutions), which affect, to a large extent, current conditions.

month varieties), beans (3-month and 4-month varieties), maize (5-month and 12-month varieties) and vegetables; and perennial crops such as coffee (intercropped with plantain) and sugarcane. The vegetative period of a LUT may change for different varieties. This is the case of cassava, beans and maize as shown in Appendix C. In higher lands are often cropped cassava and maize varieties with longer vegetative periods. Bean plants, of less bush architecture and shorter period, are also seen in those lands. These activities together with intercropping and sharecropping activities comprise the LUTs included in the model (Appendix C). Cattle, not a widespread activity at the time of this study, was originally included but later on discarded because of a lack of reliable input-output data. Altogether, mono-cropping, intercropping, sharecropping and fallow activities, farmers can select 33 different LUTs. Blackberry, a potential activity, is introduced later in one of the market scenarios.

Activities are constrained by time and space. Their limiting values are carefully chosen to avoid controversies. For instance, productivity risk depends on time variations and cropping is determined by the farm's soil quality. Besides per year, constraints are expressed in per month and per six-month period. The definition of months permits a detailed description of land and labour use requirements of the LUTs, while the specification of periods within the year demarcate the cropping seasons in the study region and help to ensure an even temporal distribution of income and labour in the optimisation procedure. The symbols used in the equations of the COOPERA model are defined in three tables at the end of this chapter: indices in Table 9.2, variables in Table 9.3 and coefficients in Table 9.4.

Each agricultural activity X is specified per plaza per year and defined to produce a certain level of yield q_j of product j through land use type l, thereby using (1) a_{sm} units soil type s (defined per month m), (2) e_m labour days (defined per month m) and (3) an amount of c input costs. The combination of activities, yield, and the corresponding total cultivated area results in a total periodical production (Q_j) per product (subscript j). As there are several activities (different LUTs) producing a certain product, the total production per product is obtained through the sum of the activities producing that product. Since two cropping periods are identified within each year (subscript y), production is defined to be released in one or more of the periods (subscript t), and the production balance per year y per period t per product j (in kg period^{-1} or 'units' period^{-1}) is given by:

$$Q_{ytj} \leq \sum_{l}\sum_{s} q_{ytjls}\, X_{yls} \qquad \text{all } y, t, j \qquad (9.1)$$

Farm produce can be sold on the market ($d=1$) and/or be used for self-consumption ($d=2$). The product destination balance per period per product (in kg period^{-1} or 'units' period^{-1}) is given by:

$$Q_{ytj} \geq Q_{ytjd=1} + Q_{ytjd=2} \qquad \text{all } y, t, j \qquad (9.2)$$

This expression is important, since the farm has to meet the household consumption requirements [expressed by a minimum consumption requirement (m_{tj}) for each product per period per year][121]. Household consumption requirements can either be met by self-consumption ($Q_{jd=2}$) or through market purchase (B_j)[122]. Household consumption per period per product (in kg period^{-1} or 'units' period^{-1}) is now given by:

[121] A minimum consumption level was defined for each product based on data gathered from appraisals on farmer consumption patterns and living costs (see Chapter 6).

[122] Farm household consumption comprises food needs and other basic domestic expenditures on items such as education, health, household furniture, clothing and taxes. These expenditures form a fixed amount per period.

$$Q_{ytjd=2} + B_{ytj} \geq m_{ytj} \qquad all\ y,\ t,\ j \qquad (9.3)$$

As noted before, the model does not affect both output prices and market purchase prices. Output prices, however, differ by cropping period. Labour use is another possibility open to the farm household. The available farm labour can be used for on-farm and off-farm employment. On-farm employment is directed to meet the labour input needs of the LUTs and off-farm employment is primarily used on agricultural activities in other farms. Off-farm employment represents an additional income to the farm household.

9.6 Farm household objectives

Producers in the Cabuyal region pursue a variety of objectives. Discussions with farmers revealed objectives such as maximise profits, satisfy household consumption, risk reduction, a year-round income distribution and 'keeping themselves busy'. Therefore, the following model variables are identified: discretionary income (*DINC*), risk associated with annual fluctuations in prices and productivity (*RISK*), and on-farm employment by farm members (*EMPL*). In addition, soil erosion (*EROS*), although not mentioned as a farmers' objective, reflects the aim of this study in examining trade-offs of soil sustainability and income for different market scenarios. Food security was defined as a model constraint.

Discretionary income

Discretionary income is defined by Campbell et al. (1999) as the "amount of the farmer's income available for spending after the essentials (such as productions costs, food, clothing, health and shelter) have been taken care of". The result is a part of the disposable income that can be used to finance from vacations to retirement or invested or saved fully at the farmer's discretion.

Discretionary income (*DINC*) is calculated as the sum of earnings from agricultural and non-agricultural sources net of production and capital costs, less household consumption requirements[123]. Since yearly even income distribution is an important objective of the individual producer, the *DINC* is specified per six-month period. On the one hand, earnings from agricultural activities (X) are obtained from the at farm gate prices ($p_{ju=1}$) sold output ($Q_{jd=1}$) of product (j) as well as from non-agricultural earnings obtained from off-farm employment (O) valued at the off-farm wage rate (o). Appendix C shows the gross margins and yields of the products in Cabuyal in local units. On the other hand, the production costs (C) resulting from the execution of agricultural activities are comprised of input costs, hired labour costs and transaction costs (calculated through equation 9.18 in Section 9.7.3).

Other costs include the opportunity costs of family labour (F_t) valued at the off-farm wage rate (o); the use of capital (W_w) which involves a cost (i_w)[124]; and the consumption costs equivalent to

[123] As noted, consumption products can be produced or bought. The inclusion of bought consumption products in the objective function will enable the farmer to maximise his income given the fact that he can partly produce (at farm gate price) or consume (at market price) food products.

[124] The use of capital (W_w) in the production process is specified for the use of own capital ($w=1$), formal ($w=2$) and informal credit ($w=3$). The use of capital involves a cost i_w related to: 1) the use of own capital, which equals the opportunity cost of capital of 21% per year; 2) the use of formal credit as valued against the market interest rate of 32% per year; and 3) the cost of informal credit provided by rural moneylenders as valued at the local market interest of 44% per year. The opportunity cost of capital corresponds to the interest rates of bank saving at the time of this study. Credit interest rate corresponds to the prevalent rate for bank credits, while the rate for informal loans is an estimation determined from the 'terms of trade' appraisal undertaken with key local traders (Chapter 6).

at the market price ($p_{ju=2}$) bought consumption (B_j). The *DINC* per period (in Col.\$ period^{-1}) is given by:

$$DINC_{yt} = \left(\sum_j p_{j,u=1,t} Q_{ytjd=1} + \sum_m o_{ym} O_{yt} \right) - \left(C_{yt} + \sum_m o_{ym} F_{yt} + \sum_w i_w W_{ytw} + \sum_j p_{j,u=2,t} B_{ytj} \right) \qquad all\ y,\ t \qquad (9.4)$$

The objective *DINC* function equals the sum of the at *r* discounted *DINC$_t$*'s obtained in the different periods *t* (in Col.\$). thus:

$$Max \quad DINC = Max \sum_y \sum_t r^t DINC_{yt} \qquad (9.5)$$

where $r = \frac{1}{(1+i)}$, with discount rate i=21% per year

The discount rate is based on the interest rate prevalent for bank savings. Income in the Cabuyal region is highly seasonal, and therefore, the farmer's objective of distributing income through the calendar year is achieved indirectly by maximising discretionary income per period of six months.

Soil sustainability

Control of soil erosion (*EROS*) is not a specific objective of the producer itself, though central in this investigation. Each activity reflects a level of soil erosion (s_l) in ton per plaza and is defined over the months in which the activity is carried out. Appendix C shows the erosion data per activity per year.[125] The EROS per year (in ton year^{-1}) is given by:

$$EROS_y = \sum_l \sum_s s_l \, X_{yls} \qquad all\ y \qquad (9.6)$$

The objective *EROS* function over the two years (in ton) yields:

$$Min \quad EROS = Min \sum_y EROS_y \qquad (9.7)$$

Risk

In Cabuyal, crop prices fluctuate and crop production is subjected to pests and weather irregularities. Risk resulting from price and yield fluctuations is incorporated into the model through the *EL-criterion MOTAD* module forwarded by Hazell and Norton (1986). This module is a linear approximate solution for optimising risk. Based on the assumption that risk can be expressed as the variance of farm income[126], the module estimates the standard deviation of farm income using time series sample data. The procedure comprises two steps: first, the calculation of

[125] Since the erosion index is valid for the whole cropping period, the erosion index of each activity enters into the erosion balance in its year of planting (subscript *y*), and is not repeated in other year in which it might still be on the field.

[126] According to Norton et al. (1986), farmers will prefer plans having higher expected income and lower variances of income. That is, for a given level of mean income, farmers will prefer the farm plan with the lowest variance of income. Since the objective is the Minimisation Of the Total Absolute Deviations, Hazell et. al called it the MOTAD module.

the deviations z_r in gross margins ('risk-row balance') for each risk semester r; and second, the estimation of the standard deviation D of the expected income for each year y adjusted by a factor k (that relates the sample variance to the population variance) corrects for non-linearity[127].

The *EL-criterion MOTAD* module postulates the expected (price and productivity) risk as the product of the producer's risk aversion factor[128] v and the standard deviation in expected income D of the activity mix in year y, and discounted at factor r. Therefore, the risk objective function (in Col.$) over the two years equates to:

$$Min \quad RISK = Min \quad v \sum_y r_y D_y \tag{9.8}$$

where $r_y = \frac{1}{(1+i)}$, with discount rate i=21% per year

The deviations in gross margins in this study were assessed using series of production and price data for a four-semester period (i.e. number of risk semesters $r = 4$).[129]

On-farm employment
Farmer's objective of "keeping themselves busy" is pursued by allocating in the best possible manner the on-farm labour (F) within each period. Therefore, the use of own farm labour in the execution of the different activities will be maximised. The objective *EMPL* function (in laboured days) over the periods and years is given by:

$$Max \quad EMPL = Max \sum_y \sum_t F_{yt} \tag{9.9}$$

Model optimisation
The maximisation or minimisation of the model objectives operates in the following manner. The COOPERA model optimises sequentially each objective, with this sequence determined by a farmer's decision-making case. Next chapter will distinguish two cases: an 'income maximising'

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127 The *risk-row balance* postulates that the negative deviations in gross margin z_r for each of the activities X, may not exceed the value of the negative deviation counter Z_r per risk semester r. The risk-row balance per risk semester per year is given by:

$$Z_{ry} \geq -\sum_l \sum_s z_{rl} X_{yls} \quad all\ r,\ y$$

A second constraint states that the standard deviation D in expected income should equal the sum of the products of the deviation constant k and the negative deviations in gross margin Z_r per risk semester r. The standard deviation in expected income per year is given by:

$$D_y = k \sum_r Z_{ry} \qquad all\ y, \quad \text{where} \quad k = \frac{2}{r}\sqrt{\frac{r\pi}{2(r-1)}}, \qquad \text{with } r\text{=4 semesters (1993-1994)}$$

128 The producer's aversion factor v was estimated by averaging three risk-aversion indicators that measure the farmer's preferences or avoidance of situations known as risky in the study region (see Chapter 8). Each indicator (avoidance of vegetable production, grow of new crops and being in debt) describes whether the farmer prefers (values close to 0) or avoids (values close to 1) risky situations.

129 Risk considerations are further incorporated into the model through the inclusion of: (1) crop rotation and fallow requirements to account for risk management aspects related to soil fertility; (2) intercropping activities which spread yields over the duration of the activity; (3) sharecropping activities in which price (input and output) and productivity risks are shared; and (4) minimum consumption requirements and basic expenditures in the *DINC* objective function, which are specified per period (semesters) within the year to ensure an even temporal distribution.

farmer and a 'soil conservation' farmer[130]. According to this, the four objectives (maximum discretionary income, minimum erosion and risk, and maximum family labour) are optimised as follows (objectives in brackets correspond to the sequence in the 'soil conservation' case):

First step: discretionary income is maximised (or erosion is minimised) subject to defined constraints and regardless of the remaining three objectives.
Second step: the model is re-run to minimise erosion (or maximise income) with a goal value for discretionary income (or for erosion).
Third step: risk is in turn minimised and a goal value is assigned to erosion (or to discretionary income) with discretionary income (or erosion) still fixed.
Forth step: the model is re-run to maximise employment with a goal value for risk and with discretionary income and erosion still fixed.

The 'goal value' assigned to an objective is 5 percent below the optimal value if the objective was maximised and 5 percent above the optimal value if the objective was minimised. This margin of 5 percent is intended to give a "feasibility space" to the objective that is next to optimise.

9.7 Farm household constraints

The farm is described in terms of resource constraints (see Table 9.1) that, on the one hand, make activities possible, though, on the other hand, constrain the maximisation or minimisation of the objectives. These constraints are of physical and technical nature and are specified for land, labour and capital resources.

9.7.1 Land resources

One of the basic restrictions for land use is that it can be used for only one LUT at a time. The availability of LUTs is illustrated in Appendix C.

Cropping patterns can change according to the season. In March and September cassava can be intercropped with bean and/or maize, and in January and June-August it can be found as a monocrop. Cassava is intercropped with maize, or maize and beans in the second semester due to more abundant rains. Moreover, farmers may change planting patterns in order to reduce risks. By varying crops in space and time, farmers try to reduce market and agronomic risks: cassava and vegetables are good examples of this. The different Cabuyal planting patterns per period are provided in Appendix C.

Finally, each activity implies a certain land use (a_{ymls}), defined per soil type, month and production technique, the total use of which may not exceed the monthly soil type availability (b_{yms}) (Table 9.1). The monthly soil type use (in plaza month^{-1}) can be written as:

$$\sum_{l} a_{ymls} X_{yls} \leq b_{yms} \qquad all\ y,\ m,\ s \qquad (9.10)$$

Crop rotations

[130] These two cases pursued to assess the trade-off between farm income and soil sustainability between and across market scenarios.

Crop rotation is one of the main practices in soil fertility management in the Cabuyal region. As soils are acid and of volcanic origin, soil fertility falls rapidly especially in the cultivation of cassava. Although soil fertility can be improved through the application of fertilisers, higher capital requirements and market incorporation, and the consequent associated risk, make fallow practices a must in soil fertility management.

Chapter 6 identified the following fallow requirements:

- A two-year fallow should follow cassava cropped once/twice on poor/eroded soils.
- A two-year fallow should follow maize or beans cultivated in monocrop three times consecutively
- Vegetables (e.g. tomatoes) cannot be cropped in row

In consequence, the farming of cassava, maize and beans activities per year y, per soil s (in plaza year^{-1}) is accompanied by a certain fallow area $f_l\ a_l$ [131]. The minimum area in fallow for each soil type per year is given by:

$$\sum_l \sum_m f_{sl} a_{ymls} X_{yls} \leq \sum_m a_{yml=fallow,s} X_{y,l=fallow,s} \quad all\ y,s\ and\ l=\text{cassava,beans,maize,tomatoes} \tag{9.11}$$

9.7.2 Labour resources

Labour includes on-farm labour and day-labourers hired to cover the balance of the LUT's labour requirements. Labour requirements depend on the activity and the cropping calendar (e.g. labour is scarce during coffee harvests). Wages are lower in the high altitude zone due to scarce economic opportunities there. Labour is expensive in March, during the main coffee harvest, and most abundant in summer (June-August), when there are few farming activities. The labour required by each LUT per month is shown in Appendix C.

A specific level of labour input (e_m) is necessary to undertake activities and is balanced by the farm (F_{ym}) and hired (H_{ym}) labour supply[132]. The labour use balance per year per month (in days month^{-1}) is given by:

$$\sum_l \sum_s e_{yml} X_{yls} \leq F_{ym} + H_{ym} \qquad all\ y, m \tag{9.12}$$

Since the *DINC* objective is defined per six-month period, the family-labour use balances per year per period (in days period^{-1}) are given by:

[131] Since the model's time horizon is two years, the fallow time requirements are not possible to specify as stated above. Instead, the relationship between cropping and fallow is expressed in space terms. For instance, if twice 16-month cassava cropping corresponds to 24 months of fallow, one plaza of cassava should correspond to 0.75 plazas [i.e. 24/(2*16)] of fallow in poor soils. Henceforth, the area in fallow results from multiplying the index f_l, which takes values between 0 and 1, and the amount of land use a_l given in plazas.

[132] While farm labour is restricted by its availability [see equation (9.15)], hired labour is assumed to be restricted only by capital availability (as an effect of the wage involved in the use of hired labour).

$$F_{y,t=1} = \sum_{m=1}^{6} F_{ym}$$
$$F_{y,t=2} = \sum_{m=7}^{12} F_{ym} \qquad \textit{all } y \qquad (9.13)$$

Similarly, the hired labour use balances per year per period (in days period^{-1}) are given by:

$$H_{y,t=1} = \sum_{m=1}^{6} H_{ym}$$
$$H_{y,t=2} = \sum_{m=7}^{12} H_{ym} \qquad \textit{all } y \qquad (9.14)$$

The available farm labour per month (g_{ym}) (Appendix C) can be used for on-farm as well as off-farm employment[133]. Per year per month this equates to (in days month^{-1}):

$$F_{ym} + O_{ym} \leq g_{ym} \qquad \textit{all } y, m \qquad (9.15)$$

And per year per period (in days period^{-1}):

$$F_{y,t=1} + O_{y,t=1} = \sum_{m=1}^{6} F_{ym} + \sum_{m=1}^{6} O_{ym}$$
$$F_{y,t=2} + O_{y,t=2} = \sum_{m=7}^{12} F_{ym} + \sum_{m=7}^{12} O_{ym} \qquad \textit{all } y \qquad (9.16)$$

Off-farm employment is characterised by a limited availability p_{ym} (Table 9.1). Per year per month this equates (in days month^{-1}):

$$O_{ym} \leq p_{ym} \qquad \textit{all } y, m \qquad (9.17)$$

9.7.3 Capital resources

The execution of activities requires a certain level of input and hired labour use. Labour costs were discussed previously. Input costs comprise expenditures in seeds, fertilisers, pesticides, packing sacks, fuel, and other items. Appendix C illustrates the costs undergone by each activity through each period.

For each period, the sum of the costs committed to the purchase of inputs (c), hired labour (H) valued at a monthly hired wage rate (w_{ym})[134] and transaction costs[135] (t) of sold production (which refer to the costs involve in the commercialisation of farm products) are balanced by total production costs (C_t). The production cost balance per year per period (in Col.$ period^{-1}) is given

[133] Here off-farm employment refers to work on other farms. Employment in other type of activities was comparatively unimportant due to limited job opportunities in other areas such as agro-industry (Cabuyal census).

[134] It must be noted that the off-farm wage rate was found to be around 10% lower than the hired farm wage rate as a result of the transaction costs involved.

[135] Transaction costs refer to marketing costs incurred during buying and selling, storage, transportation, and market intelligence activities.

by:

$$C_{yt} = \sum_{l} \sum_{s} c_{ytl} X_{yls} + \sum_{m} w_{ym} H_{yt} + \sum_{j} t_{ytj} Q_{ytjd=1} \qquad all\ y,\ t \qquad (9.18)$$

In turn, total production costs may not exceed work capital availability (W_{ytw})[136]. Table 9.1 shows the capital availability per source and the associated costs. The working capital balance per year per period (in Col.$ period^{-1}) is given by:

$$\sum_{w} W_{ytw} \geq C_{yt} \qquad all\ y,\ t \qquad (9.19)$$

The periodic availability of own working capital ($W_{yt,w=1}$) is a function of the discretionary income obtained in the previous period ($DINC_{y,t-1}$)[137]. Probably it is most appropriate to consider a certain percentage (d_t) of the discretionary income as working capital to account for savings and contingencies[138], so (in Col.$ period^{-1}) this results in:

$$W_{yt,w=1} \leq \sum_{t=1}^{t-1} d_{yt} NINC_{yt} + d_{yt} W_{y,t-1,w=1} \qquad all\ y,\ t \geq 2 \qquad (9.20)$$

where $W_{y,t=1,w=1} \leq$ restricted owned-work-capital period 1

Farmers have access to formal bank credit ($W_{w=2}$) only once and after the first period to account on credit restrictions and bank application process. The total amount of formal credit is thereby restricted to a certain debt capacity level ($h_{w=2}$). This equates to:

$$W_{y=1,t=2,w=2} + \sum_{t} W_{y=2,t,w=2} \leq h_{w=2} \qquad (9.21)$$

Finally, informal credit ($W_{w=3}$) can be obtained in both cash and kind and amounts depend on weeding and chicken manure expenditures (see Chapter 6). Therefore, it can be assumed that a percentage (u) of the input costs is attainable as informal credit[139]. Per period the informal credit availability (in Col.$ period^{-1}) is given by:

$$W_{yt,w=3} \leq u_{yt} \sum_{x} \sum_{s} c_{ytl} X_{yls} \qquad all\ y,\ t \qquad (9.22)$$

Next, the indices, variables and coefficients used in the COOPERA model are presented in Table 9.2, Table 9.3 and Table 9.4, respectively.

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[136] As noted earlier, work capital can be obtained from three sources (w), to know discretionary income form the previous period ($w=1$), formal credit ($w=2$) and informal credit ($w=3$). VMS credit ($w=4$) is made available in the VMS type market scenarios as explained in Chapter 10.

[137] In the first period, the owned work capital availability ($W_{y=1,t=1,w=1}$) is calculated from the production plan apparent in the actual situation. In period two onwards, the available own working capital ($W_{y=1,t=2,w=1}$ and $W_{y=2,t,w=1}$) is determined by the model generated levels of discretionary income in the previous periods, which equal respectively $DINC_{y,t-1}$, plus the working capital available in the previous period ($W_{y,t-1,w=1}$).

[138] d_t was defined 85, 80 and 75 percent for periods 2 of the first year and periods 1 and 2 of the second year, respectively.

[139] Ten percent is the average proportion spent on weeding and manure with respect to overall input costs.

Table 9.2 Indices in COOPERA

Indices	Description	Elements
t	Period	1=March-August, 2=September-February.
y	Year	1=year 1 (March-February), 2=year 2 (March-February).
m	Month	1=March; 2=Abril; ... ; 12=February.
l	Land use type	34 LUTs (see Appendix C).
j	Product	1=coffee, 2=plantain, 3=cassava 16m, 4=cassava 20m, 5=bush beans, 6=climbing beans, 7=maize, 8=tomatoes, 9=pasture, 10=blackberry, 11=milk, 12=meat, 13=rice, 16=other[1].
s	Soil type	1=rich, 2=poor, 3=eroded.
r	Risk semester	1=1993a, 2=1993b, 3=1994a, 4=1994b.
d	Product destination	1=market, 2=on-farm consumption.
u	Product price type	1=farm-gate price, 2=market price
w	Work capital type[1]	1=own, 2=bank credit, 3=informal credit, 4=VMS credit.

1= includes non-food consumption products such as education, health, clothing, transport, furniture and taxes.

