Market Opportunities Associated with Hydrological Changes
In a Tropical Montane Cloud Forest

Introducing the Key Issues

An Exploratory Paper looking at the Socio-economic Impacts of Biophysical Changes in Land Use in Monteverde, Costa Rica

Ina T. Porras (IIED/CLUWRR)
Miriam Miranda (CINPE)
Rob Hope (CLUWRR)

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1 Introduction

The socio-economic impacts of biophysical changes in tropical montane cloud forests are usually poorly understood in terms of the sequence and significance of the drivers of land use conversion. While important efforts are being applied to understanding the biophysical outcomes of land use in terms of modified flow regimes of cloud forest land cover, little is known about the social drivers of conversion of cloud forest to pasture in terms of the beliefs, perceptions and livelihood opportunities of communities in the upper catchment area. A better understanding of the human-hydrological-economic interface of land use conversion in the upper catchments of Central America will allow a more holistic analysis of who benefits and loses from differing policies that modify the incentives to conserve, reforest or convert upper catchment zones.

This paper introduces the DFID funded FRP-8174 project, entitled "Socio-economic impacts and market opportunities associated with land use and hydrological change in tropical montane cloud forest areas in Arenal, Costa Rica", as a companion to the FRP-7991 research project currenly quantifying the hydrological effects of cloud forest conversion in the Monteverde Area. This project will analyse the economic impact on the sectoral interests of upstream landowners and downstream users following the outcome of the biophysical component.

The main objective of this document is to provide a basis for the rest of the project in terms of the overall objective of the research, and the biophysical and socio-economic characteristics of the area. The specific objectives are:

a. To present the general objectives and framework of the overall FRP project.
b. To present the general biophysical characteristics of the Study Area.
c. To present initial exploratory work in different communities to identify and characterise stakeholders in order to develop a map. This stakeholder map will be used as a based for the narrative and perceptions work previously described. Stakeholders will include local inhabitants, producers (livestock, coffee and others), NGOs, academic community, women groups, governmental officials (National Potable Water and Sewers Institute, Costa Rican Electricy Institute, National Forestry Office, National System of Conservation Areas, etc), formal and non-formal education groups, tourism chambers, Monteverde and Santa Elena Cooperative, and religious groups.
d. To present an initial review, compilation and analysis of existing socio-economic/livelihoods literature within the Arenal/Monteverde study area.

2 The FRP Project in Monteverde

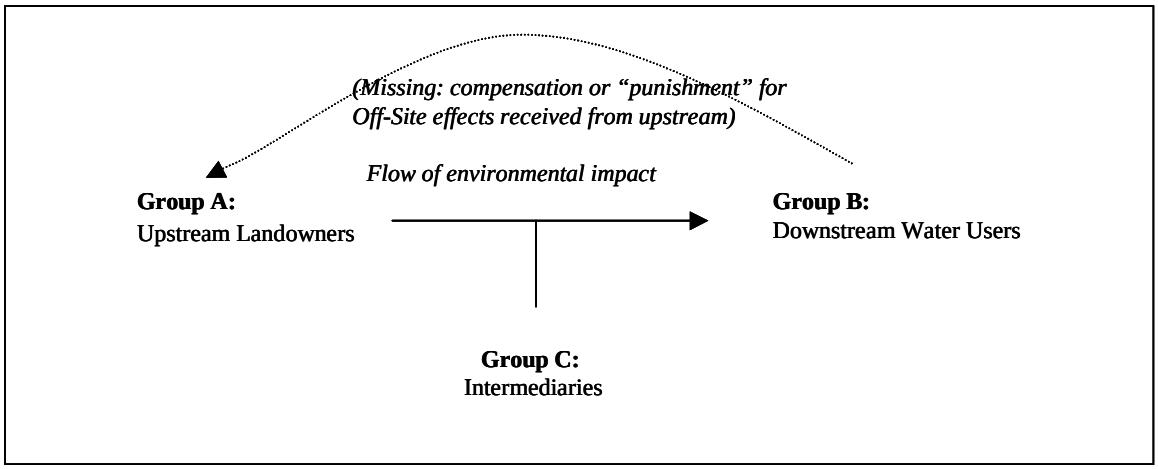
Changes in water flows and their quality, especially during the dry season, constitute a major problem causing great hardship to large numbers of rural and urban poor people all over the tropics. It is generally thought that in montane tropical areas, clearance of cloud forests may serve to diminish streamflow, as the extra input of

moisture stripped by these forests from passing clouds tends to become lost upon the removal of the trees, leading to potentially lowered groundwater tables and thus reduction of stream baseflow.