Table 9.3 Variables in COOPERA

Variable	Description	Unit[1]
Q_{ytj}	Production per period per product	kg or 'units' $period^{-1}$
Q_{ytjd}	Production per period per product per destination	ditto
$Q_{ytj,d=1}$	Sold production per period per product	ditto
$Q_{ytj,d=2}$	Consumption production per period per product	ditto
X_{yls}	LUT per year per soil	plaza $year^{-1}$
B_{ytj}	Consumption purchases per period per product	kg or 'units' $period^{-1}$
C_{yt}	Production costs per period	Col.$ $period^{-1}$
O_{yt}	Off-farm employment per period	days $period^{-1}$
$O_{y,t=1}$	Off-farm employment in period 1	ditto
$O_{y,t=2}$	Off-farm employment in period 2	ditto
O_{ym}	Off-farm employment per month	days $month^{-1}$
F_{yt}	On-farm family labour per period	days $period^{-1}$
$F_{y,t=1}$	On-farm family labour in period 1	ditto
$F_{y,t=1}$	On-farm family labour in period 2	ditto
F_{ym}	On-farm family labour per month	days $month^{-1}$
H_{yt}	Hired labour per period	days $period^{-1}$
$H_{y,t=1}$	Hired labour in period 1	ditto
$H_{y,t=2}$	Hired labour in period 2	ditto
H_{ym}	Hired labour per month	days $month^{-1}$
W_{ytw}	Working capital per period per work capital type	Col.$ $period^{-1}$
$W_{yt,w=1}$	Own working capital per period	ditto
$W_{y=1,t=2,w=2}$	Bank credit capital in period 2 of year 1	ditto
$W_{y=2,t,w=2}$	Bank credit capital in year 1	ditto
$W_{yt,w=3}$	Informal credit capital per period	ditto
$DINC_{yt}$	Discretionary income per period	ditto
DINC	Objective function discretionary income	Col.$
$EROS_y$	Erosion per year	ton $year^{-1}$
EROS	Objective function erosion	ton
RISK	Objective function price and output risk	Col.$
EMPL	Objective function on-farm family labour	days
Z_{ry}	Negative gross margin deviation counter per risk semester per year	Col.$ $year^{-1}$
D_y	Standard deviation in expected income per year	Ditto

1= other 'units' include bunches, *panela* units and litres for plantain, sugarcane and milk, respectively.

Table 9.4 Coefficients in COOPERA

Variable	Description	Unit
q_{ytjls}	Yield of a LUT per period	kg or 'units' $period^{-1}$
m_{ytj}	Farm household consumption per product per period	ditto
$p_{j,u=1,t}$	Farm-gate price of a product	Col.$ kg^{-1} or $per.^{-1}$
$p_{j,u=2,t}$	Market price of a product	ditto
o_{ym}	Off-farm work wage	Col.$ day^{-1}
i_w	Capital cost per work capital type	% $period^{-1}$
r	Discount rate per period	ditto
r_y	Discount rate per year	% $year^{-1}$
s_l	Annuity soil erosion of a LUT	ton $plaza^{-1}$
a_{ymls}	Land use of a LUT per month	plaza $month^{-1}$
b_{yms}	Land availability per month per soil type	ditto
f_{sl}	Fallow requirement per soil type per LUT	index
z_{rl}	Negative deviation in gross margin	Col.$ $year^{-1}$
v	Risk aversion factor[1]	index
k	Deviation constant[2]	constant
e_{yml}	Labour use of a LUT per month	days $month^{-1}$
g_{ym}	Family labour availability per month	ditto
p_{ym}	Off-farm work availability per month	ditto
c_{ytl}	Input costs of a LUT per period	Col.$ $plaza^{-1}$
t_{ytj}	Transaction cost per sold product	% of price
w_{ym}	Hired labour wage	Col.$ day^{-1}
d_{yt}	Available working capital discounting for savings and contingencies	% $period^{-1}$
$h_{w=2}$	Debt capacity level of bank credit	Col.$
u_{yt}	Informal credit availability as a proportion of input costs	% $period^{-1}$

1: v was estimated from risk-aversion indicators obtained for the econometric model in Chapter 8.

2: $k = \frac{2}{r}\sqrt{\frac{r\pi}{2(r-1)}}$, with r=4 risk semesters.

10 THE COOPERA MODEL: SCENARIO ANALYSIS OF THE RELATIONSHIP BETWEEN MARKETING, SOIL SUSTAINABILITY AND DISCRETIONARY INCOME

The preceding chapter described the COOPERA household model in terms of a multiple goal LP model designed to capture the relationship between production, consumption and resources of a farm in the Cabuyal watershed. This chapter introduces alternative market scenarios and presents their impact on income, soil and other farm management variables, by analysing the model outputs.

The analysis of the impact of the market scenarios on farm management attempts to evaluate the potential effect of different marketing conditions on soil conservation, the economic returns to the farmers and the risks faced by them. In particular, this chapter seeks to evaluate the role of marketing in promoting sustainable production systems.

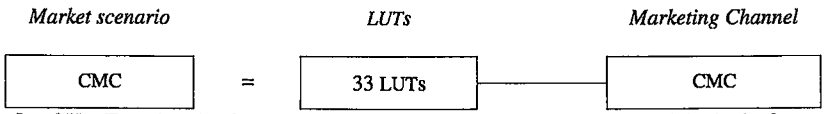
Three scenarios are proposed, namely marketing through a conventional marketing channel (CMC), marketing through a vertical marketing system (VMS) and marketing through a vertical marketing system introducing a new crop (marketing opportunity MO). In CMC, all crops are commercialised in the open market. Farmers have a minimum degree of marketing planning as they can produce and commercialise all, and any amount of products in the market place. In VMS, vertical marketing systems become available to beans and tomato growers. This market scenario requires some degree of marketing planning in terms of crop choice, price agreement and marketing channel decision. The MO is a more complex market scenario since it involves a VMS channel complemented with the introduction of blackberry, a new product for the Cabuyal watershed region with a growing demand. The MO market scenario requires a higher degree of marketing planning in terms of (new) crop choice, price agreement and marketing channel.

In order to examine the trade-off between farm income and soil sustainability, the impacts of the CMC, VMS and MO scenarios are analysed with respect to two cases. In the first case, the analysis examines the impact of a farmer placing more emphasis on income maximisation than on soil conservation ['income maximising' farmer (IM)]. In the second case, the analysis examines the impact of a farmer placing more emphasis on soil conservation than on income maximisation ['soil conservation' farmer (SC)].

The first two sections of this chapter focus on the description of the market scenarios in terms of assumptions and value setting. Sections three to six turn to the analytical procedure of the COOPERA model and present the model results. The resulting allocation of land, labour and capital and the estimated impact on discretionary income, soil erosion and other objectives are presented. Lastly, section seven discusses the main findings of the chapter.

10.1 Market scenarios

As noted in Chapter 6, the Cabuyal marketing channel is predominantly 'conventional' as farmers usually seek buyers on the harvest day. Vertical integration between farmer and buying firms in the form of contractual arrangements is scarce as market activities are primarily driven by bargaining rather than by relationships. Market intelligence, finance and other market services are restricted. In this context, the first market scenario (CMC) represents the small farm households' 'baseline' case, which resembles the most common and current marketing situation in Cabuyal and serves as reference point for comparison with other scenarios.



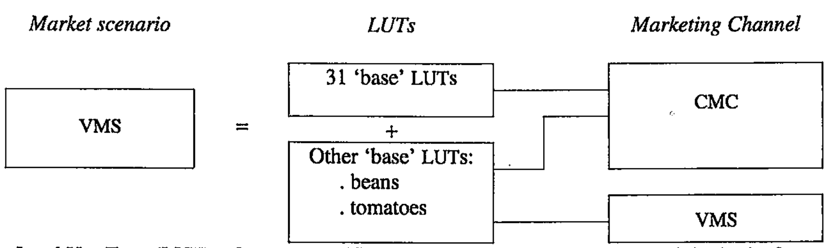
Land Use Type (LUT) refers to a specific kind of land use or agricultural activity in the farm.

Figure 10.1 LUTs in the CMC market scenario

In the CMC market scenario, small farm households can opt for up to 33 LUTs comprising mono-cropping, intercropping and sharecropping activities (including fallow). As illustrated in Figure 10.1, only CMCs are available to these 33 LUTs. Contract farming does not take place, and, instead, farmers bargain for prices with small traders who buy variable quantities of assorted produce. As noted in Chapter 9, households are 'price-takers' which results in product prices fixed per cropping period and independent of production volume. However, if all farms change their crop plan in the same direction, this independence assumption will not hold any more. This point will be revisited in the MO scenario.

Working capital is mainly from farmers' own sources or from rural moneylenders, which is at high interest rate. Market information is deficient and technical assistance is limited due to the absence of coordination in the marketing channel. The CMC marketing scenario requires a minimum degree of marketing planning as farmers are free to produce and market any number and amount of products, they are not constrained by production contracts, as a result, open market forces primarily influence farmers' market activities.

The VMS market scenario, as a marketing channel for beans and tomatoes, encompasses a rural based cooperative purchasing by contractual arrangements. Beans and tomatoes can be commercialised in a CMC or, alternatively, in a VMS channel by means of contractual arrangements, while other crops from the same farm continue being commercialised in CMC (Figure 10.2).



Land Use Type (LUT) refers to a specific kind of land use or agricultural activity in the farm.

Figure 10.2 LUTs in the VMS market scenario

In a VMS the grower is receiving a number of market signals, e.g. on product quality, quantity and price and related services, before choosing that type of marketing channel[140]. Having chosen a VMS, the farmer is committed for the period of the contract. The justifications for including this alternative market scenario in the study area are threefold. First, farmers are knowledgeable about

[140] Production costs of 'VMS' crops are similar to those in CMC but differ in market costs (e.g. transaction and capital costs) as discussed ahead. Appendix D provides an overview of the economic aspects of the VMS crops compared to CMC crops.

the production system for beans and vegetables (see Chapter 6). In particular, Cabuyal has traditionally been an important bean-producing region in Colombia. Second, farmers have had in the past some experience with contract farming for beans and tomato (see Chapter 6). Third, these crops compete with cassava for cropland area in the study region (particularly beans) and their cultivation causes less soil erosion.

In the VMS market scenario, it is assumed that a rural-based cooperative is interested in having contractual arrangements with local bean and tomato growers to secure a steady supply to consumers in Cali, a main consumer centre about 100 km from Cabuyal. The cooperative wishes to ensure the delivery of these products directly from farmers. The cooperative offers a specific price when the contract is made, purchases all of the production and provides suitable production inputs. The interest of the cooperative is also motivated by a government programme offering financial support to rural marketing by means of injecting money into poor marginal areas of Colombia[141]. The cooperative relies on efficiencies in management and economies of scale to facilitate a limited amount of inputs at competitive prices. Capital advanced to the farmer is discounted from the harvest payment. Contracted farmers, in turn, must comply with a minimum supply and an average price. The surplus of production that cannot be sold through the contract, can be sold in spot markets. The VMS market scenario requires some degree of marketing planning in terms of crop choice (e.g., 'CMC' crops versus 'VMS' crops), marketing channel and the price fixing (cooperative price versus open market prices).

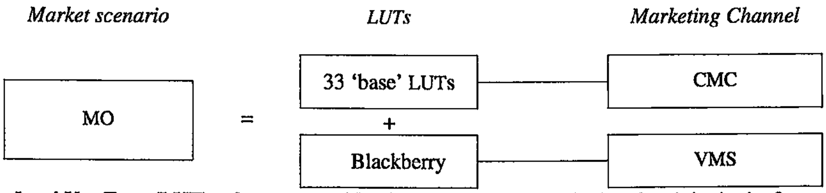
Finally, the MO is a different kind of market scenario. The MO market scenario differs from the previous market scenarios in that a new product (blackberry) is introduced to Cabuyal farmers in conjunction with a VMS channel. This implies that here it is not possible to isolate the contribution of VMS from the product since there is not a 'baseline' scenario (i.e. 'CMC' blackberry) that could serve as a reference point. MO arises from the interest of the CIAT Hillsides Program in evaluating the feasibility of new market opportunities that promise improvements in soil resource conservation and agricultural productivity. Blackberry was identified as a potential crop with a good marketing opportunity by a CIAT Hillsides' study on the basis of promising market demand, high site adaptability and soil conservation (see Appendix D). Several factors support the need for a coordinated channel such as VMS for the commercialisation of blackberry. Firstly, surveyed supermarkets and food industry buyers reported great interest in contracting Cabuyal farmers to ensure regular supply as alternative supplies came from distant blackberry producing areas. Secondly, interested buyers stressed the need for having control of the production and post-harvest stages of blackberry to ensure quality. Thirdly, production must be carefully scheduled to assure stable supply. Fourthly, given its perishability, blackberry requires channel arrangements that minimise the shipping distance and handling in the movement from producer to end consumers.

Blackberry is currently cropped in Cabuyal but on a very small scale (Ostertag et al, 1996). The main blackberry producers opt for contracts while smaller or sporadic producers opt for spot markets (Roa, 2001). The Cabuyal region offers potential buyers comparative advantages for blackberry production and marketing: appropriate agro-ecological conditions, abundant labour and a strategic geographical location[142]. CIAT concluded that this high-value fruit has the potential to bring in economic advantages to the small farm households while, at the same time,

[141] It should be noted that a cooperative guaranteeing a price to farmer members would have to carry the price risk itself. If prices fall drastically below the guaranteed price, the cooperative will make losses and the members of the cooperative have to foot the bill. This can be avoided if the cooperative is also selling the product to its customers on the basis of a fixed price or if it receives financial support from the government.

[142] Moreover, there is high motivation among growers towards new market opportunities. About 68 percent of Cabuyal farmers expressed interest in growing a new crop if they would earn more (Market survey, 1995).

contributing significantly to soil conservation.



Land Use Type (LUT) refers to a specific kind of land use or agricultural activity in the farm.

Figure 10.3 LUTs in the MO market scenario

In the MO scenario, blackberry is promoted by offering an attractive marketing channel to potential growers[143] (Figure 10.3). The following assumptions have been made in the MO market scenario. A contracting firm looks for contractual arrangements with farms that can guarantee a steady supply of blackberry for which there is a growing demand in Cali's market. As with the VMS scenario, the firm is motivated by government financial support intended to promote the development of and innovation in agriculture in the rural areas of Colombia.

10.2 Specification of the market scenarios

This study uses a wide set of market and technical instruments to portray the market scenarios in the COOPERA model. The scenarios are described, not only in terms of price, but also in terms of traded quantity, transaction costs, credit modality and interest rates, risk bearing and production technology.

Price and quantity

In CMC, prices for agricultural products are the result of market demand and supply, rather than the result of bilateral relationships between parties. The produce is taken to the marketplace as soon as it is harvested to minimise post-harvest losses. Without contracts that limit trading habits in any manner, farmers sell their produce to the highest bidder at the best price. There is no minimum limit for the amount to be traded as conventional traders buy all sorts of quantities and qualities. Thus, prices in the CMC scenario correspond to those prevalent at the market at the time of this study (see Appendix C).

In the VMS scenario, beans and tomato prices, in comparison, are the result of pre-harvest deals that mostly conform to formula prices. The formula used for 'VMS' crops is a moving average price system, where the contracting party guarantees an average price free of sharp fluctuations. 'VMS' prices were estimated using average market prices for previous periods and were held constant during two consecutive periods (see Appendix C). The contract is economically feasible if farmers can supply an agreed minimum quantity of beans or tomatoes. For this purpose, the cooperative establishes a minimum supply equivalent to the production of 0.5 plazas a year of

[143] Blackberry production costs and other technical coefficients were obtained from a few key blackberry growers in Cabuyal. These coefficients are provided in Appendix C. Appendix D provides an overview of the economic feasibility of the crop in comparison with VMS and CMC crops.

these crops to growers interested in enrolling in the agreement[144].

In the MO scenario, the contract is also associated with the pre-planting determination of crop prices based on a moving average price of blackberry[145]. Blackberry prices were estimated as explained above for 'VMS' crops (see also Appendix C). Farmers must supply at least the equivalent to 0.5 plazas a year of blackberry production to join the contract. The market scope of blackberry is, however, limited. As shown in Appendix D, the food industry and supermarket business in Cali could absorb about 876 ton per semester of blackberry, which would be equivalent to a full-scale blackberry production of 40 percent of the farms in the high agro-ecological zone of Cabuyal. Blackberry must be packed in polystyrene trays of one pound (500 gr.). The use of polyethylene packing enables wide and efficient market trading, prevents physical deterioration, cuts quality losses and achieves better aesthetic appeal. The buyers feel that they and their customers (in the case of supermarkets) can select the fruit more easily, thereby increasing their willingness to pay higher prices because they are sure of the produce quality.

Technology

In the CMC scenario, links between farmers and traders are driven primarily by price bargaining rather than by relationships. Consequently, farmers do not receive a meaningful feedback from traders on technology to improve production systems.

In the VMS and MO scenarios, the contracting party pursues uniform quality and quantity in the production and commercialisation of the products to simplify buying and selling and to achieve efficiencies in market transactions. The contracting party provides farmers with knowledge of the essential production activities so that the product meets market standards. In striving for cost reduction and quality improvement, the contracting party finds it profitable to provide technical assistance, production inputs and credit to growers. Technical assistance improves productivity and offers the buyer more certainty about product quality while provision of inputs (e.g. fertilisers, packing material) and other services (such as advice on packing) eases farmers' financial concerns. Technical assistance and the provision of recommended inputs by the buyer are reflected in a 5 percent reduction of the input costs.

Transaction costs

Transaction costs (TC) are defined in terms of information search, bargaining and enforcement costs (van Tilburg, et al., 1995). They comprise fixed and variable costs. The first type includes costs associated, in particular, with collecting information and supervision costs. The second type includes transport costs and other costs related to the quantity of traded produce.

VMS, aiming at a long term relationship, have relatively higher fixed costs that CMC because the costs of building and maintaining that relationship, such as the costs of advice, services, control, supervision and contracting, are, to a large extent, fixed costs. CMC, in turn, have relatively higher variable costs because the costs originating from imperfect information and coordination form an important share of the variable transaction costs. Consequently, transaction costs per unit are decreasing with respect to quantity in both marketing systems, but at a faster

[144] Assuming that no added supply of beans and tomatoes is made available from other domestic or foreign sources, the market is assumed to be in capacity to absorb an increased supply of these crops. In the case of beans, current production levels (200 ton semester^{-1}) are far below of the levels of early 1990's (1,000 ton semester^{-1}), which leave room for added supply.

[145] Growers unfamiliar with farming contracts may see that, sometimes, the agreed price is lower than an alternative market outlet. They may then feel inclined to 'leak'. But once they have better knowledge, they realise that the overall expected net return is often higher with the contract agreement. Nonetheless, enforcement is initially costly to the firm and this is translated into higher transaction costs (see transaction costs below).

rate in the VMS (Figure 10.4). Therefore, the latter becomes more competitive as output expands (economies of scale).

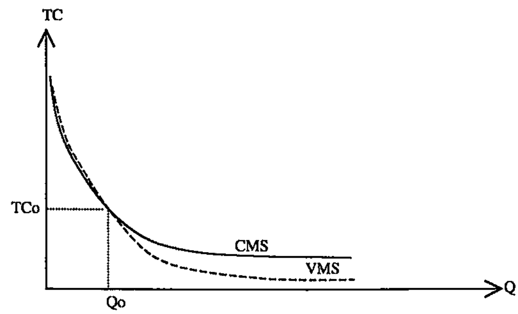


Figure 10.4 Transaction costs per unit (TC) versus quantity per transaction (Q), in case of CMC and VMS

Figure 10.4 shows that when the household sells less than Qo, CMC has lower transaction costs per unit, but once the transacted quantity exceeds Qo, economies of scale make transaction costs per unit lower in VMS. A profit-maximising farmer will opt for a CMC when transacting less than Qo and for a VMS when transacting more than Qo.

In the Cabuyal region, farmers in CMC sell small quantities of produce at a time. Based on information on transport costs and on the opportunity cost of the time devoted in the transaction, ten percent of the price was considered a reasonable estimation of the average transaction costs that farmers incur in commercialising the produce output in CMC[146]. In VMS, farmers sell greater quantities of produce at one time to meet their contract with the cooperative/firm. This results in lower transaction costs for the farmer due to economies of scale. Consequently, five percent was considered a reasonable estimation of the average transaction costs that farmers incur in VMS and MO scenarios[147].

Credit and interest rate

Credit is vital in Cabuyal since farmers often lack the capital required to cover necessary farm inputs, farm improvements and living costs while waiting for crops to mature and be sold. Conventional traders work informally, do not pay tax and offer limited credit to ensure supply from rural peasants. Marketing institutions, such as cooperatives, interested in contract production must also offer credit if they wish to ensure regular supplies. Chapter 6 identified three sources of working capital, namely farmers' own capital, formal credit from banks and informal credit from

[146] In Cabuyal, an average transport fare was Col$500 per 62.5 kg sack of beans in 1995. In average, farmers transported three sacks per trip. Summing this cost, the farmer's ticket and the opportunity cost of the time invested in marketing the produce, the transaction cost is equivalent to around 7 percent of beans' price. Transaction costs range from 10 to 13 percent for other products. Henceforth, 10 percent of the price is considered a fair estimation of the transaction costs in Cabuyal.

[147] Using a similar estimation procedure in VMS, but assuming greater transacted quantities of produce, transaction costs decline considerably (from 3 to 7 percent of produces' price). The reason for this is that the opportunity cost of the time invested in marketing the produce will be lower per transacted unit. Henceforth, 5 percent of the price is considered a fair estimation of the transaction costs in VMS channels in Cabuyal.

moneylenders.

In the CMC, VMS and MO scenarios, the cost involved in the use of bank credit is valued at the commercial interest rate (32 percent per year, as of 1995); while the cost of informal credit is valued at the local market interest (44 percent per year, as of 1995)[148]. Both, formal and informal loans are subtracted from crop payment at harvest. Formal credit is available from two state-owned banks and amounts are restricted by the debt capacity of the farm. Informal credit is related to weeding and fertiliser application. Therefore, it is estimated that up to ten percent of input costs can be procured by farmers as informal credit[149].

In the VMS and MO scenarios, in addition to credit from formal and informal sources, contracted farmers have access to credit from the contracting cooperative at competitive rates. The contracting buyer sees the benefit of facilitating inputs and credit to contract growers to ensure adequate and timely supplies. Loans are granted in cash or kind (inputs) and amounts are proportional to the area under contracted crops. Loans are deducted from the harvest payment at an annual interest rate of 25 percent. Interest rates are competitive compared to commercial bank rates due to efficiencies in financial functions, economies of scale in input purchases and subsidised resources obtained from the government as part of a rural program intended to inject money into peasant communities (see government support below).

Risk

Risk results from product loss caused by natural hazards, changes in value of a product due to changes in consumer taste and increases in input prices and other sharp fluctuations as a result of poor infrastructure. In the CMC scenarios, risk is described using temporal fluctuations in yields (in kg plaza^{-1}) and output prices in each LUT (see the *EL-criterion MOTAD* module in Chapter 9).

As discussed in Chapter 2, vertical integration of functions is often attempted to reduce or transfer risks between contract parties by agreeing fixed-prices or taking some effective control over the kind and amount of production available. In the VMS and MO scenarios, market risks arising from price fluctuation is reduced since production is contracted and the price has been agreed in advance. This fact enables the farmer to make timely decisions regarding the cropping area. Farmers, reduce uncertainty as they count on a more secure market outlet. Other risks, stemming from physical hazards, are also considerably reduced in the VMS and MO scenarios since there is advise and instruction on the production process and the handling, storage and transport of the contracted products.

Sustainability

Each farm activity (LUT) reflects a level of soil erosion for the months in which the activity is carried out (see Chapter 9). Appendix C shows the erosion indices per activity in ton plaza^{-1}. The balance of erosion over all LUTs establishes the soil sustainability level of the farm.