Although the importance of cloud forests for water production in Costa Rica was stressed since the early 1980's (Zadroga 1981, a report for the Costa Rican Electricity Institute), in-depth investigations were not carried out. While various bodies within Costa Rica have commissioned consultant reports over the years to ascertain the influence of forest on streamflow (CT Energia, 2000; IUCN-ORMA, 2001), limitations in the available data (notably high year-to-year variability in rainfall) and the black-box approach adopted in such studies (simple rainfall-runoff comparisons for individual catchments without taking underlying processes or subregional differences in rainfall regimes into account) have rendered such attempts inconclusive or even misleading (J. Fallas, personal communication, November 2001; Aylward et al., 1998).

Even in cases where sufficient scientific knowledge exists to improve land use and hydrological services – poor communication of such results to stakeholders – particularly low-income inhabitants of upper reaches of remote catchments and policy-makers driving water resources projects means that potential livelihood and welfare gains are often not realized. Figure 1 presents a sketch of how the project will address the concerns of the different stakeholders.

Figure 1. Sketch of stakeholders in study area



(note: a full stakeholder analysis is presented in Section 5)

- *Group A* represents the upstream landowners, and includes private forest reserves, agricultural producers, livestock producers, tourism industry, urban areas and major potential land-use changers. *Their needs* include*:* water for their own uses, and land use for other economic activities besides natural forests. *The Project will:* estimate a possible *Willingness to Accept* (WTA) figure that would be necessary to incentive better land management techniques.

- *Group B:* represents the downstream water users, including ICE (and rest of the country through electricity) and the irrigation project. *Their needs* include*:* maximum water supply throughout the year (i.e. maximum forest cover

through cloud forest). *The Project will:* estimate a *Willingness to pay (WTP), or Ability to Pay* (ATP) based on the marginal value that standing cloud forest or improved land use management will have on water resources.

- *Group C:* represents the intermediaries, or potential intermediaries, in an Integrated Catchment Management approach. It will include MINAE, FONAFIFO, FUNDECOR and other NGOs. Their role is potential intermediaries in the negotiation process of upstream/downstream flows of externalities and compensations. *Their needs* include*:* information about plausible policies to maximize the potential benefits of catchment management for all stakeholders. *The Project will:* provide the intermediaries with information about the "willingness to pay- willingness to accept" bracket, that would be the starting point for a local negotiation process.

This action and learning oriented-research intends to address this gap by promoting mutual learning among scientists, low-income communities in the target catchments and ICE. The companion project will provide state-of-the-art hydrological research. This project will provide a state-of-the art investigation into why and how water quantity and water quality matter to low income groups and identify their corresponding set of beliefs and attitudes towards land and water relationships. The physically-based, spatially distributed model emerging from the companion project will serve as the basis then for quantitative prediction of the economic implications of land use change and serve as a basis for suggestions for improved land management practices and more realistic policy formulations and payment schemes. The project ultimately seeks to facilitate access to these results (from the research under both projects) for local communities and policy-makers and thereby initiate a dialogue on the potential developmental benefits to be gained by low-income groups from responding to this new knowledge and following through on its implications.

To achieve these objectives, the project will produce an evaluation of the socio-economic and livelihood impacts of changes in stream flow resulting from the historical conversion of cloud forest to pasture and the potential for reforestation or silvopastoril management in the Arenal region of Costa Rica, together with recommendations for land management options and the development of watershed service markets that positively impact on livelihoods of low-income groups. More specifically the outputs will consist of:

(i) Documentation and analysis of the historical trends and patterns of settlement, land/vegetation/water use and water resources development for the upper watershed area of Lake Arenal and surrounding areas (See Porras and Miranda, 2004 - *forthcoming*).

ii) Sharing and recording of knowledge, perceptions, beliefs, and attitudes of stakeholders at local level in Rio Chiquito and Caño Negro sub-watersheds and other important decision-makers at the national level, regarding land use and hydrological interactions and identification and compilation of headwaters and downstream low-income groups dependence on and needs for hydrological services. (See Porras and Miranda, 2004 - *forthcoming*)

(iii) Livelihoods assessment in Rio Chiquito and other selected subcatchments looking at different wealth groups, land use conversion and compensation mechanisms (See Hope, 2004 *forthcoming*).

(iv) On-site assessment of land use changes in terms of private and socio-economic costs for different production units (see Porras and Hope, 2004 *forthcoming*).

(v) Valuation of the downstream implications for hydropower of improved land management watershed and assessment of the distributional impacts assessed in the Rio Chiquito sub-watershed employing the FIESTA model.

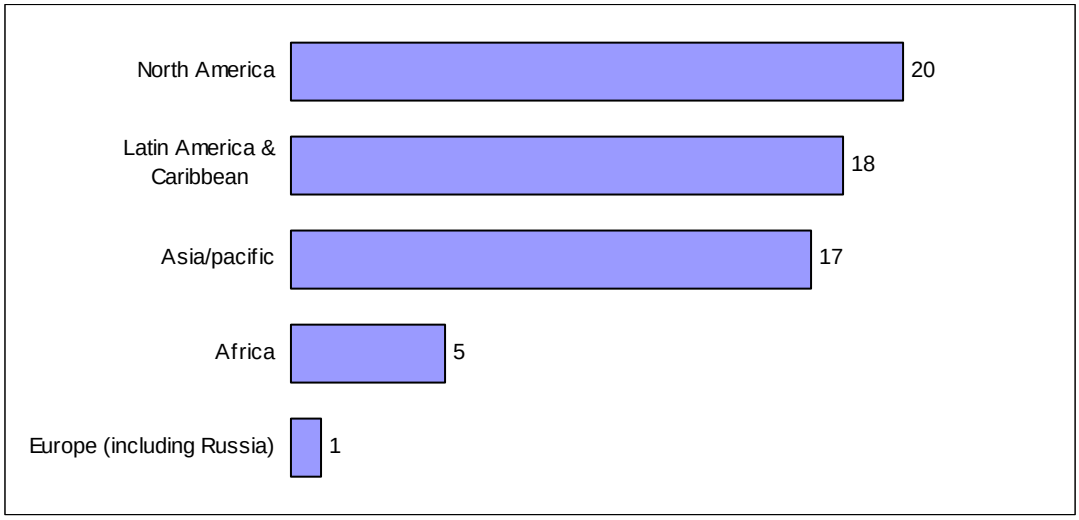
(vi) Action-learning with local and national actors based on results of companion FRP projects to formulate proposals for land use/management improvements, institutional arrangements and payment schemes consistent with livelihood needs of low-income producers and optimizing hydropower generation.

3 The Political Context: Markets for Watershed Services

3.1 Growing interest, but major gaps exist

Market-based mechanisms are currently being heralded as an alternative to management of environmental goods and services. It is expected that markets will encourage not only environmental protection, increase economic efficiency and save public funds. A considerable number of initiatives of market-based mechanisms for watershed protection has been identified by Landell-Mills and Porras (2002), where 61 cases of markets were found in 22 countries (see Figure 2), most of them "marketing" to water quality and regulation. In most of these cases, the private sector seems to dominate the supply and demand (in the form of private landholders for the former and large projects for the latter), while intermediaries have mostly taken the form of government, local municipalities and NGOs.

Figure 2 Markets for Watershed Services: summary of global initiatives



Source: Landell-Mills and Porras (2002)

There is however, little information regarding the biophysical linkages of land use and the provision of a watershed service, and also what do watershed markets mean for welfare and poverty alleviation. While economic benefits could take the form of income generation for suppliers, new jobs, cost savings in relation to command and control and source pollution control, increased efficiency in hydroelectric and water supply systems and other positive spin-offs for other water-user activities, there could be significant economic costs to watershed management in the form of provision of watershed protection, transaction costs associated with the market, and opportunity costs of forgone land uses. Social benefits highlighted in the literature review included health benefits, environmental education, training in improved land uses, improved recreational opportunities, and reduced sound and smell pollution. Other benefits include social institution strengthening, improved scientific knowledge and land title clarification. It is worth noting that the literature review did not present any information as to social costs of watershed markets, and nearly in general, little or nothing was said as to what markets might mean for poor households. In most cases, it is simply assumed that people will benefit, and no especial measures are taken to understand the impact of markets in their livelihoods, and how to maximize their potential participation in them. The main constrains identified in market development were especially related to (Landell-Mills and Porras, 2002):

- High transaction costs, in the case of multiple-stakeholder transactions, lack of cost- effective intermediaries, poorly define property rights (for land tenure and service rights), and the lack of clear and comprenhensive regulatory framework.
- On the demand side: lack of scientific evidence of the relation of land use and water, lack of participation of key stakeholders, and lack of willingness to pay.
- On the supply side: low awareness of market opportunities and the capacity to exploit these, lack of credibility in service delivery, and cultural resistance.