In all scenarios, beans and tomatoes cause lower physical disturbance to the soil in comparison to cassava. Beans (10.8 ton plaza^{-1}) and tomatoes (6.7 ton plaza^{-1}) farming leads to less loss of soil than cassava farming, which leads to a volume of soil loss from four to seven times greater. Cassava, by comparison, is slow to establish a canopy surface over the soil surface, which exposes the topsoil to rain and wind erosion, particularly on steep slopes. Moreover, the harvesting of cassava tubers brings about removal of nutrient soil layers and perennial vegetative cover, which further increases the susceptibility of the region's fragile soil to erosion.

[148] Credit interest rates correspond to the prevalent rate for bank credits in 1995, while the rate for informal loans is an estimation determined from the 'terms of trade' appraisal carried out with key local traders as described in Chapter 6. In some cases, implicit interest rates of informal loans were more than double than those in commercial markets.

[149] This percentage equals the average share of input costs spent on weeding and manure activities as compared to total input costs.

In the MO scenario, blackberry is a perennial crop with creeping characteristics highly "friendly" to the soil. In comparison to annual cropping systems such as cassava or maize that imply removal of perennial vegetative cover, blackberry provides a continuous root structure and canopy cover, and is suitable for sloping terrain. It is highly tolerant to live covering (i.e. it does not require weeding) and very flexible as a strip-crop or live barrier. Consequently, soil loss due to blackberry production is below the average for other crops in the Cabuyal watershed. Erosion amounts to about 4.8 ton per plaza per year (Amezquita, 1996).

Government support

In the CMC scenario there is no specific government programme support for production and marketing activities. Government support is limited to technical assistance and credit from local institutions (see formal credit above). Credit, however, is only available to traders/farmers that meet the bank requirements and have collateral.

In the VMS and MO scenarios it is assumed that, as part of a rural development programme, the government implements a programme intended to stimulate traders to supply services to crop growers in highlands, in order to make more cost-effective the use of scarce public resources. With this purpose, the government directs its banking system to finance marketing operations in those areas. The government injects finance into farming communities by assisting cooperatives and other related rural enterprises with soft credit at subsidised interest rates.

Table 10.1 summarises the market and technical instruments that shape the COOPERA model's scenarios.

Table 10.1 Market and technical instruments of the market scenarios

	CMC[1]	VMS[2]	MO[2]
Market price	$P_{CMC\ crops} = P$	• $P_{VMS\ crops} = P_{avg}$ • Other crops as in CMC	• $P_{b/berry} = P_{avg}$ • Other crops as in CMC
Transaction costs	10% of P	• 5% of P_{avg} if Q>0.5 plazas • Other crops as in CMC	• 5% of P_{avg} if Q>0.5 plazas • Other crops as in CMC
Risk	P and Q risk	• Lower for 'VMS' crops as P_{avg} is fixed under contract • Other crops as in CMC	• Lower for blackberry as P_{avg} is fixed under contract • Other crops as in CMC
Credit			
• Bank	• Yes (<debt capability)	• As in CMC	• As in CMC
• Informal	• Yes (<10% input costs)	• As in CMC	• As in CMC
• VMS/MO	• No	• Yes (tied to crops area)	• Yes (tied to crop area)
Interest rate			
• Bank	• 32%	• 32%	• 32%
• Informal	• 44%	• 44%	• 44%
• VMS/MO	• -	• 25%	• 25%
Government Support	Limited to some tech. assistance/credit	As in CMC and financed by a rural programme	As in CMC and financed by a rural programme
Techn. Assist. from buyer	No	Yes (-5% of input costs)	Yes (-5% of input costs)
Soil sustainability	As in Appendix C	VMS beans: 10.8 ton $plaza^{-1}$ VMS tomato: 6.7 ton $plaza^{-1}$	Blackberry: 4.8 ton $plaza^{-1}$

1: P=price prevalent at the market in a particular cropping period (see Appendix C)
2: P_{avg}= annual average market prices were estimated from historic series of 5 years for 'VMS' crops and blackberry (see Appendix C).

10.3 The analytical procedure for the COOPERA model

The impact of each market scenario on farm income and soil sustainability is examined with respect to two cases: an *'income maximising' farmer* (IM) and a *'soil conservation' farmer* (SC). In the first case, the farmer's first concern is the maximisation of his discretionary income, while in the second case the farmer puts soil conservation first. Thus, these two cases embody two different types of decision-making with regards to income and soil conservation objectives, whose comparison intends to provide insight into the trade-off between economic and environmental objectives within market scenarios.

The optimisation of the COOPERA model was undertaken independently for each scenario and each case. Within each case, the objectives maximum *discretionary income*, minimum *soil erosion*, minimum *risk* and maximum *on-farm employment* were optimised for each market scenario as explained in Chapter 9. In the particular case of SC, it should be noted that the minimisation of soil erosion in each scenario led always to zero erosion (with fallow and coffee as the only activities in all scenarios). Therefore, in order to provide a more realistic view of erosion as a result of farming, as well as to provide a 'feasibility space' to the maximisation of discretionary income, soil erosion was fixed in the SC case. The objective soil erosion was set to a maximum 'tolerable' level of 50 percent of the erosion level observed in the respective scenario for the IM case.

The results of the market scenarios are presented in two parts. The first part (Section 10.4) presents the results of the CMC and VMS market scenarios, which will show the impact of VMS channels on the model objectives. The second part (Section 10.5) presents the results of the MO market scenario, which will show the impact of product innovation, in conjunction with VMS, on the model objectives. Since the MO scenario lacks a 'baseline' scenario, results are contrasted to the CMC and VMS scenarios for easier interpretation. The results presented show not only the impact on farm income, soil sustainability and other objectives but also the associated effects on factor use (i.e. land, labour and capital). Tables and figures showing overall results accompany the discussion. Appendixes 10.3 onwards provide details on land use and cash flow. It should be noted that in order to facilitate the comparison of risk across scenarios, risk is reported in relative terms, i.e. risk as measured by El-MOTAD (see Chapter 9) expressed as a percentage of discretionary income[150].

10.4 The results of the CMC and VMS market scenarios

This section presents the results of the VMS market scenario as compared to CMC, the baseline market scenario, under the assumption of two cases: an 'income maximising' farmer and a 'soil conservation' farmer.

10.4.1 CMC and VMS: the 'income maximising' (IM) farmer case

The first case involves a farmer who first pursues the maximisation of income regardless of outcomes in soil conservation. After a maximum level of income is achieved, the farmer may give up to 5 percent of that level to minimise erosion and risk and maximise on-farm employment. This income maximisation decision brings about impacts on factor use and objective achievement.

Factor use

Table 10.2 presents indicators on factor use -in terms of productivity, intensity and percentage- for CMC and VMS scenarios over the two-year period of analysis. In CMC, the farm is far less intensive in respect of inputs and labour than in VMS. Around 72 percent of the land is used for cropping purposes. Appendix D shows the use of the land in the CMC scenario. The farm devotes the richest soil entirely to the coffee-plantain intercrop (the most profitable activity in this scenario), while in other soils is clear the dominant role of cassava (alone or intercropped with beans and maize). The importance of cassava in this scenario arises from the fact that this crop is labour rather than capital intensive, labour being a resource amply available in Cabuyal.

Nonetheless, although the farm is focused on labour intensive activities, it uses just over 50 percent of the farm labour available. Capital is fourfold after two years but lack of financial resources prevents the farm from more intensive farming resulting in below average gross margins.

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150 COOPERA estimates risk using deviations in gross margins over a two-year period through the El-MOTAD module (see Chapter 9). The way risk is defined here means that higher gross margins can result in larger gross margin deviations and, therefore, larger risk levels. Therefore, in order to make meaningful comparisons between risk in various scenarios, a relative measure of risk is reported here: El-MOTAD risk divided by discretionary income.

Table 10.2 Factor use in the CMC and VMS market scenarios, IM case (and % change)

	CMC	VMS	VMS wrt CMC (%)
FACTORS			
Cropland (plazas)	15.9	15.8	(-1)
Family labour (man-days)	805	1,374	(71)
Total labour (man-days)	813	2,142	(164)
Input (million Col$)	2,9	11.1	(277)
Gross margin (GM) (mill. Col$)	14.3	33.2	(132)
PRODUCTIVITY			
GM/land (mill. Col$.plaza^{-1})	0.9	2.1	(134)
GM/labour (thous. Col$.man-day^{-1})	18	16	(-12)
GM/input	4.9	3.0	(-39)
INTENSITY			
Input/land (thous. Col$.plaza^{-1})	184.6	704.0	(281)
Input/labour (thous. Col$.man-day^{-1})	3.6	5.2	(43)
Labour/land (man-day.plaza^{-1})	51.0	135.9	(167)
FACTOR USE			
Land %	72	72	(1)
Family labour %	53	90	(71)
Δ in capital %	398	807	(103)

The development of a vertical marketing system for beans and tomatoes has resulted in major changes in farm resource use. The relative change of factor use in VMS with respect to the CMC scenario ('wrt') is shown in brackets in Table 10.2. In the VMS scenario, the utility of available land rose as did the use of labour and capital. Appendix D shows that the use of cropland differs, to a large extent, among the CMC and VMS scenarios. In VMS, although the farm keeps devoting the richest soils to the coffee-plantain intercrop, other soils are virtually all cropped with contracted beans and tomatoes. Poor soils, formerly cropped with cassava and intercrops in CMC, shifted to VMS beans (two-thirds) and VMS tomatoes (one-third). This shift was propelled by the better marketing conditions available to these crops. Crop rotation requirements, intended to recover soil fertility after cultivation, deter beans and tomatoes from ensuring a larger area.

The use of inputs relative to labour and land was intensified, particularly with respect to unit area which rose threefold in this scenario. Added capital introduced by input credit from the contracting cooperative is the reason for this difference. In consequence, gross margins per unit area rose by 134 percent. Gross margins relative to labour and, particularly, input use declined in VMS as compared to CMC. This is due to the fact that cassava, widely cropped in CMC, is, comparatively, less labour and input intensive than beans and tomatoes produced under contract.

Capital growth was double in VMS as compared to CMC. Appendix D shows that credit from the contracting buyer and other sources, higher agricultural earnings and off-farm income contributed to the capital growth of the farm.

Solutions of model objectives

Table 10.3 presents the solutions to maximum discretionary income, minimum erosion and risk, and maximum on-farm employment objectives over the two-year period of analysis, under the assumption that the farmer gives the first priority to income maximisation (IM).

Table 10.3 Solutions of model objectives for CMC and VMS, IM farmer case

	CMC	VMS	VMS wrt CMC (%)
Discretionary Income (million Col$)	3.7	7.5	(103)
Erosion (ton.plaza^{-1})	14.4	11.4	(-21)
Risk relative to Disc. Income (%)	13.6	7.1	(-48)
Labour (man-days)	805.0	1,373.6	(71)

Discretionary income, also illustrated in Figure 10.5, is adjusted by a 21 percent discount annual rate. Discretionary income amounts to Col.$3.7 million (US$3,895)[151] and Col.$7.5 million (US$ 7,906) in CMC and VMS, respectively. The doubling of discretionary income in the VMS scenario, in comparison to the CMC scenario, is due to the different marketing channel and the greater availability of capital from the contracting firm, which enhanced farm cash flows and the farmer's capacity to put greater emphasis on "input intensive" crops such as beans and tomatoes.

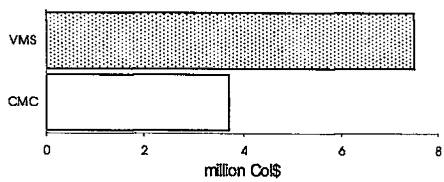


Figure 10.5 Discretionary income for CMC and VMS, IM farmer case

Appendix D shows the cash flow and the resulting discretionary income for all scenarios. It demonstrates the lack of working capital and income sources in CMC with the resulting low discretionary income. Capital is mainly obtained from farmer's own sources. The farmer did not make use of bank loan because he could not afford loan instalments. In VMS, farm activities are primarily financed by loans from the VMS cooperative (74 percent), bank loans (13 percent) and informal loans (13 percent). Transaction costs per unit in VMS (8.8 percent of the average price) are lower than in CMC (10 percent), contributing to a higher discretionary income in that scenario. As in CMC, on-farm consumption requirements are fulfilled by both produced and bought products in VMS (Appendix D).

Figure 10.6 shows the level of *soil erosion* in ton per plaza in the CMC and VMS scenarios. Soil erosion amounted to 14.4 ton plaza^{-1} in CMC and 11.4 ton plaza^{-1} in VMS. The bulk of soil loss in CMC is made up by cassava in the cassava-intercrop systems. Lack of capital and income sources force farmers to depend on low-input crops such as cassava that heavily rely in the natural fertility of the soil and lead to higher levels of erosion. The largest part of the soil loss is caused during the first months after planting as cassava provides low cover and the soil is exposed to rain and wind erosion.

[151] Values in 1995 Colombian Pesos: US$1 =Col.$950.

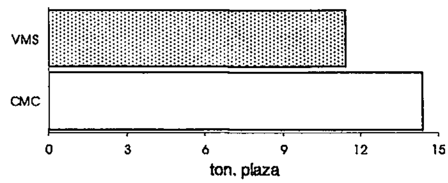


Figure 10.6 Soil erosion for CMC and VMS, IM farmer case

The VMS scenario improved substantially the soil loss panorama of the farm. Soil erosion was reduced by 21 percent due to a shift from cassava to contract production of beans and tomatoes. Better market conditions in the VMS scenario stimulate the adoption of these high-input crops that demand a large deal of fertilisers in order to grow. This result indicates that the improvement of market conditions to some local products in VMS have not only resulted in the doubling of farm income but also in a significant reduction of soil erosion levels in Cabuyal. This finding supports the viability of VMS, of the type proposed here, as an economic alternative to address soil resource degradation while, at the same time, improving the financial situation of Cabuyal farmers.

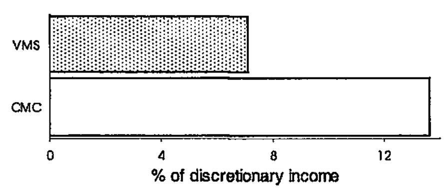


Figure 10.7 Relative risk for CMC and VMS, IM farmer case

Figure 10.7 shows that CMC *risk* accounts for about 14 percent of discretionary income, while VMS risk accounts for only 7 percent. The VMS scenario represents a 48 percent reduction in the level of risk in relation to discretionary income in Cabuyal. This indicates the positive impact of contract production on the minimisation of risk in VMS channels.

Figure 10.8 shows the amount of *farm labour* employed in the farm. With 805 man-days, the farm uses just over half of the family labour available in CMC. Appendix D shows that, family labour is also used on off-farm activities. Compared to VMS, family labour is more highly employed on off-farm activities in CMC[152]. This reflects the limited availability of profitable agricultural activities and capital inadequacy in this scenario. In VMS, the use of on-farm labour increases substantially by 71 percent to 1,374 man-days (or 90 percent of the family labour available) due to the labour-demanding characteristics of beans and, especially, tomatoes production. The farm in this scenario takes greater advantage of this inexpensive resource by focusing on activities more profitable than cassava.

[152] Besides on-farm and off-activities, farm labour can also be employed in other activities not included in the analysis such as animal feeding, farm maintenance and leisure.

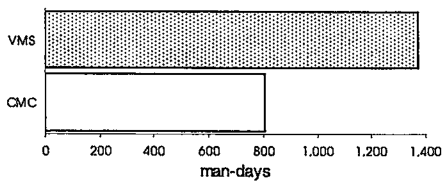


Figure 10.8 On-farm employment for CMC and VMS, IM farmer case

10.4.2 CMC and VMS: the 'soil conservation' (SC) farmer case

In the second case, the farmer primarily pursues the minimisation of erosion. After a 'tolerable' level of erosion is arrived at (see Section 10.3), the farmer may give up to 5 percent of additional erosion in order to maximise discretionary income, reduce risk and maximise on-farm employment.

Factor use

Table 10.4 presents indicators of productivity and intensity in factor use for the CMC and VMS scenarios over a two-year period as well as the percentage of change with respect to other scenarios ('wrt') and the corresponding scenario in the IM case. In general, the use of land, labour and input decreased in CMC and VMS scenarios, particularly in CMC, as compared to the 'income maximising' case. Less land has been put under the plough in the SC case (24 and 20 percent less for CMC and VMS, respectively). Appendix D shows that the cropping systems did not vary substantially from the IM case to the SC case in the CMC scenario. Coffee-plantain still dominates the richest soils in all scenarios while cassava (intercropped with beans and maize) continues dominating in other soils. In other soils, conversely, significant areas previously allocated to cassava and beans intercrops shifted to fallow. While in VMS coffee-plantain covers the richest soils of the farm, the areas allocated to contracted bean and tomato production declined significantly, particularly in beans. Consequently, compared to the IM case (Section 10.3.1), VMS tomatoes displaced VMS beans as the most important contracted crop of the farm.

Overall, the differences between the CMC and VMS scenarios observed in the IM case in relation to factor use still hold in the 'soil conservation' case. The vertical marketing system for beans and tomatoes in VMS results in greater intensity in the use of land, labour and capital. Improved market conditions and input credit from the contracting buyer are the reasons for these differences. Gross margins have risen because of greater commercial orientation, credit assistance from the contracting buyer and greater input availability (see Appendix D). Gross margins relative to land were particularly significant, while gross margins relative to labour and, particularly, input use, are still lower in VMS as compared to CMC. This is due to the low input and labour requirements of cassava in the latter scenario.

Table 10.4 Factor use in the CMC and VMS market scenarios, SC case (and % change)

	CMC	VMS	VMS wrt CMC (%)	CMC wrt IM (%)	VMS wrt IM (%)
FACTORS					
Cropland (plazas)	12.1	12.5	(4)	(-24)	(-20)
Family labour (man-days)	635	1,310	(106)	(-21)	(-5)
Total labour (man-days)	637	1,688	(165)	(-22)	(-21)
Input (million Col$)	2.0	8.3	(317)	(-32)	(-25)
Gross margin (GM) (mill. Col$)	11.3	26.2	(132)	(-21)	(-21)
PRODUCTIVITY					
GM/land (mill. Col$.plaza^{-1})	0.9	2.1	(124)	(4)	(-1)
GM/labour (thous. Col$.man-day^{-1})	17.7	15.5	(-12)	(1)	(0)
GM/input	5.7	3.2	(-44)	(16)	(5)
INTENSITY					
Input/land (thous. Col$.plaza^{-1})	164.8	662.5	(302)	(-11)	(-6)
Input/labour (thous. Col$.man-day^{-1})	3.1	4.9	(57)	(-14)	(-5)
Labour/land (man-day.plaza^{-1})	52.6	134.6	(156)	(3)	(-1)
FACTOR USE					
Land %	55	57	(4)	(-24)	(-20)
Family labour %	42	86	(106)	(-21)	(-5)
Δ in capital %	293	631	(115)	(-26)	(-22)

Solutions of model objectives

Table 10.5 and Figures 10.9 to 10.12 present the solutions to minimum erosion, maximum discretionary income, minimum risk and maximum on-farm employment objectives over a two-year period, assuming a 'soil conservation' farmer.

Table 10.5 Solutions of model objectives for CMC and VMS, SC farmer case

	CMC	VMS	VMS wrt CMC (%)	CMC wrt IM (%)	VMS wrt IM (%)
Disc. Income (million Col.$)	2.7	5.9	(115)	(-26)	(-22)
Erosion (ton.plaza^{-1})	7.2	5.7	(-21)	(-50)	(-50)
Risk relative to Disc. Income (%)	10.2	6.3	(-38)	(-25)	(-11)
Labor (man-days)	635	1,310	(106)	(-21)	(-5)

Table 10.5 and Figure 10.9 show that *discretionary income* was Col.$2.7 million (US$2,874)[153] and Col.$5.9 million (US$6,183) in the CMC and VMS scenarios, respectively. Discretionary income in VMS more than doubles (up 115 percent) the levels in CMC. Table 10.5 shows that the halving of soil erosion, in the 'soil conservation' case, has had an impact on the discretionary income of both scenarios. Discretionary income dropped by 22 percent in VMS and by 26 percent in CMC. This result indicates that even when soil conservation prevails over the income objective, VMS does much better than CMC from the financial point of view.

[153] Values in 1995 Colombian Pesos: US$1 =Col.$950.

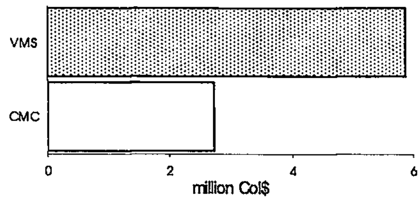


Figure 10.9 Discretionary income for CMC and VMS, SC farmer case

Figure 10.10 shows the level of *soil erosion* in ton over two years in CMC and VMS scenarios. Soil erosion amounted to 7.2 ton plaza^{-1} in CMC and 5.7 ton plaza^{-1} in VMS. This represents over a 20 percent reduction of soil loss in VMS as compared to CMC.

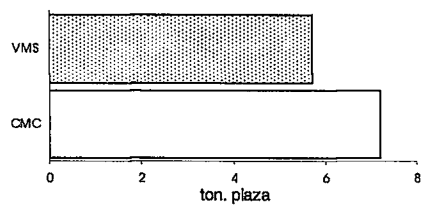


Figure 10.10 Soil erosion for CMC and VMS, SC farmer case

The bulk of soil loss in CMC is made up by cassava intercrops due to the low cover provided by this crop. Soil erosion is reduced in VMS due to a shift from a low-input crop such as cassava to high-input crops such as beans and tomatoes. Table 10.5 shows that the erosion levels in the 'soil conservation' case are half of the erosion levels observed in 'income maximisation' scenarios. The results of discretionary income and soil erosion for CMC and VMS suggest a trade-off between these objectives, which is discussed in Section 10.6.

Table 10.5 and Figure 10.11 show that relative *risk* is 38 percent lower in VMS scenario (6 percent) as compared to the CMC scenario (10 percent).

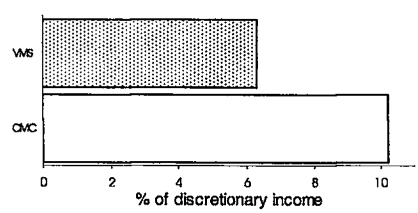


Figure 10.11 Relative risk for CMC and VMS, SC farmer case

Table 10.5 shows that, compared to the IM case, relative risk fell by 25 percent in CMC and by 11 percent in VMS. The halving of soil erosion helped primarily to reduce risk levels in CMC because of the larger areas that were shifted from crop production to fallow in that scenario.

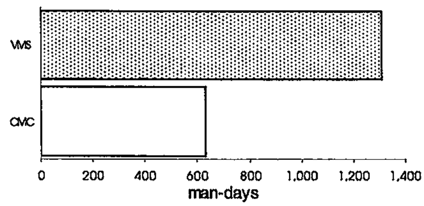


Figure 10.12 On-farm employment for CMC and VMS, SC farmer case

Figure 10.12 shows that the employment of *on-farm labour* was 635 man-days in CMC (less than half of the available family labour) and 1,310 man-days in VMS (86 percent of available labour). This represents more than a doubling in the use of farm labour in VMS. This indicates that, in VMS, the farm takes greater advantage of such an inexpensive factor by focusing on activities far more profitable. Table 10.5 illustrates that on-farm labour was the objective least affected by the 50 percent reduction in soil erosion. Compared to the IM case, on-farm labour employment fell by 21 percent in CMC while it was hardly affected (-5 percent) in VMS. In VMS, the reduction of soil erosion mainly affected hired labour, which dropped by 21 percent, while, in CMC, family labour was also used on off-farm activities to generate additional income (Appendix D).