One issue that the development of watershed markets must overcome is property rights. While land resources are not that problematic and land has 'owners' (private property and large reserves), water ownership must be determined. In Costa Rica, water rights belong to the State, and the Ministry of Environment has control over it,

granting exclusive rights to particular users but not allowing user right transfers, therefore eliminating the possibility of creating water markets. Until now, implicit water prices are obtained through the value of land nearby water works (rivers, springs, lake, and water canals of the irrigation system), and licences to use water for recreation. Prices for domestic water use, irrigation, and entrance fees are decided by another [independend] authority: ASESEP (Celis and Segnestam 2001).

3.2 Markets for Environmental Services in Costa Rica

The effects of land use, and particularly changes on forest cover, on water quantity and quality have been an on-going debate in Costa Rica, particularly during the past decade with the introduction of the Payments for Environmental Services and the recent involvement of private groups as demanders of better and more reliable water resources. The Law states that owners of forests could claim compensation for the environmental services their forests produce, in the form of biodiversity conservation, carbon sequestration, landscape beauty and water conservation. From the beginning these four services have been bundled together for simplicity sake, and the only difference allowed within types of forest is for conservation (US$200/ha/over 5 years), sustainable forest management (US$320/ha/over 5 years), and reforestation projects (US$450/ha/over 5 years)[1].

The amount of payment initially established tried to consider different aspects, including the opportunity cost of land[2]. Additionally, the law was introduced at the time when carbon markets were being presented as a glamorous opportunity in the international markets, and this is reflected in the payment levels allowed for reforestation (i.e conservation projects receive considerably less than reforestation as the amount of carbon to sequester in the former is smaller). Since that, new developments have taken place at local, national and international level that question the way that the Law is being applied. While international consensus has not been reached in terms of carbon markets, local initiatives for watershed conservation have been put forward as a more reachable target for marketing environmental services, with a "packed produce" of improved water quality, quantity and improved dry season flows.

While the scientific evidence of the physical links between water and land use (especially forest cover) appear to be tenuous, and in some cases non-existing or even counterproductive, local initiatives are already underway and payments are being collected and allocated within different watersheds. There is not common consensus as to what is being sold and bought, and it could be argued that while current initiatives may have evolved based on a willingness to improved public relations on the part of companies or even on the precautionary principle of risk reduction if land

[1] The payments are made in Costa Rican colones, therefore, the dollar figures might change depending on the exchange rates used.

[2] This remains one of the flaws of the system, as the opportunity cost was selected in terms of pasture for the whole country, not allowing for variation within the country. For example, Miranda, Moreno and Porras (2003) present an analysis of the impact of PES within the central region of Costa Rica and suggest that reforestation projects are not likely to take place in the amount initially expected because the opportunity cost of land in the area is much higher than the suggested payment.

use changed, it is not likely that long term initiatives will survive unless it is clear that a tangible service is really taking place.

Watershed services provided by forests have been recognized in Costa Rica for a long time. As early as 1888 a decree was passed declaring a 2-km wide strip of the sides of Barva Volcano as State-owned land, with the objective of protecting the streams and springs that supplied drinking water to the towns of Alajuela and Heredia (Watson et al. 1998). Nevertheless, the first case of an incipient case of market for watershed services took place in 1997, when the National Company of Power and Electricity (CNFL) agreed to pay landowners located in the Virilla watershed in order to ensure conservation and reforestation of existing forest on their land.

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Table 1). There is not common consensus as to what is being sold and bought, and it could be argued that while current initiatives may have evolved based on a willingness to improved public relations on the part of companies or even on the precautionary principle of risk reduction if land use changed (Calvo, 2000; Rojas and Aylward 2003, Pagiola 2002, J Kellenberg per.comm. 2001), it is not likely that long term initiatives will survive unless it is clear that a tangible service is really taking place.