10.5 The results of the MO market scenario

This section of the chapter presents the results of the MO market scenario. As noted, the MO market scenario differs from the other scenarios in that two innovations are carried out simultaneously: the introduction of a new product (blackberry) in conjunction with a VMS channel. Therefore, in the absence of a 'baseline' reference point (i.e. 'CMC' blackberry), the results are compared to those of the other scenarios. Tables accompany the discussion and Appendixes 10.7 onwards provide details on land use and cash flow.

10.5.1 MO: the 'income maximising' (IM) farmer case

Factor use

The introduction of blackberry through a VMS channel in the MO scenario has brought about radical changes in resource allocation and use. The use of land, labour and capital rose drastically as shown in Table 10.6. Appendix D shows that over 80 percent of prime soils, earlier fully covered by coffee-plantain, have been shifted to blackberry growing. Similarly, on poor soils, that formerly hosted cassava and beans intercrops, have also been committed to blackberry production. With only blackberry and coffee-plantain, the farm has switched from a semi-commercial system to a fully commercial system. The use of farm labour rose to almost 100 percent while capital growth climbed to levels over three or seven times higher than other scenarios.

Table 10.6 Factor use in the MO market scenario, IM case (and % change)

	MO	MO wrt IM CMC (%)	MO wrt IM VMS (%)
FACTORS			
Cropland (plazas)	21.7	(36)	(38)
Family labour (man-days)	1,355	(68)	(-1)
Total labour (man-days)	2,514	(209)	(17)
Input (million Col$)	12.2	(314)	(10)
Gross margin (GM) (mill. Col$)	64.7	(351)	(95)
PRODUCTIVITY			
GM/land (mill. Col$.plaza^{-1})	3.0	(232)	(42)
GM/labour (thous. Col$.man-day^{-1})	26	(46)	(66)
GM/input	5.3	(9)	(78)
INTENSITY			
Input/land (thous. Col$.plaza^{-1})	562	(204)	(-20)
Input/labour (thous. Col$.man-day^{-1})	4.8	(34)	(-6)
Labour/land (man-day.plaza^{-1})	116	(127)	(-15)
FACTOR USE			
Land %	99	(36)	(38)
Family labour %	89	(68)	(-1)
Δ in capital %	3,171	(697)	(293)

The intensity in the use of input factors such as production inputs and labour also soared dramatically, but it declined, however, compared to VMS reflecting the high input- and labour-intensive characteristics of beans and tomatoes production. Blackberry is, after tomatoes, the most input intensive crop in the region. Weekly harvests and post-harvest activities also make blackberry very demanding in labour. Analogously, gross margins per land and input use were also impressively high in the MO scenario. Productivity per cropped area is up to threefold, while productivity per man-day is up 46 to 66 percent the corresponding indicators of other scenarios. The productivity per input invested is almost double that of the VMS scenario and only 9 percent higher than that of the CMC scenario. As a result of land, input and labour intensification, gross margins are double to fourfold in the MO scenario. A contractual arrangement, as of the type described in the MO scenario, has provided a unique opportunity to Cabuyal highlanders to substantially improve market access and farm income.

Although the improvement in the farm conditions is very positive from the economic and environmental point of view, changes in the production system may have some associated agronomic and market risks that must also be taken into account, an issue that will be considered in the discussion part at the end of the chapter.

Solutions of model objectives

Table 10.7 and Figures 10.13 to 10.16 present the solutions of the MO scenario to maximum discretionary income, minimum erosion and risk, and maximum on-farm employment objectives, assuming an income maximising (IM) farmer. The respective solutions of CMC and VMS scenarios are included below to make possible a comparison of results.

Table 10.7 Solutions of model objectives for MO, IM farmer case

	MO	MO wrt CMC (%)	MO wrt VMS (%)
Discretionary Income (million Col.$)	29.5	(697)	(293)
Erosion (ton.plaza^{-1})	4.3	(-70)	(-62)
Risk relative to Disc. Income (%)	4.4	(-68)	(-38)
Labor (man-days)	1,355.2	(68)	(-1)

Discretionary income soared to Col.$29.5 million (US$31,053) in MO, which is about 3 to 7 times the discretionary income observed in the other scenarios (Figure 10.13). This is due to the high profitability of blackberry, continuous production of the crop, optimal use of inexpensive labour, better returns from production factors and a contractual arrangement that enables economies to be made in input and credit use.

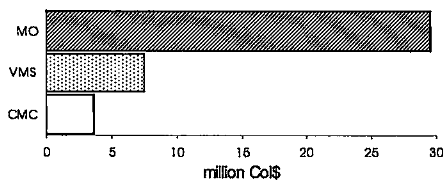


Figure 10.13 Discretionary income for MO, IM farmer case

Appendix D shows that farm activities are primarily financed by loans from the contracting firm and reduced transaction costs. Transaction costs per unit in the MO scenario (5.1 percent of the average price) is about half of those observed in the CMC and VMS scenarios and contribute to a higher discretionary income in that scenario. Production for on-farm consumption is reduced up to half. This is motivated by the substitution of staple crops such as beans, cassava and maize by blackberry. This indicates the shift taken by the farm towards commercial production in MO.

Figure 10.14 shows the level of *soil erosion* in ton per plaza in the MO scenario. Soil erosion amounted to 4.3 ton plaza^{-1} in MO, which represents 70 percent and 62 percent reductions of the erosion levels observed in CMC and VMS, respectively. Key agronomic characteristics of blackberry contribute greatly to soil resource conservation in this scenario. Its perennial characteristics, large canopy, widespread root system and fast growth provide the soil with excellent protection from rain erosion, soil slide and nutrient leaching runoff. The attractiveness of the MO vertical marketing channel scenario successfully promoted blackberry cultivation, which overtook areas formerly cropped with other more erosive crops such as cassava. This finding shows that the introduction of a profitable and more sustainable product through a VMS channel, as defined in this study, can reduce the levels of soil loss in Cabuyal while increasing farm income. This finding supports the hypothesis that marketing alternatives can be aimed at improving the economic conditions of Cabuyal farmers and, at the same time, protecting the region's fragile lands from resource degradation.

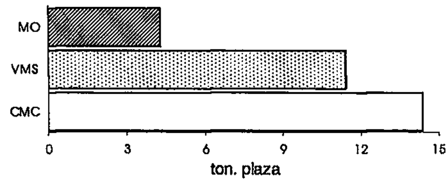


Figure 10.14 Soil erosion for MO, IM farmer case

Figure 10.15 shows that relative *risk*, with respect to discretionary income, was significantly lower in MO. MO risk accounts for just over 4 percent of discretionary income, which is considerably lower than CMC risk (14 percent) and VMS risk (6 percent). This represents a reduction of more than two-thirds in the level of relative risk faced by Cabuyal farmers in 'conventional' marketing channels.

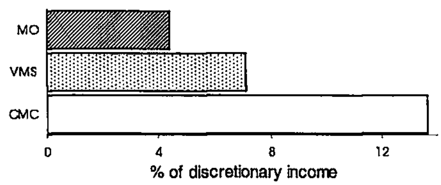


Figure 10.15 Relative risk for MO, IM farmer case

Figure 10.16 shows the amount of *farm labour* employed in the farm. The use of on-farm labour in MO amounts to nearly 89 percent of the available family labour (1,355 man-days), which is comparable to the VMS scenario and 68 percent up from the CMC scenario.

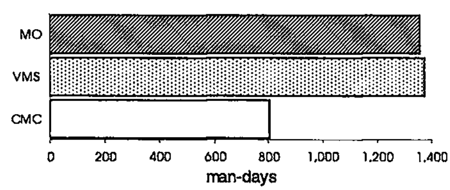


Figure 10.16 On-farm employment for MO, IM farmer case

The increase in on-farm labour in MO is due to the high labour requirements of blackberry in both production and post-harvest activities. The finding points toward a more intensive use of farm labour in integrated marketing channels. This finding has important implications for Cabuyal, both economically and socially, as it makes a more optimal use of this abundant resource in the region.

10.5.2 MO: the 'soil conservation' (SC) farmer case

Factor use

Table 10.8 presents indicators of productivity and intensity in factor use for the MO scenario in the SC case. The percentage of change with respect to other 'SC' scenarios and the MO scenario in the IM case ('wrt') are also presented. In general, the use of land, labour and input decreased in the MO scenario as compared to the 'income maximising' case. Appendix D shows that coffee-plantain displaced blackberry from the richest soils of the farm. This is explained by the lower soil erosion levels caused by coffee-plantain (virtually zero), as compared to blackberry (4.8 ton plaza^{-1}). In other soils, blackberry areas declined 17 percent in order to give place to some fallow/pasture areas and, therefore, reduce soil erosion. Notwithstanding the reductions in cropland, MO continues driving the Cabuyal farm towards commercial oriented business helped by improved market conditions and access to capital and input. The development of a vertical marketing system for blackberry continues resulting in greater intensity in the use of land, labour and capital. Henceforth, the differences between MO and other scenarios observed in the 'income maximising' case still hold in the 'soil conservation' case. Improved market conditions for and high-profitability of blackberry are the reasons for these differences.

Table 10.8 Factor use in the MO market scenario, SC case (and % change)

	MO	MO wrt CMC (%)	MO wrt VMS (%)	MO wrt IM (%)
FACTORS				
Cropland (plazas)	19.6	(62)	(56)	(-10)
Family labour (man-days)	1,380	(117)	(5)	(2)
Total labour (man-days)	1,778	(179)	(5)	(-29)
Input (million Col$)	7.7	(286)	(-7)	(-37)
Gross margin (GM) (mill. Col$)	41.6	(268)	(58)	(-36)
PRODUCTIVITY				
GM/land (mill. Col$.plaza^{-1})	2.1	(127)	(2)	(-29)
GM/labour (thous. Col$.man-day^{-1})	23.4	(32)	(50)	(-9)
GM/input	5.4	(-5)	(71)	(2)
INTENSITY				
Input/land (thous. Col$.plaza^{-1})	394	(139)	(-41)	(-30)
Input/labour (thous. Col$.man-day^{-1})	4.3	(38)	(-12)	(-11)
Labour/land (man-day.plaza^{-1})	90.9	(73)	(-32)	(-22)
FACTOR USE				
Land %	89	(62)	(56)	(-10)
Family labour %	90	(117)	(5)	(2)
Δ in capital %	1,881	(541)	(198)	(-41)

Solutions of model objectives

Table 10.9 and Figures 10.17 to 10.20 present the solutions of the MO scenario to maximum discretionary income, minimum erosion, minimum risk and maximum on-farm employment objectives, assuming a 'soil conservation' farmer. The solutions of CMC and VMS scenarios are included in the figures to make possible a comparison of results.

Table 10.9 Solutions of model objectives for MO, SC farmer case

	MO	MO wrt CMC (%)	MO wrt VMS (%)	MO wrt IM (%)
Discretionary Income (million Col.$)	17.5	(541)	(198)	(-41)
Erosion (ton plaza^{-1})	2.2	(-70)	(-62)	(-50)
Risk relative to Disc. Income (%)	4.4	(-57)	(-30)	(0)
Labor (man-days)	1,380	(117)	(5)	(2)

Table 10.9 and Figure 10.17 show that *discretionary income* was Col.$17.5 million (US$18,421) in the MO scenario. This level is from two (VMS) to almost six times (CMC) the discretionary income levels of other market scenarios due to better market conditions and credit assistance from the government in MO. Compared to the IM case, MO discretionary income in the SC case dropped by 41 percent, which is substantially larger than in, respectively, the CMC and VMS scenarios. The stronger reduction of discretionary income in MO is due to the more stringent level of erosion allowed in this scenario (2.2 ton per plaza, compared to 7.2 and 5.7 ton per plaza in other scenarios), which lowers farm income.

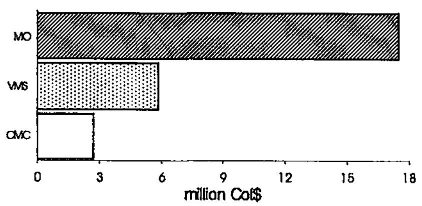


Figure 10.17 Discretionary income for MO, SC farmer case

Figure 10.18 illustrates that *soil erosion* amounted to 2.2 ton plaza^{-1} in MO. Table 10.9 shows that this level represents 70 percent and 62 percent reductions of the erosion levels observed in CMC and VMS, respectively.

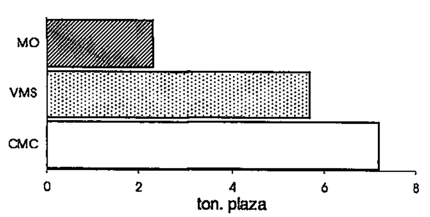


Figure 10.18 Soil erosion for MO, SC farmer case

The comparatively low soil erosion level in MO is due to the perennial and larger canopy characteristics of blackberry plants that cover significant areas of the farm. Soil erosion in the SC case of the MO scenario is half the erosion of the IM case. The results above indicate a significant trade-off between discretionary income and soil erosion, an issue that is discussed below.

Figure 10.19 shows that *risk* accounts for just over 4 percent of the discretionary income in MO. This represents a halving of the relative risk in conventional marketing channels of Cabuyal and a 30 percent reduction compared to VMS. The reduction of risk in MO reflects lower price fluctuations and higher market certainty of contract production in VMS channels. A cross comparison between IM and SC cases shows that relative risk has been stable in the MO scenario.

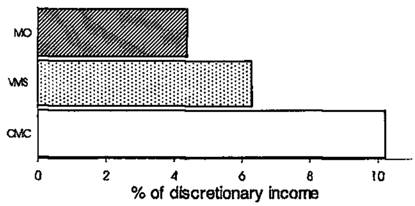


Figure 10.19 Relative risk for MO, SC farmer case

Table 10.9 shows that, in MO, the farm employs 1,380 man-days as *on-farm labour* (90 percent of the available farm labour). This is 117 percent higher than the on-farm labour employment in CMC and comparable to that in VMS. In the MO scenario farm labour is slightly up in the SC case as compared to the IM case. Appendix D0 shows that the halving of soil erosion mainly affected hired labour, which dropped by 29 percent. This result reflects the advantage of integrated marketing channels for the use of this inexpensive factor, by focusing on more profitable activities.

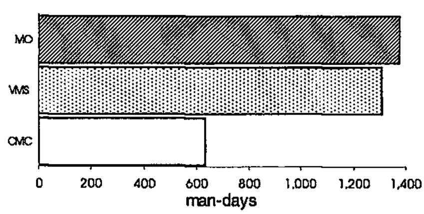


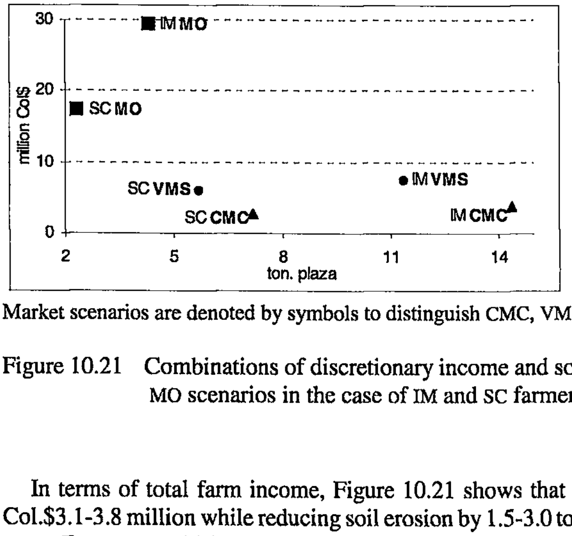
Figure 10.20 On-farm employment for MO, SC farmer case

The results presented above for the MO market scenario project a massive adoption of blackberry farming as a result of its high profitability and VMS commercialisation. In practice, the impact of blackberry might be limited by several factors. First, there could be some technical problems and barriers that create obstacles for the specialisation of the farmer in blackberry production. Second, the demand for blackberry is limited to an estimated demand of 876 ton per semester, which nearly equals the full production of 40 percent of the farms. Third, demand and supply movements will eventually result in lower market prices as farms start producing blackberry on a larger scale, which could lead to a diminishing profitability of the crop. Notwithstanding these caveats, the results of the MO scenario are meaningful since they show that, with the appropriate market conditions, high-value crops can substantially improve the economic and soil environmental conditions of Cabuyal farms.

10.6 Trade-off between discretionary income and soil erosion

Figure 10.21 compares discretionary income with soil erosion for the CMC, VMS and MO scenarios in the cases of farmers giving priority to income maximisation (IM) or to soil conservation (SC). From the figure the inverse relationship between discretionary income and soil erosion is clear. Larger income levels are accompanied by greater losses of soil, while the opposite is also true.

Figure 10.21 also shows that the 'VMS' types of scenarios (VMS and MO) perform better with respect to minimising soil erosion than CMC, without seriously compromising farm income. MO, in particular, does much better in keeping soil losses down while enabling much higher income levels. Discretionary income, regardless of the case (IM or SC), is over twice (VMS) up to seven times (MO) higher, while soil erosion is from 21 percent (VMS) up to 70 percent (MO) lower than in CMC.



Market scenarios are denoted by symbols to distinguish CMC, VMS and MO.

Figure 10.21 Combinations of discretionary income and soil erosion for the CMC, VMS and MO scenarios in the case of IM and SC farmers

In terms of total farm income, Figure 10.21 shows that farmers could increase income by Col.$3.1-3.8 million while reducing soil erosion by 1.5-3.0 ton plaza^{-1} when moving from CMC to VMS. Farmers could increase income by an additional Col.$11.6-22.0 million while further reducing soil erosion by 3.5-7.1 ton plaza^{-1} when moving from VMS to MO. This finding suggests that, when shifting to VMS type of channels, farmers have an opportunity to adopt more profitable and more sustainable production systems.

Figure 10.21 shows that, in the sequence MO, VMS, CMC, farmers trade off less income per every ton of soil saved from loss, in moving from IM to SC. Farmers earn Col.$6 million (MO), Col.$290,000 (VMS) and Col.$135,00 (CMS) less income per ton of soil saved[154]. The data indicate that even if SC farmers in the MO scenario have a higher discretionary income than IM farmers in VMS and CMC, they might be less inclined to shift from IM to SC because of the substantial fall in discretionary income. This might be a problem for stimulating farmers to shift from IM to SC behaviour. This observation is, however, tentative since results are based on a single case study.

A cross-comparison between cases suggests that, even with a 50 percent soil loss reduction (SC case), discretionary income is 60 percent (VMS, with Col.$5.8 million) to almost four times

[154] The estimates result from assuming a linear trend between IM and SC points of each market scenario.

(MO, Col.$17.5 million) higher than the best discretionary income of the 'baseline' scenario (Col.$3.7 million). A tentative conclusion is that the availability of a VMS channel either to a local or new crop, as defined in this study, can considerably increase the economic returns of Cabuyal farmers while contributing to the enhancement of soil sustainability.

10.7 Discussion of results

An analysis of the impact of different marketing situations on farm income, soil sustainability and other two objectives has been undertaken. This impact was examined in relation to two decision-making cases (IM farmer case and SC farmer case) in order to assess the trade-off of farm income and soil erosion. The results reveal sub-utilisation of production factors of the farm due to adverse market conditions and suggest numerous potential gains for the farm as a result of improvements in the marketing channels in the Cabuyal region. Main findings are:

- VMS channels, based on long-term relationship and having some credit support from the government, do better with respect soil sustainability than CMC. It appears that under this marketing situation, farmers are more willing to take on attractive crops, such as tomatoes and beans, which are capital-intensive and more risky to produce in CMC.
- VMS do better with respect soil sustainability than CMC even in the case where the farmer has income maximisation as the first priority and minimisation of soil erosion as the second priority.
- New crops, being attractive from the point of view of a VMS channel, market price and soil conservation, appear to contribute substantially both to soil sustainability and discretionary income of farming.

The results also show both an increase in discretionary income and a reduction of soil erosion when farmers shift from CMC to VMS type of channels. This suggests that farmers concerned with current production systems are likely to shift to VMS channels because of the prospect of both higher income and more sustainable farming systems.

A shift from income maximisation to soil-erosion minimization, as the first objective, results in a larger trade off between discretionary income and reduction in soil erosion in the sequence CMC, VMS and MO. This result suggests that farmers would be less inclined to put soil conservation ahead of discretionary income when discretionary income is higher as a result of changing marketing situation.

The results of the COOPERA model depend, to a large extent, on the assumptions of and instruments in the market scenarios[155]. Some caveats are worth mentioning with respect to the validity of the research results:

- Prices might decline as farms increase the production of a specific crop substantially[156].
- Farmers might not be willing to specialise to the extent the COOPERA model results project, because of technical, cultural and infrastructural reasons.
- Farmers might perceive a substantial shift to specialisation as being too risky.

Policy implications

The study's findings point to the need for improving the marketing channels and infrastructure of the Cabuyal community so livelihood opportunities can be promoted and farmers can enjoy the

[155] Secondary data and data obtained from several appraisals were used for setting input/output values, while market instruments were set based on contractual experiences in the region.

[156] Prices would decline quicker for beans than for tomatoes or blackberry, as demand is stronger for the latter crops.

benefit from husbanding their lands and making investments in soil productivity enhancement.

- Policy makers should create the conditions to reduce the dependence of small farmers on conventional traders by stimulating the emergence of VMS channels in Cabuyal such that alternative economic activities can arise.
- Strengthening credit options by the government appears to be a very important element in its support to rural marketing.
- The potential contribution of the government to soil sustainability and rural income seems particularly significant in the development of marketing channels for high-value and environmentally-sound products.

Conclusions about the usefulness of the COOPERA model

The COOPERA model appears to be a useful explorative model to simulate and evaluate the impact of different marketing structures and decision-making on soil sustainability of farming, income, employment and risk. The model enabled to examine the trade-off between farm income and soil conservation as a result of different priorities in farmers' objectives. This feature is, in itself, a contribution to the research on farm soil conservation from the marketing point of view.

The COOPERA model offers certain limitations. Firstly, it considers only one type of farm. The consideration of other types of farms (e.g. with other agro-ecological conditions) might improve the model scope. Secondly, soil loss is constant over the time. A stricter definition of soil loss could be achieved by considering the residual effect of erosion throughout the time and by differentiating it by soil type[157].

[157] In contrast to the econometric analysis undertaken in Chapter 7, the COOPERA model focuses on a single farm. Henceforth, soil sustainability is analysed in terms of soil loss rather than on the adoption of conservation practices. Other suitable enterprise-specific approaches, however, could have been applied including the soil nutrient balance approach (see Chapter 7).

11 CONCLUSIONS AND IMPLICATIONS OF THE STUDY

This chapter presents a discussion of the study results and the implications that emerge. The first section recalls the problem definition and the objectives of the study. The second section presents the main findings of the empirical research results. The third section draws out the general conclusions of the study, in particular with respect to the study hypotheses. Section four puts forward possible policy implications. The last section presents suggestions for further research.

11.1 Problem area and objective of the study

The aim of this study is to better understand in what way alternative marketing systems can contribute to promoting the adoption of soil sustainability on small-farm production systems. It involved the following research questions: To what extent are alternative marketing channels or arrangements better equipped to contribute to the adoption of sustainable farm production systems? What is the added contribution of other factors, such as physical, institutional, economic and personal factors, to affect farmer's decision to use sustainable production systems? What is the impact of greater levels of sustainable production systems on farm income?

The research aim arose from the need to evaluate the merit of marketing strategies to provide incentives for sustainable agriculture in developing countries, as public interventions to promote sustainable adoption have often been less than successful. In particular, the research examined changes in the marketing channels that would stimulate resource-users towards sustainable soil management. The problem definition focused the study on the implications of marketing, in particular marketing channels and marketing systems, to the sustainability problems of small farm systems in the tropical hillside areas. The problem was focused on marketing channels because of their influence on farm household decisions, production systems and farm sustainability. The following general hypotheses were formulated:

H1: Vertical Marketing Systems (VMS) are better equipped than Conventional Marketing Channels (CMC) to stimulate farmers to adopt farm soil sustainability

H2: A government policy supportive of marketing and production activities encourages farmers' investment in soil sustainability

H3: Market incentives, promising income enhancement, are likely to stimulate the adoption of farm soil sustainability

In order to analyse the relationship between marketing and soil sustainability in small farms of developing countries, a research framework was developed. The framework involved firstly, a method for measuring the *adoption of sustainable agricultural practices* (ASAP); secondly, an econometric model for testing the influence of marketing and other factors on ASAP; and thirdly, a multiple-goal LP model to simulate and evaluate the impact of alternative marketing structures on soil sustainability. The framework developed was applied to the Cabuyal river watershed, a small-farm peasant community located on the Andean region of Colombia.

11.2 Main findings from the empirical research

The empirical research revealed several findings that are enumerated below.

1. The method developed to measure ASAP in Cabuyal led to the finding that soil sustainability was built up on three essential components *soil-disturbance control*, *soil protection* and

run-off control[158]. Each of these components represented a specific aspect of ASAP.

2. A cluster analysis showed that the way Cabuyal farmers combine the various aspects of ASAP gave rise to five possible strategies leading to sustainable soil management. The analysis suggested that marketing factors, such as ease of access to market centres, good access to marketing services and entrepreneurship, were positively associated with ASAP. Other important factors for ASAP included long-term planning, innovativeness, better education and awareness of soil degradation problems.
3. The econometric model revealed that the various aspects of soil sustainability appear to be distinctly influenced by institutional (e.g. marketing), economic, personal-social and physical factors. Firstly, education and managerial variables appear the most important with respect to soil disturbance control. Secondly, marketing and managerial variables appear the most important with respect to soil protection. Thirdly, farm labour and physical variables appear the most important with respect to run-off control.
4. Economic and marketing factors appear to be the most critical factors for the adoption of soil sustainable practices. Adopters of soil sustainable technology comprised entrepreneurs having a long-term focus and being integrated to the market with comparatively better access to institutions, marketing services and farm labour. Marketing factors, in particular, were the primary factors for the protection of the topsoil, which is crucial for Cabuyal as loss of topsoil (the nutrient layer) is the leading conservation challenge in the region.
5. Government factors, such as the strength of and links to technical institutions, appear significant with respect to only one aspect of the adoption of soil agricultural practices in Cabuyal, reflecting a possible lack of emphasis of technical extension on wider aspects of soil conservation.
6. The multiple-goal LP model revealed that VMS channels, based on long-term relationship and having some credit support from the government, have a positive impact on the use of, and income from, production factors of the farm, and do better with respect to soil sustainability than CMC. It appears that under this marketing situation, farmers are more willing to take on crops, which are capital-intensive and more risky to produce in CMC.
7. Farmers in VMS channels appear to perform better with respect soil sustainability than in CMC even in the case where they make income maximisation the first priority and minimisation of soil erosion the second priority.
8. The positive impact of VMS on farm soil sustainability and income appears to strengthen substantially when coupled with new crops, being attractive both from the point of view of market price and soil conservation.

[158] Soil-disturbance control refers to soil conservation practices, such as low tillage and non-root harvest, with low mechanical impact on the soil structure. Soil protection refers to practices such as grass strips, mulch, live barriers and other physical barriers intended to provide topsoil protection from rain erosion. Run-off control refer to physical practices, such as interception drains made at the margins of farm plots, intended to cope with soil surface run-off by carrying the water flow away.

11.3 General conclusions regarding the research hypotheses

The first hypothesis stated that *VMS are better equipped than CMC to stimulate farmers to adopt farm soil sustainability.*

The empirical findings support a positive and significant association between farmers being vertically integrated to the market (on the basis of a long-term relationship) and adoption of sustainable soil practices. The findings showed that adopters of sustainable soil practices also involve farmers with good access to market and marketing services, greater commercial orientation, entrepreneurial skills and a marked preference for long-term commitments.

The findings validate the hypothesis that VMS arrangements positively affect farmers and stimulate them towards more environmentally sound production systems. Farmers are stimulated in several ways by VMS channels. Farmers in VMS can plan decisions regarding farm resource allocation, production mix and other farm management decisions including soil management. VMS stimulates long-term planning horizons in farmers. Long-term horizon is translated into a stable market relationship and also into a higher commitment for the sustained use of the soil resource. Farmers in VMS gain sales security, more income stability and improved market access. They are also more motivated to pursue a continuous improvement of farm management skills both at the production and marketing levels.

Another interesting result delivered by the econometric model was that Cabuyal farmers, commercially engaged with starch processors, exhibited unsustainable practices with disturbing effects on the soil. Too much concern with short-term benefits, reflected in hard selling behaviour and careless attitudes towards cassava farming systems, may induce unsustainable farming patterns. In consequence, it is concluded that the time horizon of the marketing channel is a significant factor for farm soil sustainability. If the marketing channel leader has a short-term perspective and is more concerned with short-term gains at the cost of long-term benefits (sustained profit), sustainable farm production systems are unlikely to occur. This is because soil sustainability is a factor of time and it is soil management that determines the yield capacity of the land over time.

The second hypothesis of the study stated that *a government policy supportive of marketing and production activities encourages farmers' investment in soil sustainability.*

The results from the empirical research showed that links to governmental and non-governmental technical organisations and access to their services are positively associated with the adoption of soil sustainable practices, in particular, to the adoption of topsoil protection practices. This finding shows the importance of the role of the government in sustainable agriculture and suggests a need for greater emphasis in technical extension on a wider range of soil conservation practices. Farmers with good links with these institutions can count on better information on matters such as farming practices, measures to overcome soil erosion and other yield affecting problems.

The results from the empirical research also showed that VMS channels, having credit support from the government, seem to stimulate the adoption of more sustainable production systems. Channelling financial support through the marketing channel would have assisted a shift to capital-intensive activities that would have improved watershed farmers' income while at the same time enhancing soil sustainability.

Therefore, it is concluded that government support of marketing and farm production activities create better conditions for the attainment of farm soil sustainability. In particular, VMS would have the greatest impact when a broader government policy is oriented towards assisting the operations of these channels in rural areas. Government assistance can be more efficiently channelled through VMS because of the economic incentives that it entails for the adoption of sustainable production systems.

The third and final hypothesis of the study stated that *market incentives promising income enhancement are likely to stimulate the adoption of farm soil sustainability*

The results from the COOPERA household model showed that market incentives being attractive from the point of view of a VMS channel, long-term relationship and credit support had a positive impact on the soil sustainability of the farm. The results also showed that this impact was particularly significant when these market incentives where combined with a new profitable crop involving an environmentally sound production system.

The evidence drawn from this empirical analysis suggests that strategically planned market development supports rather than counteracts sustainable land use. Managed and planned commercial opportunities can create stimuli for a better allocation and management of the small-farm soil resource. This is particularly the case when the crop(s) involved are comparatively less erosive than other crops.

On the basis of these findings it is concluded that market incentives involving the possibility of improvements in farm income, could also be successfully used to promote sustainable production systems in Cabuyal. In particular, market incentives based on long-term goals, bring economic benefits, specifically income stabilisation, and increased commitment for the conservation of the natural productive resource.

Conclusions on the methodology

The empirical analysis benefited substantially from the methodology developed in this study.

First, a method for the measurement of ASAP was developed which bridges the gap between the existing approaches, being either too general regarding the actual adoption process (e.g. adoption/non-adoption) or too detailed (e.g. ton of soil lost per ha). This measure of ASAP showed great flexibility for the application of quantitative methods, which has enabled an insight into the soil conservation adoption process. The methodology, it is believed, contributes substantially to the empirical appraisal of soil sustainability.

Second, the econometric model, resulting from the integration of approaches from several disciplines, attempted to explain ASAP on the basis of a wide range of possible affecting factors. The approach enabled an unbiased estimation of the effects of marketing factors and their comparison with the effects of other explanatory factors. The study also illustrated the usefulness of Principal Component Regression (PCR) in estimating holistic models through parameter reduction. The procedure minimised the problem of multicollinearity and enhanced model estimation. The use of PCR, however, prevented a precise test of the influence of the underlying explanatory variables.

The econometric model approach constitutes a sound option to help explain the adoption of soil sustainability practices on the basis of various factors. Even though the proposed methodology was centred on soil sustainability, it seems applicable to other aspects of sustainability in further environmental studies too.

Third, the multiple-goal LP household model (COOPERA) explored the impact on farm income and soil erosion of contrasting market situations. The model contributed in two ways to the research on farm soil conservation. First, from the marketing point of view, the model enabled the definition of and comparison between a conventional market channel scenario (CMC) and vertical market channel scenarios (VMS) with respect to farm soil sustainability. Second, the model enabled the examination of the trade-off between farm income and soil conservation as a result of specifying different priorities in farmers' objectives.

11.4 Study implications

This research has demonstrated that the interactions of farm sustainability and marketing systems are very significant. The findings illustrate that the marketing system can also play a significant role in facilitating and even inducing the use of sustainable agricultural technology. The prospect of promoting soil conservation through marketing channels has important implications for the sustainable development of the Cabuyal watershed region. Following sections discuss some of these implications.

11.4.1 Implications for marketing policies of companies

This research has led to the conclusion that conventional marketing channels are not an appropriate marketing scenario when soil conservation or the reversing of soil degradation is the objective. Vertical marketing systems, in contrast, have been shown to be a more pertinent scenario for this aim. VMS channels pose lower risks and are more long-term oriented, crucial factors for farm soil sustainability.

Long-term orientation in VMS, in particular, has been shown to be an essential factor for the adoption of sustainable farming systems. Greater emphasis on quality production, on stable long-term price perspectives and on controlling price volatility contributes to long-term horizon among channel members. The prospect of sustained economic returns in VMS will extend farmer's planning periods, who will favour the long-run benefits from soil conservation over the short-term benefits from mining the land. The advantage of VMS in stimulating soil sustainable agriculture will be particularly meaningful when marketing companies:

- are not only concerned with price and quantity but also with quality production;
- are long-term oriented and favour the maintenance of the productive resource over time;
- provide extension to and share market information with farmers so resources can be allocated in a more skilful and timely manner;
- provide inputs and finance, which reduces farmer's concerns about production financial constraints.

11.4.2 Implications for policy makers in Cabuyal

The conclusions of the study point to a need for a more proactive role of the government for promoting a more meaningful impact of marketing strategies on soil sustainability. The understanding of how marketing and other factors influence ASAP is useful for the formulation of policy strategies aiming at the adoption of sustainable agricultural systems in Cabuyal.

- Firstly, if the interest lies in promoting *low tillage and other low-disturbing soil conservation practices*, policy makers must consider that adoption is mainly influenced by economic factors (long-term planning, prevalent crop and labour availability), predominantly, and by marketing factors (commercial orientation and marketing integration). From the economic point of view, adoption is favoured when production activities involve crops such as coffee, fruit trees and other perennial crops. These crops involve production systems that pose lower stress on the soil physics and incite long-term planning attitudes on farmers. From the marketing point of view, first adopters will involve farmers with entrepreneurial attitudes who are better integrated to the market. Policy makers should, however, bear in mind that this strategy is likely to fail with farmers having contractual arrangements with starch processors, being short-term oriented entrepreneurs.
- Secondly, if the interest of decision-makers focuses on promoting *soil protection practices to*

curb topsoil losses due to rain erosion (a key environmental problem in Cabuyal), marketing factors are the most important policy instruments. Policy must be oriented at improving small farmers' access to markets and institutions, while supporting the establishment of processing plants, cooperatives and other VMS institutions.
- Lastly, if the interest lies in promoting of practices to *control run-off of soil nutrients*, economic factors and, to a lower extent, physical factors are key factors for adoption. Farm labour shortage and gentle slopes are key constraints for adoption. Educational campaigns should acquaint resource-users about the implementation of run-off control practices and about the risks of non-adoption in less steeper lands.

These examples illustrate the important role played by marketing in policies aiming at sustainable farm production systems. Policy makers must create the conditions that stimulate the emergence of vertical marketing systems that help to reduce the dependence of small farmers on conventional intermediaries. Preferably, policy makers should favour the development of marketing channels for products such as blackberry, strawberry and local fruits such as *lulo* and *uchuva*, that can offer farmers both economic returns and sustainable viability. An important way to stimulate appropriate marketing channels is by improving the working environment of marketing channels:
- strengthening supporting organisational structures (e.g. financial institutions, insurance agencies and rural transport companies);
- improving the physical infrastructure (e.g. roads, electrification and communication services);
- integrating the development of marketing to other rural development policies.

Such policies initiatives are likely to stimulate the emergence of marketing systems, such as VMS, that can better undertake marketing endeavours and sustainable soil practices.

There exist, however, some risks for failure[159]; but their recognition helps to strengthen the viability of marketing strategies like VMS. The partnership between all stakeholders, government, marketing companies and farmers, would maximise the economic and environmental benefits that marketing strategies like this may have.

11.5 Suggestions for further research

Even though a number of suggested policy reforms and initiates have been addressed in this discussion, many gaps remain in the precise effects of their implementation, since such potential changes raise complexities and trade-offs that cannot be resolved easily. Determining the specific reforms requires detailed analysis and assessment of the relevance for each case. Other aspects need further research. With the evidence that marketing channel development is a major factor for the encouragement of small-farm soil sustainability, this study brings up some questions that need further elucidation:
- What kinds of VMS institutions are better empowered to bring about sustained rural economic development and more optimal use of farm resources?
- What is the most efficient way in which scarce government resources in poorer countries, namely capital, technology, etc., can be allocated to promote the adequate development of rural marketing channels and the sustainability of farm systems?
- Will market liberalisation stimulate the growth of quality food and organic market consumer segments that are willing to pay premium prices for sustainable produced commodities?

[159] As noted in Chapter 2 (Section 2.2), risks associated with VMS include being capital intensive, abuse of monopsony position in contracts and limited coverage of contracts.

These questions create opportunities for further research activities that would provide a more effective inclusion of marketing in agricultural policies for developing countries, which, nowadays, are confronted by dilemmas both domestically and internationally. Firstly, developing countries face incremented rural environmental degradation and the need of sustained supplied for a growing urban demand. And secondly, developing countries face liberalisation of international trade while environmental concerns from consumer markets are growing.

Other suggestions for further research pertain the research methodology. The research methodology developed in this study should be tested for generality:

- Additional case studies should show whether the three dimensions of ASAP identified hold for small-scale farming in general or are specific for Cabuyal.
- Future research could reveal whether the principal components of the variables explaining ASAP in this study are valid in general or specific for Cabuyal.
- Research might be done on the usefulness of introducing soil-disturbance control, soil protection and run-off control, the identified ASAP dimensions, as separate activities in the COOPERA model.

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Appendices

Appendix A Appendix to Chapter 4. Organic markets and other sustainability adoption efforts

Organic markets

A relatively recent 'user-pays' strategy addressed to internalise environmental costs in food prices is that of organic or gourmet products. This market initially begun with coffee and cocoa but progressively have included other products such as fruits, vegetables and other staple food, cotton, meat, poultry and dairy products. These products are marketed by the so called fair trade organisations using clean production as the unique sales attribute. Examples of these organisations are Max Havelaar, which came to existence in the Netherlands in 1988, followed by Belgium two years after and by Switzerland in March 1992; in the United Kingdom a somewhat different concept was launched under the name of Cafèdirect in 1992. In Germany, at the beginning of 1993, the Fair Trade initiative TransFair started its campaign under the umbrella of TransFair International, a joint structure of TransFair Germany (and in future countries) and the European Alternative Trade Organisation EFTA. All of them comprise the International Fair Trade Coffee Producers' Register (ICR), which through a quality mark, guarantees the consumer that the price they pay for that product is a fairer price, which gets where it should get: directly from producers' cooperatives. These cooperatives compose of small farmers must meet criteria of organisation, equality, and sustainable agricultural production. Farm products must be grown under certain moisture and temperature conditions. No chemical applications and organic fertilisation are also requirements. The trade organisation confers a quality mark and direct long-term contracts are made between the cooperative and an exporting firm.

Max Havelaar and TransFair International have registered cooperatives in Latin America, Africa and/or Asia. In Colombia, the "Consejo Regional Indigena de Caldas" (CRIDEC) located in the Coffee Region, is an example of a registered cooperative. It comprises small farmers from the indigenous reservations of Cañamomo, Lomaprieto, San Lorenzo, and La Montaña. They export semi-organic coffee since some chemicals are still used. ICR is considering the application of other cooperatives from Chaparral and Popayán.

Organic coffee in Latin America is mainly produced in Mexico (as a result of 'Solidaridad' programme under Salinas' government), Brazil, and Costa Rica. Coffee bushes are grown under shade trees (to ensure that the moisture content is regulated naturally and the soil is not dried out), on high slopes (2000 m.); no chemicals are used, and fertilisation takes place using organic compost. The result: organic coffees, more select, best quality, chemically clean and rewarded with premium prices (up to twice the price of common coffee).

Adoption and market failure

Disappointing experiences in the search for technological solutions to unsustainable land use in the tropics have identified market factors as reasons for failure. Several projects implemented in the tropics showed that, although they had clear merits and were technically sound, the projects have had difficulties in getting farmers to adopt the proposed practices:

- Budelman and van der Pol (1992) provide a review of projects carried out in Sub-Saharan Africa by the Farming System Research and Development Program (FSR&D). Although the high suitability of the technologies promoted, farmers rejected the adoption of those technologies. This was considered a common experience of the Program in the tropics. A main conclusion was that prices were often too low to encourage farmers to invest in the maintenance of the lands they occupy.
- White et al. (1991) also provide an example of failure in the Paute Watershed, Southern Ecuador. Promotion of soil conservation practices to overcome extreme soil degradation failed despite subsidy offers. An important reason for failure was the lack of economically attractive technological alternatives for exploiting cropland or forest in a sustainable manner.
- In Burkina Faso, various integrated development projects involving the implementation of soil and water conservation activities were attempted (van de Graaf, 1992). However, the rate of adoption was rather disappointing. The general consensus was that produce prices were too low, and sustainable practices at every level (community, farm, and crop system) demanded too much resources of labour, space, sometimes capital, and energy. Such resources were, and are often, scarce, and as consequence, implementing land management was unattractive to the land users who felt that they had to make too large a sacrifice.

A main conclusion from the above cases is that marketing is an important component in promoting the adoption of sustainable production systems. Conservation technology needs to be developed as part of an overall rural investment strategy, which takes into account not only the trade-off between production and conservation for the individual farmer, but seeks to provide opportunities for improving the return of a scarce factor of production important locally via the introduction of suitable conservation practices. The adoption of sustainable production systems in most of the cases mentioned has been not only because of the intrinsic moral and ethic feeling for protecting the environment and the consumers' health but because of the opportunity to increase income with sustainable production occurring at the same time.

Appendix B Appendix to Chapter 6. Data collection and study questionnaire

Operative issues

The timing of the farm survey was decided considering the most suitable date for the farmers in regard of farm activity. Sowing and other farm activities were classified according to their timing between the last quarter of 1994 and the first quarter of 1995. The survey should take place after sowing, when sowing land use decisions had been made and when the farmer accounted on time to respond the questionnaire. Accordingly, November-December was selected as the most convenient period for the farm surveying. A pilot survey was tested in 14 farms in beginning November, which was followed by a second pilot version tested in a four-day training course. Four local interviewers were trained but only three were effectively available for the survey. A third and final version of the survey (see Appendix B) was obtained after including valid modifications during the course and the pilot tests.

Three interviewers and the author carried out the data collection. The interviewers were local farmers with high school degrees and previous surveying experience. Each of them was asked to perform no more than two surveys a day. This quota aimed at avoiding any rush on the interviewers in the benefit of the quality of the information. Each survey took around two hours including visits to up to two plots. Farmers were first asked whether they could answer the survey in that moment or, otherwise, asked for an appointment. Each survey was reviewed, corrected or returned to the interviewer in case of missing data. Each farm was geo-referred in further visits, which were also used for data verification. Data collection was especially troublesome in December during the rainy season. Rains affected terrain roads and made very difficult the access to some villages. Some farms could only be accessed by horse means.

Data coding

The data was coded and recorded in a UNIX ORACLE database to allow much friendly management, consult and open access to the information. The data was filtered and analysed. The database is public and can be consulted within the CIAT network. Its definition and structure allows easy interface with any statistical package for analysis. The following table shows the timing of the activities involved in data collection and coding.

Timetable of data collection and coding

	1994			1995					
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Sample size estimation	■								
Survey design and pilot test	■	■							
Survey corrections	■	■							
Contact of interviewers	■	■							
Reproduction of surveys		■							
Training of interviewers		■							
Data collection			■	■					
Farm geo-reference and data verification				■	■				
Database design and coding						■	■	■	
Data filtering and gap filling								■	■

Study questionnaire

Estudio del efecto de los sistemas de mercadeo sobre la sostenibilidad de sistemas agrícolas en laderas de la Micro-cuenca Cabuyal (Cauca) Noviembre 1994

Señor agricultor, esta encuesta es la continuación de la encuesta de Cipasla realizada un año atrás. En esta, hablaremos del mercadeo de sus productos y de algunas prácticas de conservación. La entrevista toma alrededor de 1 hora, si considera que en el momento no nos puede atender, por favor díganos a que hora podemos volver. Gracias.

1. Identificación: *Elija al dueño de la finca o a quién trabaje la tierra de la finca*

A. Nombre del Agricultor						
B. Vereda						
C. Nombre del encuestador						
D. Fecha	Día		Mes		Año	1994

2. Composición familiar: etnia

	Caucano (blanco\mestizo)	Guambiano	Paez	Nariñense	Otro
Cuál es su origen ?					

3. Tenencia

Área Total de esta Finca (Plazas o Ha)	

4. Importancia de los lotes

		Lote 1	Lote 2
Cuáles son los dos lotes más importantes de esta finca ? *(describa los lotes en términos de sus cultivos)*	Cultivo principal [A]		
	Intercalado con [A]		
	Asociado con [A]		
	Cultivos cosechados		
Por qué son estos lotes los más importantes para usted ? *(NO enumere y marque con X una solo opción)*	Consumo		
	Ingreso		
	Semilla		
	Area		
	Trabajo		
	Cercano a la casa		
	Suelo		
	Otro ________		

A: 1=café, 2=yuca, 3=frijol, 4=maíz, 5=caña, 6=plátano, 7=verduras, 8=arveja, 9=habichuela, 10=papa, 11=zapallo, 12=frutales, 13=tomate, 14=soya, 15=piña, 16=pastos, 17=arroz, 18=Cabuya/fique.

5. Lotes: características. Hablemos ahora de estos dos lotes.

Nota: Encuestador debe ir al lote. Lote 1 es mas importante y Lote 2 es el que le sigue en importancia.

		Primer lote	Segundo lote
Cultivo principal [A]			
Tamaño (Plazas)			
Tenencia del lote *(enumere y marque con X una opción)*	Propio		
	Compañía		
	En arriendo		
	Otra		
Tipo suelo *(enumere y marque con X una opción)*	Bueno		
	Regular		
	Malo		
Color suelo *(enumere y marque con X una opción)*	Negra		
	Mezcla		
	Colorada		
Longitud Pendiente (mts)			
Inclinación Pendiente (%)			
Que profundidad tiene la capa superior de la tierra (tierra arable) (cm.) ?			
Qué siembras hizo después del descanso? [A]			
Cuántos meses/años lo dejó descansar ?			
Qué problemas tiene en cada lote ? *Enumere y marque con X*	Erosión		
	rodamiento, derrumbe		
	tierra desgastada, cansada		
	arrastres, escorrentias		
	lluvia intensa		
	Sequía		
	canjilones, cárcavas		
	otro, cual? ____		
	Ninguno		
Qué hace para controlar cada uno de los problemas que mencionó ? [B]			
Cuando llueve, la tierra del lote rueda *(marque una X)*	Bastante		
	Poco		
	Nada		

A: 1=café, 2=yuca, 3=frijol, 4=maíz, 5=caña, 6=plátano, 7=verduras, 8=arveja, 9=habichuela, 10=papa, 11=zapallo, 12=frutales, 13=tomate, 14=soya, 15=piña, 16=pastos, 17=arroz, 18=Cabuya/fique.

B: 1=terrazas, guachos, 2=barreras (bordes, piedras, vivas, etc), 3=cobertura, franjas de pastos, 4=desagües, canales, zanjas, acequias, 5=trinchos, 6=cero labranza: cajuela, holladura, pica barretón, 7=corta rastrojo e incorpora al suelo, 8=siembra atravesado, 9=siembra en chorrillo, 10=abona con residuos, basura, maleza muerta, 11=abono boñiga, 12=gallinaza, 13=compost, lombricompuesto, 14=aplica Cal, 15=deshierba con machete, 16=control biológico, 17=siembra árboles, reforestación, 18=otro____________

6a. Conservación: Marque con X los lotes en los que realiza las siguientes practicas.

		Lote		Para cualquiera de los lotes en que haga la practica, puede decirme						
		1	2	Cuando lo hizo? (años)	Aún está? Si/No	Hacerlo fue: difícil	Reg.	ácil	Uso m.o.: contratada	familiar
ADECUACIÓN										
Terrazas, Guachos										
Caballones, heras										
Barreras *Enumere y marque X*	Telembí, imperial									
	King-grass									
	Elefante									
	Vetiver									
	Citronella, limoncillo									
	Caña									
	Piña									
	Maní									
	otro, cual______									
Cobertura, pastos, rastrojo										
Otro										
MANEJO DE AGUA										
Desagües, canales, zanjas, acequias										
Trinchos										
Otro										
PREPARACIÓN										
Monte	Corta y quema									
	Corta y recoge									
Cal u otro acondicionador										
Cajuelas, Holladura										
Pica a barretón										
Arado Bueyes	En lote nuevo									
	En zoca									
Arado tractor										
SIEMBRA (cult. ppl.)										
Siembra atravezada										
Chuzo										
Chorrillo										
Estaca, plantado										
Otra										

	No hay plata	Conserva suelo	No hay bueyes	Otra, cual
Porque no usa bueyes?				

6a. Conservación (continuación): marque con X los lotes en los que realiza o piensa realizar las siguientes prácticas:

		Lote		*Marque X*				
				Hacerlo fue			Usó mano de obra	
		1	2	difícil	regular	fácil	contratada	familiar
ABONAMIENTO								
No abona								
Residuos, Rastrojo muerto								
Boñiga								
Gallinaza								
Compost, lombricompues								
Químicos								
CONTROLES								
Deshierba	Machete							
	Azadón, pala							
	Plateo							
	Herbicida							
COSECHA (cult. ppl.)								
Arranca mata de raíz								
Arranca mata sin raíz								
Recoge el fruto								

6b. SI TIENE Barreras o Cobertura. Elija uno de los lotes y describa las barreras en:

Barrera o Cobertura	Distancias entre barreras (mts.) *(marque una X)*				No. de surcos por barrera *(marque X)*		Porque siembra barreras o deja cobertura ? *(marque 1 a la 1ra razón y 2 a la 2da)*			
	1-5	5-10	10-20	> 20	1-2 surcos	Mas de 2	Alimento humano o animal	Detiene el suelo o el agua	Uso medicinal, o industrial	Otro, cual ____
Telembí, Imperial										
King-grass										
Elefante										
Vetiver										
Citronella, Limoncillo										
Caña										
Piña										
Maní										
Cobertura, rastrojo										
Otro:____										

6c. Conservación en el resto de la finca. Tiene prácticas en otros sitios de la finca ?

		Cuando lo hizo?	Aún esta ?		Hacerlo fue			Usó mano de obra	
			Si	No	Difícil	Regular	Fácil	Contratada	Familiar
ADECUACION									
Terrazas, guachos									
Barrera enumere y marque X	Telembí								
	King-grass								
	Elefante								
	Vetiver								
	Citronella, Limoncillo								
	Caña								
	Piña								
	Maní								
	Otro, cual ___								
MANEJO DE AGUA									
Desagües, canales, zanjas, acequias									
Trinchos									
Aislamientos									
Cuidado de quebradas, nacimientos, acequias									
Pozos									
ABONOS									
Fosa de basura									
Modulo de lombrices o de compost									
OTROS									
Reforestación									
Otro, cual ________									

---> AHORA DESPLACESE A LA CASA DEL AGRICULTOR <--

6d. Conservación: actitudes hacia el recurso, y períodos de planeación *Enumere si no responde*

	Si/ No	En caso que si, cuales ? *(marque con X las obras que nombre)*							
		obras en la casa	establo, galpons, cocheras	bodega	Beneficiador Molienda Heldas, etc	pozos, barreras, modulo lombriz, fosa basura, etc	adecuar tierra, lotes	compra de tierra	otra, cual?
Ha invertido/realizado cualquier tipo de obra en la finca en últimos 5 años?									
Piensa invertir o modificar algo de la finca en los próximos 5 años?									
Qué es lo mas urgente que necesita la finca para mejorar?									

6d. Conservación: actitudes y planeación (continuación)

		Marque X
Que le gustaría hicieran sus hijos cuando adultos ? *(si son adultos, preguntar que hace la mayoría)* *NO enumere y marque una X*	Trabajar la tierra	
	Estudiar, ser professional	
	Ir a la ciudad	
	Lo que quieran	
	Otro:__________	
Vendería usted su finca ? *Marque una X*	Si	
	No	
	Tal vez	
Si respondió si o tal vez: Qué necesita una finca, para que se venda bien: *NO enumere y marque 1 a la primera razón y 2 a la segunda.*	Cercanía a la carretera o al pueblo	
	Buenos lotes de cultivo	
	Presencia de agua	
	Fertilidad del suelo	
	Buena casa	
	Otra, cual: ____________	

7. Orientación hacia la agricultura *NO enumere las opciones*

Usted porque trabaja en la agricultura ?	*Marque con X solo una opción*
Lo heredo de sus padres	
Le gusta trabajar la tierra	
Le gusta tener su independencia y ser su propio jefe	
Porque es rentable y le da lo que necesita para vivir	
Mejor aquí a que si tuviera un empleo con la mismas ganancias	
Porque no ha podido vender la finca	
No hay oportunidades, en la ciudad hay mucho desempleo	
Es lo único que sabe	
Otra:____________________	

8. **Cosecha:** En la última cosecha, qué producción obtuvo en estos cultivos y qué destino les dio ?

		Unidades que utiliza *(marque X)*				Producción obtenida	Que cantidad destinó a:		
		@	cargas	cargas (choclos)	racimos		Consumo	Semilla	Venta
LOTE 1	Café								
	Yuca								
	Frijol								
	Maíz								
	Plátano								
LOTE 2	Café								
	Yuca								
	Frijol								
	Maíz								
	Plátano								

9a. **Comercialización con instituciones:** Que cantidad de su producción venderá o vendió a ?

		CUANTO destinará o destinó a *(unidades como en el cuadro anterior)*								
		Mayorista (tienda, depósito, granero)	Intermediario [A] Plaza mercado	Rallandero	Coop	Coop. de cafeteros	Idema	Otro comerciante	Puesto en *(marque x)*	
									finca	pueblo[B]
LOTE 1	Café									
	Yuca									
	Frijol									
	Maíz									
	Plátano									
LOTE 2	Café									
	Yuca									
	Frijol									
	Maíz									
	Plátano									

A: agentes que toman el producto del agricultor al mayorista.
B: 1=Santander, 2=Piendamó, 3=Mondomo, 4=Siberia, 5=Popayán, 6=Pescador, 7=otro ____________

9b. **Comercialización: Continuidad de la relación contractual**

Cambió alguna vez de entidad o comprador en el momento de vender su producto principal ?	Si		Cuál entidad dejó ?		No
Si es así, porque prefirió vender a otro comprador? *(marque con X **hasta dos** opciones)*	Trámites rápidos (atención, pago)	Mejor precio	Menos exigencia en calidad	Otro, cual ?	

10a. Mercado: Distancias En el cultivo principal:

		Lote 1	Lote 2
Cual es la distancia de cada lote a la carretera (mts) ? A			
Que medio de transporte utiliza del lote a la carretera ? *(marque X)*	Animal		
	Vehicular		
	Humano		
Cual es la distancia que recorre el producto principal de cada lote a su lugar de mercado (km) ? B			
Qué medio de transporte utiliza de la carretera al mercado ? *(marque con X una sola opción)*	Animal		
	Vehicular		
	Humano		
Cuanto paga por transportar un bulto de la finca al mercado ? *($/bulto)*			

A: se considera carretera una vía transitada por vehículos tales como jeep, bus o camión

B: El lugar de mercado puede ser diferente para cada producto

10b. Mercado: Información sobre precios *NO enumere las opciones y marque una sola X*

	Cómo se entera usted del precio a que están pagando cada producto ?								
	Radio	TV	Teléfono	Periódico	Otro Agricultor	Mercado local	Rallandero	Cooperativa	Extensionista
Café									
Yuca									
Frijol									
Maíz									
Plátano									

10c. Mercado: grado de orientación a la comercialización

		Marque X			
Cuando va a vender cualquiera de sus productos, usted normalmente:		Si	No	A veces	Por qué no/a veces?
Lleva cuentas de costos e ingresos de algún cultivo ? Cual?					
Quien fija el precio de venta ?	Usted				
	El comprador				
	Los dos				
Le gusta vender el lote "en mata" (que cultivos) ?					
Trata de cultivar lo que produce de acuerdo a los gustos de quien le compra ?					
Trata de mejorar la forma de producción buscando asistencia de técnicos, asesores u otros agricultores ?					
Ensaya otros cultivos si se da cuenta que los están pagando mejor ?					
Explique que cosas son importantes en un producto para poder vender a buen precio ?					

10d. Mercado: disposición o temor al riesgo

		Marque con X una sola opción por pregunta
Cuando ve en su región un nuevo cultivo, una nueva variedad o una nueva práctica, usted *enumere las opciones*	No ensaya lo que no conoce	
	Espera a que los demás la ensayen	
	Ensaya un poquito	
	otro, cual________________	
Que le parece a usted trabajar con crédito ? *NO enumere las opciones*	Riesgoso e innecesario	
	Riesgoso pero necesario	
	Innecesario	
	Necesario pero la tramitología no deja conseguirlo	
	otro, cual________________	
Después de asistir a giras o visitar ensayos en otras fincas, usted *enumere las opciones*	NO ensaya ninguna practica en su finca	
	Ensayó algunas prácticas pero YA NO las tiene	
	Ensayó algunas prácticas y aún las tiene	
	No ha ido a giras ni a ensayos	
	Otro, cual ________________	
Alguna vez sembró un cultivo a bajo precio con la esperanza de que cuando cosechara el precio mejoraría ?		si [ ] no [ ]

10e. Auto-evaluación de acceso al mercado. Díganos si conseguir los siguientes servicios es Fácil (F), Regular (R) o Difícil (D)

		Procesam/. o beneficio	Insumos	Almacenam/.	Información Precios	Transporte	Compradores	Crédito	Extensión asist. tec.
Es Fácil, o Difícil conseguir... ? *Marque F, R, o D*	Café								
	Yuca								
	Frijol								
	Maíz								
	Plátano								
De las DIFICIL cuál es la **más difícil** de conseguir ? Explique breve	Café								
	Yuca								
	Frijol								
	Maíz								
	Plátano								

11a. Instituciones: Servicios. Indique donde compra o de quien recibe los siguientes servicios [A]

	Semilla	Fertilizante	Plaguicidas	Crédito	Asistenc. Técnica	Capacitación, cursos	Otro
Café							
Yuca							
Frijol							
Maíz							
Plátano							

A: 1=Recursos propios, 2=Caja Agraria, 3=intermediario, 4=banco, 5=cooperativa, 6=Comite de cafeteros, 7=Idema, 8=otro agricultor, 9=en compañía, 10=casa agrícola, 11=ICA, 12=CVC, 13=SENA, 14=CETEC, 15=FUNDAEC, 16=FIDAR, 17=UMATA, 18= CORPOTUNIA, 19=otro

11b. Instituciones: Afiliación *Enumere una por una.*

	Tiene vínculos o ha vendido a alguna de estas entidades ?		Cuanto tiempo estuvo o ha estado vinculado	Aún esta vinculado ?	Le han enseñado practicas para el manejo de suelo?		Qué practicas le han enseñado? [A]
	Si	No			Si	No	
ECONORCA							
COAPRACAUCA							
CORPOTUNIA							
COAPRAYUCAL							
Cooperativa de Cafeteros							
COOMERCAP							
COMITE de Cafeteros							
IDEMA							
CIPASLA (comité de beneficiarios)							
DRI/UNDECO							
CIAL							
CIAT							
FIDAR							
CVC							
FUNDAEC							
CETEC							
UMATA							
ICA							
SENA							
Otra, cual_____							

A: 1=terrazas, guachos, 2=barreras (bordes, piedras, vivas, etc), 3=cobertura, franjas de pastos, 4=desagües, canales, zanjas, acequias, 5=trinchos, 6=cero labranza: cajuela, holladura, pica barretón, 7=corta rastrojo e incorpora al suelo, 8=siembra atravesado, 9=siembra en chorrillo, 10=abona con residuos, basura, maleza muerta, 11=abono boñiga, 12=gallinaza, 13=compost, lombricompuesto, 14=aplica Cal, 15=deshierba con machete, 16=control biológico, 17=siembra árboles, reforestación, 18=otro____________

11c. Instituciones: Que créditos ha recibido que aún estén pendiente por pago o recién haya pagado ?

Quién le dio el crédito ? [B]	Para qué Cultivo [A]	Tipo de crédito *(marque X)*					Período *(indique fechas)*	
		efectivo	efectivo sobre la cosecha	insumos (semilla, abonos, costales)	hipoteca	otro	Desde	Hasta

A: 1=café, 2=yuca, 3=frijol, 4=maíz, 5=caña, 6=plátano, 7=verduras, 8=arveja, 9=habichuela, 10=papa, 11=zapallo, 12=frutales, 13=tomate, 14=soya, 15=piña, 16=pastos, 17=arroz, 18=Cabuya/fique, 19=descanso, 20=NINGUN cultivo en particular.

B: 1=Recursos propios, 2=Caja Agraria, 3=intermediario, 4=banco, 5=cooperativa, 6=Comite de cafeteros, 7=Idema, 8=otro agricultor, 9=en compañía, 10=casa agrícola, 11=ICA, 12=CVC, 13=SENA, 14=CETEC, 15=FUNDAEC, 16=FIDAR, 17=UMATA, 18= CORPOTUNIA, 19=otro ____________.

11d. Instituciones: Deudas

	Si	No	De que tipo ?					
			Enseres	Ropa	Alimento	Intermediario	Otro agricultor	Otro, cual ?
Tiene ahora otras deudas ?								

11e. Instituciones: Pago de deudas

	Si	No	Estuvo atrasado pero ahora refinanció
Está o recientemente estuvo atrasado en las cuotas del crédito o de las otras deudas ?			

11f. Instituciones: Subsidios, Indemnizaciones

Ha recibido pagos para cambio o manejo de sus cultivos ?		Para qué cultivo y qué área fue aplicado este subsidio ? [A]		Para que actividades [C]	En que lo recibió (Marque X)	
Si	No	Cultivo	Plazas [B]		En dinero	Productos [D]

A: 1=café, 2=yuca, 3=frijol, 4=maíz, 5=caña, 6=plátano, 7=verduras, 8=arveja, 9=habichuela, 10=papa, 11=zapallo, 12=frutales, 13=tomate, 14=soya, 15=piña, 16=pastos, 17=arroz, 18=Cabuya/fique, 19=lote de descanso

B: si no recuerda el dato en plazas, preguntar a que numero de plantas se le aplico y la distancia entre plantas.

C: 1=zoqueo, 2=renovación, 3=cambio cultivo, 4=roya, 5=broca, 6=descanso de lote, 7=otro

D: 1=oxicloruro, 2=hongos, 3=insectos benéficos, 4=otro, cual________

Appendix C Appendix to Chapter 9. The COOPERA household model

Land use types

Altogether, mono-cropping, intercropping, sharecropping and fallow activities, the farmer can select 33 different LUTs in the COOPERA model. Blackberry, a potential activity cropped in few areas of the Cabuyal region, is available in the market opportunity (MO) scenario (Chapter 10).

Land Use Types (variable X_{yls})

Monocropping	14 Maize 5 months March	24 Cassava-Beans March
2 Cassava 16 months Jan.	15 Maize 5 months Sept.	25 Cassava-Beans Sept.
3 Cassava 16 months May	16 Maize 12 months	26 Bean-Maize Sept.
4 Cassava 16 months Aug.	17 Tomato January[1]	
5 Cassava 20 months Jan.	18 Tomato August[1]	*Sharecropping*[3]
6 Cassava 20 months May	19 Tomato May[1]	27 Cassava 16m. January
7 Cassava 20 months Aug.	20 Fallow (scrub pasture)	28 Cassava 20m. January
8 Climbing beans March	21 MO blackberry[2]	29 Cassava-Bean-Maize Sept.
9 Climbing beans Sept.		30 Cassava-Bean March
10 Bush beans low input March	*Intercropping*	31 Cassava-Bean Sept.
11 Bush beans low input Sept.	1 Coffee-Plantain	32 Tomato January
12 Bush beans high input March[1]	22 Cassava-Bean-Maize Sept.	33 Tomato August
13 Bush beans high input Sept.[1]	23 Cassava-Maize Sept.	34 Tomato May

1= This crop can also be commercialised in VMS channels in the VMS market scenario;
2= MO blackberry is only available in the MO market scenario;
3= sharecropping involves sharing crop production costs and yields with another farmer or a trader.

Description of the LUTs (variable X_{yls})

	Soil type (index s)	Planting months	No. months[1]	Erosion[2] ton.plaza^{-1} (coeff. s_x)
Coffee-Plantain	Rich	Perennial	Perennial	0.0
Cassava 16/20 months	Poor, eroded	Jan, May, Aug	17/21	40.8/50.4
Bean (climbing)	Rich, poor	Mar, Sep	5	6.7
Bean low input (bush)	Rich, poor	Mar, Sep	4.5	13.2
Bean high input (bush)/VMS beans	Rich, poor	Mar, Sep	4.5	10.8
Maize 5 months	Rich, poor	Mar, Sep	5.5	10.3
Maize 12 months	Rich	Sep	12	16.0
Tomatoes/VMS tomatoes	Rich, poor	Jan, May, Aug	5	6.7
Fallow/pastures	All	Perennial	Perennial	0.3
Cassava-Bean-Maize	Rich, poor	Sep	17	22.7
Cassava-Maize	Rich, poor	Sep	17	31.7
Cassava-Bean	Rich, poor	Mar, Sep	17	40.8
Bean-Maize	Rich, poor	Sep	5.5	8.4
MO Blackberry	Rich, poor	Perennial	Perennial	4.8

1: includes soil preparation & harvest; 2: Soil loss during vegetative period.Source: Howler, 1990; Amézquita, 1996.

Labour use per LUT per month throughout a two-year period (coefficient e_{yml})

LUT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	9.3	9.3	9.3	11.6	10.6	2.5	7.5	10.2	13.4	5.5	1.3	5.9	16	16	16	4	2	2	12	9.8	29.5	5.5	2	5.3
2	0	0	12.0	0	0	0	0	0	0	9	8	25	0	0	30	0	0	0	10	0	0	30	0	0
3	0	9	8	15	0	0	12	0	0	0	0	0	0	0	0	0	0	0	10	0	0	30	0	0
4	0	0	0	0	9	8	15	0	0	12	0	0	0	0	10	0	30	0	0	0	0	0	0	0
5	0	15	0	0	0	0	12	0	0	3	18	0	0	0	10	0	0	0	10	0	30	0	0	0
6	0	3	8	0	0	15	0	0	0	0	12	0	0	0	10	0	0	0	10	0	30	0	0	0
7	0	0	0	0	3	8	0	0	15	0	0	0	0	12	0	0	0	10	0	0	0	10	0	30
8	8.4	37.8	2.8	2.8	1.4	13.5	7.0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	3	8.4	37.8	2.8	2.8	1.4	13.5	7	0	0	0	0	0	0	0	0	0	0	0
10	8.3	16.3	1.3	1.3	12.3	5.8	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	3	8.3	16.3	1.3	1.3	12.3	5.8	0	0	0	0	0	0	0	0	0	0	0	0
12	10	17.5	2.5	2.5	14.8	7	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	3	10.1	17.5	2.5	2.5	14.8	7	0	0	0	0	0	0	0	0	0	0	0	0
14	3	20	1	1	0	18.6	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	4	3	20	1	1	0	18.6	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	4	1	20	0	0	0	0	0	1	0	0	18.6	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	38	92.3	74.2	113	71.2	84.2	124	53	0	0	0	0	0	0	0	0
18	0	0	0	38	92.3	74.2	113	71.2	84.2	124	53	0	0	0	0	0	0	0	0	0	0	0	0	0
19	38	92.3	74.2	113	71.2	84.2	124	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
21	29	11.7	21.7	12.7	7.8	17.8	7.8	15.1	21.6	11.6	11.6	22.6	27	27	37	28	17.8	27.8	17.8	18.8	27.8	17.8	17.8	29
22	0	0	0	0	0	3	18	17.5	2.5	1	24.3	13.2	0	0	0	0	0	0	0	10	0	0	30	0
23	0	0	0	0	0	9	9	15	0	1	12	7.4	0	0	0	0	0	0	0	10	0	0	30	0
24	17	17.5	2.5	0	24.3	5.8	0	0	0	0	0	3	0	10	0	0	30	0	0	0	0	0	0	0
25	0	0	0	0	0	3	17	17.5	2.5	0	24.3	5.8	0	0	0	0	0	0	0	10	0	0	30	0
26	0	0	0	0	0	3	8	17.5	2.5	1	12.3	13.2	0	0	0	0	0	0	0	0	0	0	0	0
27	0	0	6	0	0	0	0	0	0	4.5	4	12.5	0	0	15	0	0	0	0	0	0	0	0	0
28	0	7.5	0	0	0	0	6	0	0	1.5	9	0	0	0	5	0	15	0	0	0	0	0	0	0
29	0	0	0	0	0	3	0	0	0	0.5	6.2	6.6	0	0	0	0	0	0	0	0	0	0	15	0
30	0	0	0	0	6.2	2.9	0	0	0	0	0	3	0	0	0	0	15	0	0	0	0	0	0	0
31	0	0	0	0	0	3	0	0	0	0	6.2	2.9	0	0	0	0	0	0	0	0	0	0	15	0
32	0	0	0	0	0	0	0	0	19	46.1	37.1	56.6	35.6	42.1	62.1	26.5	0	0	0	0	0	0	0	0
33	0	0	0	19	46.1	37.1	56.6	35.6	42.1	62.1	26.5	0	0	0	0	0	0	0	0	0	0	0	0	0
34	19	46.1	37.1	56.6	35.6	42.1	62.1	26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1: LUT codes are as in Appendix C; 2: months 1 to 24 correspond to months March to February in the first and second year

Input costs

The table below illustrates amount of input costs (other than labour) undergone by each activity through the four-period plan. Input costs comprise expenditures in seed, fertilisers, pesticides, packing sacks, fuel, and other items.

Input expenditures per period (coefficient c_{ytl})[1]

	Year 1		Year 2	
LUT[2]	Period 1 March-August	Period 2 Sept-February	Period 1 March-August	Period 2 Sept-February
1	168,324	139,388	139,388	139,388
2, 3, 4	275,000	0	0	0
5, 6, 7	155,000	0	0	0
8	918,594	0	0	0
9	0	918,594	0	0
10	337,115	0	0	0
11	0	337,115	0	0
12[3]	399,730	0	0	0
13[3]	0	399,730	0	0
14	240,000	0	0	0
15	0	240,000	0	0
16	0	15,000	0	0
17[3]	0	1,885,400	2,074,600	0
18[3]	1,027,350	2,932,650	0	0
19[3]	3,960,000	0	0	0
20	0	0	0	0
21	710,264	710,263	482,643	482,643
22	0	377,751	0	0
23	0	278,500	0	0
24	374,251	0	0	0
25	0	374,251	0	0
26	0	357,751	0	0
27	0	0	0	0
28	0	0	0	0
29	0	135,000	0	0
30	135,000	0	0	0
31	0	135,000	0	0
32	0	796,450	1,037,300	0
33	367,425	1,466,325	0	0
34	1,833,730	0	0	0

1= values in 1995 Col. pesos, US $1=Col.$ 950; 2= LUT codes are as in Appendix C; 3=input expenditures for VMS beans and VMS tomatoes are 5% lower.

Gross margins and product yields

The table below shows the margins and yields of the products commercialised in Cabuyal. Prices correspond to market prices previous to and prevalent at the time of this study.

Yields and gross margins (coefficients y_{ytjls} and $p_{j,u=1,t}$)

		Gross Margin Col $.kg^{-1}			
		Year 1		Year 2	
	Yield kg.plaza^{-1}	Per. 1	Per. 2	Per. 1	Per. 2
Coffee	507.85[3] 171.9[4]	1,600.0	1,600.0	1,600.0	1,584.0
Plantain[1]	323.3	2,000.0	2,000.0	1,980.0	1,980.0
Cassava 16 months	9,000	166.7	166.7	166.7	166.7
Cassava 20 months	7,050	180.0	180.0	180.0	180.0
Beans (climbing)	1,215	1,056.0	1,056.0	1,056.0	1,045.4
Beans low input (bush)	812.5	960.0	960.0	960.0	950.4
Beans high input (bush)	962.5	960.0	960.0	960.0	950.4
Beans (intercropped with cassava)	812.5	960.0	960.0	960.0	950.4
Maize 5 months	1,312.5	200.0	200.0	200.0	198.0
Maize 12 months	960.0	200.0	200.0	200.0	198.0
Maize (intercropped with cassava)	437.5	200.0	200.0	200.0	198.0
Tomatoes	43,500	206.9	206.9	206.9	204.8
Pasture	7,300.0	4.2	4.2	4.2	4.2
Blackberry[2]	3,125.0[5] 5,250.0[6] 4,200.0[7]	744.5	744.5	757.9	757.9
VMS beans[2]	962.5	960.0	960.0	1,089.1	1,089.1
VMS tomatoes[2]	43,500	206.9	206.9	221.1	221.1

Values in 1995 Col. pesos, US $1=Col.$ 950; 1=in bunches;
2= Prices for blackberry, VMS beans and VMS tomatoes are averages of market prices for each semester over five years. Prices are fixed through each year reflecting the buyers' guaranteed price in VMS channels;. 3=For period 1 of the first and second year, and period 2 of the first year; 4=For period 2 of the second year; 5=For period 1 of the first year; 6=For period 1 of the second year; 7=For period 2 of the first/second year;

Farm consumption requirements

The farm has to meet a certain minimum consumption requirement. In the Cabuyal region, farm gate prices are lower than market purchase prices for all of the considered products. The minimum consumption requirement per period per product is shown below.

Minimum consumption and prices for consumption products (coefficients m_{ytj} and $p_{j,u=2}$)

	Units	Farm type 1	Farm type 2	Farm type 3	Market price[3] in Col.$.kg^{-1}
Coffee	kg	37.4	44.7	31.9	4,400
Plantain	bunches	29.9	31.9	25.6	2,000
Cassava	kg	149.7	127.8	127.8	250/275 [4]
Beans	kg	37.4	38.3	44.7	1,200/1,320 [5]
Maize	kg	97.3	63.9	63.9	300
Panela[1]	units	104.8	102.2	102.2	600
Milk	lt	32.1	27.4	27.4	320
Meat	kg	10.7	11.9	9.1	1,500
Rice	kg	74.8	63.9	63.9	630
Other[2]	Col. pesos	485,000	620,000	355,745	-

1: sugarcane product;
2: household expenditures such as education, health, clothing, transport, furniture and taxes;
3: values in 1995 (Col. pesos, US $1=Col.$ 950);
4: prices for bush beans and climbing beans, respectively;
5: prices for 16-month and 20-month cassava, respectively.
Source: Farmer consumption pattern appraisal; Living costs appraisal.

Appendix D Appendix to Chapter 10. The COOPERA model, analytical procedure

Economics of the market scenarios

The table below presents an overview of the economic feasibility of the LUTs involved in the CMC, VMS and MO scenarios. The table describes the LUTs in terms of cost requirements, profit and economic return coefficients.

Economics of VMS beans, MO blackberry and CMC 'other' crops

LUT	Total Costs (TC)	Gross Income (GI)	Profit (P=GI-TC)	Input/Cost ratio	Labour/Cost ratio	Return of Investment[1]
CMC crops[2]	1,715,745	2,509,217	793,471	47	36	46
VMS beans	605,369	924,000	318,632	63	30	53
VMS tomatoes	6,254,114	9,205,298	2,951,184	60	32	47
Blackberry	4,546,362	12,616,001	8,069,639	52	34	177

Values in 1995 Col. $ per plaza, US $1=Col.$ 950;
1=Return Of Investments (ROI) is defined as P/TC; 2: calculated as the average of other LUTs excluding fallow and cassava sharecrops.

Blackberry: a market opportunity

The search for market opportunities in the Cabuyal micro-watershed was carried out by a parallel CIAT study (Ostertag et al., 1996). The search focused on products with market demand in which the study region exhibited comparative advantages, taking into consideration factors such as proximity to markets, natural resources, and labour availability. Several products were selected as market opportunities on the basis of the following criteria: (1) feasibility in the context of farmers in the study area; (2) the potential for incorporating the product in soil conservation technologies; (3) market conditions for the product. Market agents of Cali, the closest big market, were surveyed between the end-1995 and beginning-1996 and asked to distinguish products exhibiting high-demand potential, deficient supply, as well as price, quality and presentation requirements.

A sub-set of best options was tentatively identified, with farmers and soil and social scientists participating in the selection process (Castaño et. al, 1995). Options included, among others, blackberry, strawberry, local fruits such as lulo and uchuva, and lettuce. No field trials had been carried out at the time of this report and appropriated conservation practices were still under study. Blackberry was selected as having one of the best potential for market opportunity to be evaluated in the COOPERA model's MO scenario. Furthermore, blackberry counted on technical coefficients as it was already being cropped in the region, although on a very low scale. The table below presents some agronomic, market, economic and physical characteristics of blackberry.

Main characteristics of blackberry

	Characteristics	Level
Agronomics	Total cycle (years)	5
	Pre-production cycle (months)	12
	No. harvests per year	Permanent
	Soil type	Loam
	PH	5.3-6.2
	Irrigation	No required
	Altitude (m)	1,400-2,500
Market	Currently marketed	Yes
	Interested market agents	Supermarkets, Food Industry
	Technical assistance	Provided
	Market growth	Medium to High
	Quality requirement	Medium to High
	Packing	Trays/baskets
	Volume required (ton semester^{-1})	
	Food industry	>780 steady[1]
	Supermarkets	>96 steady
Economics	Initial investment	High
	Labour cost-output price ratio	High
	Capital-output price ratio	Medium
	Technological complexity	Medium
	Perishability	High
	Transport cost per kg	Average
	Profitability	High
Physical	Erosion	Very low
	Functions	cover crop, flexible as strip-crop

1= 780 plus 96 ton would be equivalent to the full production of 40% of the farms in the high agro-ecological zone in one semester. Source: Ostertag, 1996; Castaño et al., 1996; Muller, 1996 (pers. comm.)

Land use in the CMC and VMS market scenarios, IM case (and % change)

	CMC (plazas)	VMS (plazas)	VMS wrt CMC (%)
RICH SOIL			
Coffee-plantain	8.80	8.80	(0)
Blackberry			
POOR SOIL			
Cassava-beans-maize	0.21		(-100)
Cassava-beans	3.51		(-100)
Beans-maize	3.21		(-100)
Beans	0.08	0.17	(116)
VMS beans		4.25	New
VMS tomatoes		2.54	New
Blackberry			
Fallow/Pastures	5.87	5.92	(1)
ERODED SOIL			
Cassava	0.12		(-100)
Fallow/Pastures	0.35	0.48	(36)
TOTAL LAND			
Fallow/Pastures	6.22	6.40	(3)
Cropland	15.94	15.76	(-1)

'wrt' denotes changes in percentage with respect to the CMC scenario (shown in brackets); 1 plaza=0.64 ha

Cash flow and discretionary income in the CMC and VMS market scenarios, IM case (1000 Col.$)

	CMC	VMS	VMS wrt CMC (%)
Off-farm income	270.5	123.6	(-54)
Bank credit	0.0	930.4	New
VMS credit	0.0	5,430.7	New
Informal credit	68.1	948.9	(1,293)
Own capital	4,248.6	7,692.5	(81)
Total Capital	**4,587.3**	**15,126.0**	**(230)**
Input costs	2,942.6	11,095.0	(277)
Labour cost	18.6	1,885.0	(10,032)
Transaction costs per unit (as % of average price)	10	8.8	(-12)
Total costs	**4,316.7**	**15,002.4**	**(248)**
Capital costs	13.6	981.0	(7,100)
Own labour costs	1,658.1	2,785.2	(68)
Production	14,342.3	33,203.9	(132)
Consumption	686.0	630.4	(-8)
Bought Consumption	2,616.8	2,757.5	(5)
Discretionary income	**3,700.3**	**7,511.0**	**(103)**

DI= Production + Off-farm income - (Total costs + Other costs + Consumption), discounted at the annual rate of 21%; Values in 1995 Col. $; US $1=Col.$950.

Land use in the CMC and VMS scenarios, SC case (and % change)

	CMC (plazas)	CMC wrt IM (%)	VMS (plazas)	VMS wrt CMC (%)	VMS wrt IM (%)
RICH SOIL					
Coffee-plantain	8.80	(0)	8.80	(0)	(0)
Blackberry					
POOR SOIL					
Cass.-beans-maize		(-100)			
Cassava-beans	2.06	(-41)		(-100)	
Beans-maize	1.21	(-62)		(-100)	
Beans	0.04	(-51)	0.03	(-21)	(-82)
VMS beans			1.71	New	(-60)
VMS tomatoes			2.00	New	(-21)
Blackberry					
Fallow/Pastures	9.58	(63)	9.14	(-5)	(54)
ERODED SOIL					
Cassava		(-100)			
Fallow/Pastures	0.48	(37)	0.48	(0)	(0)
TOTAL LAND					
Fallow/Pastures	10.06	(62)	9.62	(-4)	(50)
Cropland	12.10	(-24)	12.54	(4)	(-20)

'wrt' denotes changes in percentage with respect to CMC scenario (shown in brackets); 1 plaza=0.64 ha

Cash flow and discretionary income in the CMC and VMS market scenarios, SC case (1000 Col.$)

	CMC	VMS	VMS wrt CMC (%)
Off-farm income	282.0	123.8	(-56)
Bank credit	-	930.4	New
VMS credit	-	2,967.8	New
Informal credit	-	599.8	New
Own capital	3,044.9	6,388.9	(110)
Total Capital	**3,327.0**	**11,010.6**	**(231)**
Input costs	1,994.2	8,307.6	(317)
Labour cost	6.1	915.8	(14,856)
Transaction costs per unit (as % of average price)	10	8.8	(-12)
Total costs	**3,044.9**	**10,886.9**	**(258)**
Capital costs	-	615.7	New
Own labour costs	1,318.4	2,656.2	(101)
Production	11,305.6	26,227.3	(132)
Consumption	659.1	628.8	(-5)
Bought Consumption	2,699.2	2,757.5	(2)
Discretionary income	**2,730.0**	**5,874.0**	**(115)**

DI= Production + Off-farm income - (Total costs + Other costs + Consumption), discounted at the annual rate of 21%; Values in 1995 Col. $; US $1=Col.$950.

Land use in the MO market scenario, IM case (and % change)

	MO (plazas)	MO wrt CMC (%)	MO wrt VMS (%)
RICH SOIL			
Coffee-plantain	1.67	(-81)	(-81)
Blackberry	7.13	New	New
POOR SOIL			
Cassava-beans-maize		(-100)	
Cassava-beans		(-100)	
Beans-maize		(-100)	
Beans		(-100)	(-100)
VMS beans			(-100)
VMS tomatoes			(-100)
Blackberry	12.88	New	New
Fallow/Pastures		(-100)	(-100)
ERODED SOIL			
Cassava		(-100)	
Fallow/Pastures	0.48	(36)	(0)
TOTAL LAND			
Fallow/Pastures	0.48	(-92)	(-92)
Cropland	21.68	(36)	(38)

'wrt' denotes changes in percentage with respect to CMC and VMS scenarios (shown in brackets); 1 plaza=0.64 ha

Cash flow and discretionary income in the MO market scenario, IM case (1000 Col.$)

	MO	MO wrt CMC (%)	MO wrt VMS (%)
Off-farm income	293.5	(8)	(137)
Bank credit	0.0	New	(-100)
VMS credit	16,007.0	New	(195)
Informal credit	0.0	(-100)	(-100)
Own capital	2,446.3	(-42)	(-68)
Total Capital	**18,746.8**	**(309)**	**(24)**
Input costs	12,179.3	(314)	(10)
Labour cost	3,007.5	(16,066)	(60)
Transaction costs per unit (as % of average price)	5.1	(-49)	(-42)
Total costs	**18,453.3**	**(327)**	**(23)**
Capital costs	1,920.8	(13,998)	(96)
Own labour costs	2,775.1	(67)	(0)
Production	64,705.9	(351)	(95)
Consumption	476.7	(-31)	(-24)
Bought Consumption	2,937.5	(12)	(7)
Discretionary income	**29,500.0**	**(697)**	**(293)**

DI= Production + Off-farm income - (Total costs + Other costs + Consumption), discounted at the annual rate of 21%; Values in 1995 Col. $; US $1=Col.$950.

Land use in the MO market scenario, SC case (and % change)

	MO (plazas)	MO wrt CMC (%)	MO wrt VMS (%)	MO wrt IM (%)
RICH SOIL				
Coffee-plantain	8.80	(0)	(0)	(427)
Blackberry				(-100)
POOR SOIL				
Cass.-beans-maize	0.01	New	New	New
Cassava-beans		(-100)		
Beans-maize		(-100)		
Beans		(-100)	(-100)	
VMS beans			(-100)	
VMS tomatoes			(-100)	
Blackberry	10.75	New	New	(-17)
Fallow/Pastures	2.12	(-78)	(-77)	New
ERODED SOIL				
Cassava				
Fallow/Pastures	0.48	(0)	(0)	(0)
TOTAL LAND				
Fallow/Pastures	2.60	(-74)	(-73)	(441)
Cropland	19.56	(62)	(56)	(-10)

'wrt' denotes changes in percentage with respect to CMC and VMS scenarios (shown in brackets); 1 plaza=0.64 ha

Cash flow and discretionary income in the MO market scenario, SC case (1000 Col.$)

	MO	MO wrt CMC (%)	MO wrt VMS (%)
Off-farm income	111.0	(-61)	(-10)
Bank credit	277.4	New	(-70)
VMS credit	8,600.6	New	(190)
Informal credit	-	New	(-100)
Own capital	2,330.5	(-23)	(-64)
Total Capital	**11,319.5**	**(240)**	**(3)**
Input costs	7,704.2	(286)	(-7)
Labour cost	1,061.7	(17,239)	(16)
Transaction costs per unit (as % of average price)	5.9	(-41)	(-33)
Total costs	**11,208.5**	**(268)**	**(3)**
Capital costs	1,073.7	New	(74)
Own labour costs	2,833.9	(115)	(7)
Production	41,558.8	(268)	(58)
Consumption	179.6	(-73)	(-71)
Bought Consumption	3,629.3	(34)	(32)
Discretionary income	**17,500.0**	**(541)**	**(198)**

DI= Production + Off-farm income - (Total costs + Other costs + Consumption), discounted at the annual rate of 21%; Values in 1995 Col. $; US $1=Col.$950.

Summary

A better understanding of the way in which alternative marketing systems can contribute to promoting the adoption of soil sustainability on small-farm production systems constitutes the aim of this study (Chapter 1). The study centred on finding answers to the following research questions. To what extent are alternative marketing channels or arrangements better equipped to contribute to the adoption of sustainable farm production systems? What is the added contribution of other factors, such as physical, institutional, economic and personal factors, to affect farmer's decision to use sustainable production systems? What is the impact of greater levels of sustainable production systems on farm income? The research aim arose from the need to evaluate the merit of marketing strategies to provide incentives for sustainable agriculture in developing countries, as public interventions to promote sustainable adoption have often been less than successful. In particular, the research examined changes in the marketing channels that would stimulate resource users towards sustainable soil management.

The problem addressed in the study was to evaluate the implications of marketing, in particular marketing channels and marketing systems, to the sustainability problems of small farm systems in the tropical hillside areas. The research was focused on marketing channels because of their influence on farm household decisions, production systems and farm sustainability. Conventional marketing channels (CMC) and vertical marketing systems (VMS) were identified as the structures that emerge as a result of the coordination (or not) of the exchange, physical and facilitating marketing channel functions (Chapter 2). A description of the marketing channels for small-farm products in the developing world led to the recognition that these channels are predominantly 'conventional' and leave room for improvement.

A review of the main aspects of global sustainability found that soil degradation is possibly the most serious environmental problem in the third world (Chapter 3). It was argued that as opposed to off-site environmental problems, on-farm environmental problems were more apparent to farmers due to their economic impacts (e.g. from declining yields), suggesting a role for marketing mechanisms to help avert such degradation. The study of sustainability was focused on on-site soil degradation at farm level. The study then turned the discussion to review the effect of marketing channels, in particular their structure, on farm soil sustainability in developing countries (Chapter 4). It was argued that coordination of functions in the marketing channel, long-term orientation and the economic appeal of market strategies appear highly relevant to farm sustainability. It was hypothesised that VMS aiming at long-term relationships has a positive effect on farm sustainability as it was argued that farmers participating in VMS likely place a higher value to the long-term benefits of better resource management and soil conservation. A review of a number of successful and unsuccessful cases of adoption of sustainable agricultural practices revealed that effective adoption of sustainable practices by farms in developing countries was attained when marketing strategies of other actors in the marketing channel accompanied the promotion of these practices. The review showed the importance of associating the promotion of sustainable practices with market strategies that bring economic benefits to small-scale farmers and allow offsetting soil conservation costs. These discussions led to the formulation of the following general hypotheses (Chapter 5):

H1: VMS are better equipped than CMC to stimulate farmers to adopt farm soil sustainability

H2: A government policy supportive of marketing and production activities encourages farmers' investment in soil sustainability

H3: Market incentives, promising income enhancement, are likely to stimulate the adoption of farm soil sustainability

A tropical hillside area of 7.4 thousand ha in southwestern Colombia was selected as a case study (Chapter 6). The study area met, not only the typical characteristics of bio-diversity of tropical

hillsides, but also most of their problems such as high population density, lack of physical infrastructure and severe erosion. The Cabuyal watershed is a small-farm peasant community located on the Andean region of Colombia. Resource-poor farms average about 3 ha, altitude ranges 1,200-2,200 m.a.s.l. and coffee-plantain, cassava (for starch production), beans and maize are the major crops. Farm produce is predominantly commercialised in local markets through middlemen while contracts with wholesalers and cooperatives are less frequent. Crops tend to be labour intensive because of the abundance and low cost of this production factor. Crops are rain-fed, while irrigation is uncommon. Soils are predominantly acid of volcanic origin, characterised by poor fertility and slopes of a gradient greater than 12 percent. Soil erosion is the most critical environmental concern.

In order to analyse the relationship between marketing and soil sustainability, a research framework was developed. The framework involved firstly, a method for measuring the adoption of sustainable agricultural practices (ASAP); secondly, an econometric model for testing the influence of marketing and other factors on ASAP; and thirdly a multiple-goal LP model to simulate and evaluate the impact of alternative marketing structures on soil sustainability.

Based on the evidence from literature review, it was noted that ASAP has been commonly measured by approaches either too elementary (e.g., adoption/non-adoption) or too elaborated (e.g. erosion in ton per ha) (Chapter 7). Therefore, a method was developed to measure soil sustainability with the advantages of representing, with fair detail, the degree of ASAP observed by the farmer and being suitable to implement on field-to-field studies. The method guided the elucidation of three basic sustainability dimensions in the Cabuyal watershed, namely 'soil-disturbance control', 'soil protection' and 'run-off control'. The first sustainability dimension referred to farm practices with a mechanical impact on the soil structure in preparation and harvest activities (such as ploughing). The second dimension referred to overall cover of the field ground with mulch, leaves, grass strips and other physical barriers as a protection from erosive tropical rainfalls. The last sustainability dimension was related to physical practices, such as interception drains made at the margins of farm plots, intended to carry the water flow away and control soil surface run-off.

Secondly, the econometric model was an 'integrated' approach with a focal point on the contribution of institutional factors (i.e. marketing and governmental factors). The development and estimation of the model involved the use of a robust estimation technique that enabled the identification of association patterns that otherwise would have remained hidden. The econometric analysis revealed that marketing factors were key contributors to the general protection of the cropland soil in Cabuyal farms (Chapter 8). In particular, marketing factors were the most significant contributors to the adoption of physical barriers, such as live barriers and mulch, addressed to provide cover to the soil from erosive rainfall. This finding is critical to Cabuyal, as rain erosion is one of the leading causes of soil erosion in the watershed.

Thirdly, the multiple-goal LP model (named COOPERA model), in turn, was a classic household model designed to obtain insights into the consequences of marketing interventions (market scenarios) on farm income and soil erosion (Chapter 9). Three market scenarios were defined, namely CMC, VMS and MO scenarios (Chapter 10). CMC portrayed the conventional marketing channel where prices for farm products are primarily determined by demand and supply at spot markets. As such, CMC serves as a baseline scenario for comparison purposes with other scenarios. In the VMS scenario, beans and tomatoes –crops less erosive than cassava- could be alternatively commercialised in VMS channels. VMS was a less imperfect market outlet where the farmer had access to clearer market signals (e.g. known price, traded quantities) and more market services (e.g. credit, inputs). Finally, in the MO scenario a VMS channel is made available to a new crop: blackberry. Blackberry is a promising market opportunity selected to promote soil conservation while providing a source of income. The trade-off of farm income and soil erosion was analysed through two cases: an 'income maximising' farmer (IM) case and a 'soil conservation' farmer (SC) case. The COOPERA model results point towards a better performance of the VMS type of scenarios (VMS and, particularly, MO) than the baseline (CMC) scenario in the Cabuyal watershed in relation to economic and sustainability factors.

The findings of the study show that marketing systems can play a significant role in facilitating and inducing the use of sustainable agricultural technology. It appears that conventional marketing channels are not an appropriate marketing scenario when soil conservation is the objective. Vertical marketing systems are a more pertinent scenario for this aim.

Samenvatting

Marketingsystemen van landbouwproducten in relatie tot duurzame productie. Een studie van de kleinschalige landbouw in de heuvels van de Andes

Het doel van dit onderzoek is het verkrijgen van een beter begrip van de wijze waarop alternatieve marketing systemen kunnen bijdragen aan de bevordering van de adoptie van duurzaam landgebruik in de kleinschalige landbouw (Hoofdstuk 1). In deze studie staat het vinden van antwoorden op de volgende onderzoeksvragen centraal. In welke mate zijn alternatieve marketing kanalen of -arrangementen beter geschikt om bij te dragen tot de adoptie van duurzame landbouwproductie? Wat is de bijdrage van andere factoren om de beslissing van de boer te beïnvloeden om duurzaam te gaan produceren? Voorbeelden betreffen fysieke, institutionele, economische en persoonlijke factoren. Wat is het effect van een grotere duurzaamheid van de productie op het inkomen van de boer? Het doel van het onderzoek vloeit voort uit de behoefte om beter te kunnen beoordelen in hoeverre marketingstrategieën een stimulerende invloed hebben op duurzame landbouw in ontwikkelingslanden. Dit is van belang omdat het ingrijpen van de overheid ter bevordering van de adoptie van een duurzame landbouw vaak niet succesvol is geweest. Het onderzoek besteedt in de bijzonder aandacht aan veranderingen in marketingkanalen die tot duurzaam landgebruik kunnen leiden.

Het vraagstuk waar dit onderzoek zich op richt is het evalueren van de gevolgen van aanpassingen in de marketing, met name bepaalde marketingkanalen en marketing systemen, voor de duurzaamheid van kleinschalige landbouwbedrijven in tropische, heuvelachtige gebieden. Het onderzoek richt zich op marketingkanalen vanwege hun invloed op beslissingen van agrarische huishoudens wat betreft productiemethodes en duurzaamheid. Verticale marketing systemen (VMS) en conventionele marketingkanalen (CMC) werden onderkend als structuren die voortvloeien uit het al of niet coördineren van ruil-, fysieke- en faciliterende marketing functies (Hoofdstuk 2). Een beschrijving van de marketingkanalen voor producten van kleinschalige bedrijven in ontwikkelingslanden leidde tot de conclusie dat deze kanalen overheersend 'conventioneel' zijn en derhalve ruimte laten voor verbetering. Uit een overzicht van de belangrijkste aspecten van duurzaamheid op mondiaal niveau blijkt dat de achteruitgang van de bodem waarschijnlijk het ernstigste milieuprobleem is van de Derde Wereld (Hoofdstuk 3). Er werd gesteld dat milieuproblemen op het bedrijf, in vergelijking met milieuproblemen buiten het bedrijf, door landbouwers van grotere betekenis worden geacht vanwege de directe economische effecten voor hun bedrijf (b.v. verminderde oogst). Dit suggereert dat marketing mechanismen kunnen helpen om verdere achteruitgang van de bodem te voorkomen. Deze studie naar duurzaamheid is dus gericht op bodemerosie op het landbouwbedrijf.

Onze studie richtte zich vervolgens op het effect van marketingkanalen, met name van hun structuur, op duurzaam landgebruik in ontwikkelingslanden (Hoofdstuk 4). Er werd gesteld dat de coördinatie van functies in het marketing kanaal, respectievelijk een lange termijn oriëntatie en de economische aantrekkelijkheid van marktstrategieën, zeer relevant blijken te zijn voor duurzaam landgebruik. Er werd ook verondersteld dat met name een VMS, dat gericht is op lange termijn relaties, een positief effect heeft op duurzaam landgebruik aangezien landbouwers die deelnemen aan een VMS waarschijnlijk meer waarde hechten aan de lange termijn voordelen van een beter beheer van de natuurlijke hulpbronnen en van de handhaving van de kwaliteit van de grond. Een overzicht van een aantal geslaagde en minder geslaagde gevallen van de adoptie van duurzame agrarische praktijken liet zien dat doeltreffende adoptie werd gerealiseerd wanneer de marketing strategieën van de andere spelers in het marketing kanaal het gebruik van duurzame praktijken ondersteunen. Het overzicht onderstreept het belang van het samengaan van duurzame praktijken met marktstrategieën die economische voordelen opleveren voor kleinschalige boeren en die de kosten van instandhouding van de bodemkwaliteit compenseren. Deze discussies leidden tot de

formulering van de volgende algemene hypotheses (Hoofdstuk 5):

H1: Een VMS is beter toegerust dan een CMC om landbouwers te stimuleren tot duurzaam landgebruik.

H2: Een overheidsbeleid dat marketing- en productie-activiteiten van landbouwers ondersteunt, zal investeringen in duurzaam landgebruik aanmoedigen.

H3: Prikkels vanuit de markt die inkomensverbetering in het vooruitzicht stellen, bevorderen de adoptie van duurzaam landgebruik.

Een tropisch en heuvelachtig gebied van 7400 ha. in Zuidwest Colombia werd geselecteerd voor ons onderzoek (Hoofdstuk 6). De karakteristieken van het gebied voldeden niet alleen aan de eigenschappen van biodiversiteit die typisch zijn voor tropische, heuvelachtige streken, maar ook aan andere bekende karakteristieken zoals hoge bevolkingsdichtheid, gebrekkige fysieke infrastructuur en ernstige erosie. Het stroomgebied van Cabuyal betreft een kleinschalige agrarische gemeenschap, gelegen in het Andesgebied van Colombia. De boerenbedrijven met relatief weinig natuurlijke hulpbronnen zijn gemiddeld 3 ha. groot. Zij zijn gelegen op een hoogte van 1200 tot 2200 meter boven de zeespiegel . Koffie, bakbanaan, cassave (voor zetmeel productie), bonen en maïs zijn de belangrijkste gewassen. Agrarische producten worden voornamelijk op locale markten verhandeld en opgekocht door handelaren terwijl contracten met de groothandel en coöperaties minder voorkomen. De gewassen zijn doorgaans arbeidsintensief hetgeen spoort met het grote aanbod van goedkope arbeid. De gewassen worden van water voorzien door middel van regen, irrigatie is niet gebruikelijk De bodem is van vulkanische oorsprong, overwegend zuur, en wordt gekenmerkt door geringe bodemvruchtbaarheid en door hellingen met een hellingshoek boven de 12 procent. Bodemerosie is de grootste zorg op milieugebied.

Om de relatie tussen marketing en duurzaamheid van bodemgebruik te analyseren werd een onderzoekskader ontwikkeld. Dit kader omvatte: ten eerste, een methode voor het meten van de mate van adoptie van duurzame landbouwmethodes (ASAP); ten tweede, een econometrisch model voor het testen van de invloed van marketing- en andere factoren op ASAP; en ten derde een multicriteria LP model (doelprogrammering) om het effect van verschillende marketingstructuren op duurzaam landgebruik te simuleren en evalueren.

Uit literatuuronderzoek bleek dat de adoptie van duurzame landbouwmethodes (ASAP) in het algemeen te simpel (b.v. adoptie versus geen adoptie) of te gedetailleerd (b.v. erosie in ton/ha.) werd benaderd (Hoofdstuk 7). Daarom werd een methode ontwikkeld om de duurzaamheid van landgebruik, zoals waargenomen door de boer, te meten in enquêtes met een redelijke mate van detaillering. De methode leidde tot het bloot leggen van drie basisdimensies van duurzaam landgebruik in het stroomgebied van Cabuyal, namelijk 'het losmaken van de bodem', 'bodembescherming' en 'beheersing van de waterafvoer'. De eerste dimensie van duurzaamheid heeft betrekking op machinale landbouwpraktijken die de bodemstructuur beïnvloeden, bijvoorbeeld bij het klaarmaken voor de teelt (ploegen) en oogstactiviteiten. De tweede dimensie verwijst naar bedekking van de bodem met voorbeeld strooisel, bladeren, grasstroken en naar andere fysieke maatregelen die de bodem beschermen tegen de eroderende tropische regenval. De laatste dimensie van duurzaamheid heeft betrekking op fysieke voorzieningen en praktijken zoals afvoerkanalen voor het opvangen van water. Deze afvoerkanalen zijn aangelegd aan de rand van een stuk land en zijn bedoeld om stromend water af te voeren en om het afslibben van het bodemoppervlak te voorkomen.

Het tweede onderdeel van het onderzoekskader betreft een econometrisch model dat een 'geïntegreerde' benadering van de verklaring van duurzaam landgebruik tot aandachtspunt heeft. Het concentreert zich op de bijdrage van institutionele factoren (d.w.z. marketing en overheidsfactoren). De ontwikkeling en schatting van het model impliceerde het gebruik van een robuuste schattingstechniek welke de identificatie van samenhangen mogelijk maakte. De econometrische analyse bracht aan het licht dat marketing factoren een doorslaggevende bijdrage leverden aan de bescherming van de landbouwgrond in Cabuyal (Hoofdstuk 8). Marketing factoren leveren met name de meest significante bijdrage aan de adoptie van fysieke voorzieningen (zoals heggen) en praktijken (zoals strooisel), gericht op bescherming van de bodem tegen eroderende regenval. Dit onderzoeksresultaat is van kritische betekenis voor Cabuyal, omdat erosie door regenval één van de belangrijkste oorzaken van bodemerosie in dit stroomgebied is.

Het derde onderdeel betreft een multicriteria LP model, genaamd COOPERA model. Dit is een huishoudmodel dat is ontworpen om inzicht te krijgen in de consequenties van marktinterventies (marktscenario's) op het inkomen van het agrarische bedrijf en op de bodemerosie (Hoofdstuk 9). Drie typen marktscenario's werden gedefinieerd, namelijk het CMC scenario, het VMS scenario en het MO scenario's (Hoofdstuk 10). Het CMC scenario weerspiegelt het gangbare marketingkanaal waarin de prijzen voor landbouwproducten voornamelijk worden bepaald door de vraag en het aanbod op reële markten. Als zodanig functioneert het CMC scenario als basisscenario bij vergelijking met andere scenario's. In het VMS scenario kunnen bonen en tomaten – gewassen die minder eroderend zijn dan cassave –worden verhandeld via VMS kanalen. VMS was, vergeleken met het CMC, een perfecter afzetkanaal waarin de boer reageerde op duidelijke marktsignalen (b.v. een gegeven prijs bij gegeven te verhandelen hoeveelheden) en toegang had tot meer commerciële diensten (b.v. kredieten, levering van inputs). Tenslotte wordt in het MO scenario een nieuw gewas, de braambes, geïntroduceerd in de context van een VMS kanaal. De braambes is een veelbelovend gewas met goede marktmogelijkheden, dat gekozen werd wegens zijn goede eigenschappen voor bodembescherming terwijl het tegelijkertijd een interessante inkomstenbron oplevert. De 'trade-off' tussen het inkomen van het landbouwbedrijf en bodemerosie werd geanalyseerd voor twee gevallen: een geval van een boer die zich in de eerste plaats richt op 'inkomensmaximalisatie' (IM) en een geval van een boer die in de eerste plaats streeft naar 'bodemconservering' (SC). De resultaten van het COOPERA model voor het stroomgebied van Cabuyal zijn beter voor de diverse VMS scenario's, in het bijzonder het MO-scenario, dan voor het basisscenario CMC. Dit betreft zowel het economisch resultaat als de duurzaamheid.

De uitkomsten van het onderzoek tonen aan dat marketing systemen een belangrijke rol kunnen spelen bij het scheppen van voorwaarden voor het gebruik van duurzame agrarische technologieën. Het blijkt dat conventionele marketingkanalen geen geschikt marketingscenario vormen voor de bevordering van bodemconservering. Voor dat doel zijn verticale marketing systemen een meer aangewezen alternatief.

Resumen

El objetivo de este estudio es una mejor comprensión de como ciertos sistemas de comercialización pueden contribuir a promover el manejo sostenible del suelo en sistemas de producción de fincas (Capítulo I). El estudio se centró en resolver las siguientes preguntas: En qué medida ciertos canales de comercialización estan mejor equipados para contribuir a la adopción de sistemas de producción sostenibles? Cuál es la contribución adicional de otros factores, físicos, institucionales, económicos y personales, para afectar la decisión de los agricultores de adoptar sistemas de producción sostenibles? Cuál es el impacto de niveles más altos de producción sostenibles en el ingreso de la finca? El tema nace de la necesidad de evaluar el mérito de estrategias de comercialización en la agricultura sostenible en países en vías de desarrollo, dado que la intervención pública para promover la adopción sostenible es, a menudo, infructífera. En particular, la investigación examinó cambios en los canales de comercialización que estimularían a los usuarios de recursos hacia un manejo sostenible del suelo.

El problema analizado fue la evaluación de las implicaciones de la comercialización, especificamente canales de comercialización y sistemas de comercialización, para los problemas del sostenibilidad de pequeñas fincas en áreas tropicales de ladera. En enfoque hacia canales de comercialización se debió a la influencia que estos tienen en fincas, sistemas de producción y sostenibilidad de dichas fincas. Los canales de comercialización convencionales (CMC) y los sistemas de comercialización vertical (VMS) fueron identificados como las estructuras que emergen como resultado de la coordinación (o no) de las funciones de intercambio, físicas y de facilitación del canal de comercialización (Capítulo II). Una descripción de los canales de comercialización para los productos de pequeñas fincas en el tercer mundo condujo al reconocimiento que estos canales son predominantemente 'convencionales', lo cual indica la necesidad de mejora.

Una revisión de los aspectos principales de la sostenibilidad a nivel mundial indicó que la degradación del suelo es posiblemente el problema ambiental más serio del tercer mundo (Capítulo III). Fue discutido que en comparación con los problemas ambientales fuera de la finca, los problemas ambientales dentro de las fincas eran más evidentes a los agricultores debido a sus impactos económicos (e.g. menores rendimientos), sugiriendo que mecanismos de comercialización podrían ayudar a evitar tal degradación. El estudio del sostenibilidad fue centrado en la degradación del suelo a nivel de fincas. La discusión giró hacia la revisión del efecto de los canales de comercialización, particularmente su estructura, en la sostenibilidad del suelo de las fincas de los países en vías de desarrollo (Capítulo IV). Se discutió que la coordinación de funciones en el canal de comercialización, la orientación a largo plazo y el atractivo económico de las estrategias del mercado parecen ser altamente relevantes para la sostenibilidad de la finca. Fue hipotetizado que VMS en relaciones de largo plazo tiene un efecto positivo en la sostenibilidad de las fincas. Tambien se discutió que agricultores participando en VMS podrían valorar los beneficios de largo plazo que resultan de un mejor manejo de los recursos y de la conservación del suelo. La revisión de un número de casos exitosos y menos exitosos de adopción de prácticas agrícolas sostenibles reveló que la adopción eficaz de prácticas sostenibles a nivel de finca en países subdesarrollados fue lograda cuando estrategias de comercialización acompañaron la promoción de dichas prácticas. Esto mostró la importancia de asociar estrategias de mercado con la promoción de prácticas sostenibles de tal forma que permitan compensar los costos que implican la conservación del suelo. Estas discusiones condujeron a la formulación de las siguientes hipótesis generales (Capítulo V):

H1: VMS esta mejor equipada que CMC para estimular a agricultores a adoptar manejo sostenible del suelo a nivel de finca.

H2: Una política del gobierno de apoyo a actividades de comercialización y producción estimula a agricultores hacia inversiónes en sostenibilidad del suelo.

H3: Incentivos de mercado, que prometen incremento de ingresos, probablemente estimulan la adopción de practicas de suelo sostenibles.

Una área tropical de ladera de 7.400 hectareas, al suroeste de Colombia, fué seleccionada como estudio de caso (Capítulo VI). El área del estudio poseía no solamente las características típicas de biodiversidad de las laderas tropicales, sino también problemas tales como alta densidad poblacional, carencia de infraestructura física y erosión severa. La cuenca de Cabuyal es una comunidad de pequeños agricultores situada en la región andina de Colombia. Las fincas, de escasos recursos, miden en promedio 3 hectareas, en altitudes que oscilan entre 1.200-2.200 m.s.n.m. Café, platano, yuca (para la producción del almidón), frijol y maíz son los cultivos principales. Los productos son comercializados predominantemente en mercados locales a través de intermediarios mientras que contratos con comerciantes y cooperativas son menos comunes. Los cultivos tienden a ser intensivos respecto a mano de obra debido a la abundancia y al bajo costo de este factor de producción. Las siembras dependen de lluvias bi-anuales mientras que la irrigación es poco común. Los suelos son predominantemente ácidos de origen volcánico, caracterizados por baja fertilidad y cuestas con pendientes mayores del 12 por ciento. La erosión del suelo es el problema ambiental más crítico.

Un marco analítico fué desarrollado a fin de analizar la relación entre comercialización y sostenibilidad del suelo. Este incluyó, en primer lugar, un método para medir la *adopción de prácticas agrícolas sostenibles* (ASAP); un modelo econométrico para evaluar la influencia de comercialización y otros factores en ASAP; y un modelo de programacion lineal múlti-proposito para simular y evaluar el impacto de estructuras alternativas de comercialización en la sostenibilidad del suelo.

Con base en evidencia extraida de la literatura, se demostró que ASAP ha sido comunmente medido por métodos o muy sencillos (e.g., adopción/no-adopción) o muy elaborados (e.g. erosión en toneladas por ha) (Capítulo VII). Por lo tanto, el estudio desarrolló un método para medir la sostenibilidad del suelo. El método representa detalladamente el grado de ASAP observado en la parcela y al mismo tiempo es sencillo de implementar en estudios finca a finca. El método condujo a la identificación de tres dimensiones de sostenibilidad básicas en la cuenca de Cabuyal: 'control de perturbación del suelo', 'protección del suelo' y 'control de escorrentía'. La primera dimensión refería a prácticas que controlan el impacto mecánico en la estructura del suelo en las actividades de preparación y de cosecha (tales como arado). La segunda dimensión se referia al cubrimiento total del suelo con residuos, hojas, franjas de hierba, barreras vivas y otras barreras físicas usadas como protección contra precipitaciones tropicales erosivas. La ultima dimensión de sostenibilidad se relacionaba con prácticas físicas, tales como drenajes y canales construidos a las márgenes de las parcelas previstas para desviar el flujo del agua y controlar la escorrentía superficial de suelo.

El modelo econométrico consitió de un enfoque 'integrado' con énfasis en factores institucionales (de comercialización y gubernamentales). La estimación del modelo implicó el uso de una técnica robusta de estimación que permitió la identificación de patrones de asociación que de otra manera hubieran permanecido ocultos. El análisis reveló que los factores de comercialización contribuyen en forma importante a la protección general del suelo en las fincas de Cabuyal (Capítulo VIII). Los factores de comercialización contribuyeron particularmente a la adopción de barreras físicas (barreras vivas y residuos) usadas para la protección contra precipitaciónes erosivas. Esta conclusión es crítica para la region de Cabuyal, puesto que la erosión debido a la lluvia es una de las mayores causas de erosión en la cuenca.

En tercer lugar, el modelo del programación lineal múlti-propósito (denominado modelo COOPERA), fue un modelo clásico de finca diseñado para mostrar las consecuencias de canales de comercialización (escenarios de mercado) en el ingreso de la finca y la erosión del suelo (Capítulo IX). Se definieron tres escenarios de mercado, a saber CMC, VMS y MO (Capítulo X).

CMC representó el canal de comercialización convencional donde los precios de los productos agricolas son determinados principalmente por la ley de la oferta y la demanda en el mercado. Como tal, CMC servía como escenario base de comparación con otros escenarios. En VMS, frijol y tomate, cultivos menos erosivos que la yuca, se podían comercializar alternativamente a traves de contratos (canales VMS). VMS es un canal menos imperfecto donde el agricultor tiene acceso a señales más claras del mercado (e.g. precio conocido, cantidades negociadas) y más servicios del mercado (e.g. créditos, servicios de información). Finalmente, en el scenario MO, mora, un cultivo nuevo y promisorio, dispone de un canal de comercializacón tipo VMS. La mora es una oportunidad de mercado seleccionada para promover la conservación del suelo y, al mismo tiempo, una fuente adicional de ingreso. El intercambio entre ingreso y erosión del suelo se analizó a través de dos casos: maximización del ingreso de la finca (IM) y conservación del suelo (SC). Los resultados del modelo COOPERA indican un mejor desempeño de los escenarios tipo VMS (VMS y, particularmente, MO) en comparación al escenario basico CMC, tanto en términos económicos como de sostenibilidad.

Los resultados del estudio demuestran que los sistemas de comercialización pueden jugar un papel significativo en facilitar e incluso inducir el uso de tecnología agrícola sostenible. Al parecer, los canales de comercialización convencionales no son escenarios de comercialización apropiados cuando la conservación del suelo es el objetivo. Los sistemas de comercialización vertical, en cambio, son un escenario mas apropiado para lograr este objetivo.

About the author

Jairo Castaño is a native at Cali, Colombia; he is married with two children. In 1987, he obtained a BSc. in Statistics from the Universidad del Valle in Colombia. His thesis involved the modelling of forest growth on the Colombian Pacific coast. In 1986, he joined the International Centre for Tropical Research (CIAT) where he worked as Statistician (Biometrics) and later as Research Assistant (Bean Economics) until 1992. This work involved the identification of new profitable technologies for farmers through econometric design and analysis of surveys.

In 1992, he obtained a British Council-Colfuturo fellowship to undertake a MSc. in Econometrics at the University of Kent, England, and graduated in 1993. The topic of his thesis was the foreign trade of Latin America. Immediately after the MSc., he obtained a fellowship from Wageningen University, the Netherlands, to undertake a Ph.D. in Agricultural Marketing, specifically the impact of agricultural marketing systems on the sustainability of small-scale farms.

He undertook the Ph.D fieldwork at CIAT's Hillsides Agroecosystem Program from 1994. He was participant of a multidisciplinary and inter-institutional project aimed at finding solutions to improve the income and sustainability of watershed farms. During those years, he was also lecturer of Econometrics at the Universidad del Valle's Economic Postgraduate Program and published the book titled 'Econometrics'.

From 1997 up to the present, he works at the Economic Information and Market Intelligence Division of the International tropical Timber Organization (ITTO), an UN-based Organization with headquarters in Japan. He is responsible for administering and strengthening ITTO's project and statistical database systems, contributing to ITTO's annual review and managing and monitoring international donor funded projects in Asia, Africa and Latin America.