Table 1. Markets and Payments for Hydrological Services in Costa Rica

Service/Mechanism/Case	Status	Summary
1. Hydrological Services to Hydropower Production		
(A) Transfer Payments: *FONAFIFO and Hydropower Companies*		
(i) Energia Global: Don Pedro and Rio Volcan Hydroelectric plant	Implemented and coming to a close, likely to be renewed	Company pays $10/ha/yr and FONAFIFO pays the remaining $30/ha/yr. FUNDECOR acts as intermediary. Over $43000 were allocated during the first year. Contracts are for 5 years.
(ii) Hidroelectrics Platanar (1)	Ongoing implementation	Company pays $15/ha/yr and FONAFIFO the remaining $25/ha/yr. For landholders without land titles the Company pays $30/ha/yr. FUNDECOR and CODEFORSA are intermediaries. Contracts are for 5 years.
(iii) Compañia Nacional de Fuerza y Luz (3) – Aranjuez, Balsa and Cote	Ongoing implementation	Company covers the full amount of the payment ($40/ha/yr) plus expenses for FONAFIFO ($13/ha during the first year and $7/ha for the remaining years. Contracts are for 10 years. There is no other intermediary between the company and FONAFIFO.
(B) Voluntary Contracts		
(i) Esperanza HEP and Monteverde Conservation League	Ongoing implementation	The agreement settles a dispute over some land where the hydroelectric plant is to be built, granting the right to the company to build and use the water during 99 years, after which infrastructure and land will be the property of MCL. Payments are made gradually starting with $3/ha during the first year, to $10/ha during the fourth year. After the amount of payment is variable and depends on production and sale price.
2. Hydrological Services to Water Supply		
(A) Transfer Payments: *FONAFIFO and Industry*		
(i) Costa Rican Brewery	Agreed	The company (FLORIDA ICE & FARM) agreed to pay US$45/ha/yr for 1000 ha located in the watershed where their water originates. It also pays additional money to FONAFIFO and FUNDECOR to administer and monitor the programme. More recently it leased with EHSP (see below) to pay for environmental services in overlapping areas.
(i) Melia Playa Conchal Hotel	Proposal	The company is exploring the option of developing a management plan for the watershed of the Nimboyores River in order to ensure the protection of the water source in the long term. This water will be key for the development of the hotel's expansion projects.
(B) Water Use Charges		
(i) Heredia Public Water Supply Company	Charges levied to water consumers, payments to forest owners pending	Company collects 1.90/m3 in 1999 to help protect the company's catchment areas (Ciruelas, Segundo, Bermudez, and Tibas rivers). Payments to landowners have not begun yet.

Source: Adapted from Rojas and Aylward, 2003

Despite the large number of initiatives within the country, markets are incipient and are constantly changing. The national context is very dynamic and evolves quickly, therefore allowing for improvements and adjustments "on the go". Additionally, very little attention is being put onto the social effects of the Payments for Environmental

Services. Although it is clear that markets for environmental services are not a poverty alleviation tool, the question of how the PES is altering the rural landscape and what are their effects on people's livelihoods has not been put forward strongly enough. For example, Miranda, Porras and Moreno (2003) suggest that the use of PES in the central valley of Costa Rica has not necessarily changed significantly the landscape since most payments have been allocated on relatively wealthy landholders who maintain their forest on their own interest, and most are not interested in reforestation because it does not pay enough to compete with other existing land uses (i.e coffee, dairy farms or possible urban developments). Nevertheless, in other areas of the country the situation might vary, small landholders might feel forced to enter into long-term reforestation projects because they lack alternatives for their land and might decide to abort the programme if market situations changed. In these cases, it may be wiser to introduce other land use systems that improve watershed management and provide short/medium term livelihoods for small landholders.

While it could be argued that for the Costa Rican case the matter of land use change has become largely academic now that deforestation in Costa Rica has virtually come to a halt in the last few years (from 16,400 ha/ year in 1986-1997 to 3,300 ha/year in 1997/2000; Sánchez-Azofeifa and Calvo, 2002) (J. Fallas, personal communication, November 2001), the question of diminished streamflows following forest removal is as acute as ever elsewhere in Central America (Kaimowitz, 2002) where upland forest protection is much less secure (IUCN-ORMA, 2001). Even further, the continued pressure to undertake revegetation activities, particularly reforestation, and the environmental services payments that promote such efforts is strong in Costa Rica, as elsewhere in the world. The need to better understand not just the hydrology but also the economics of reforestation or watershed management efforts is tremendous as demonstrated by Kaimowitz (2002). However, social issues have often been tertiary in this process due to top-down and centralized approaches to watershed management.

4 Geographical context: The Arenal Watershed

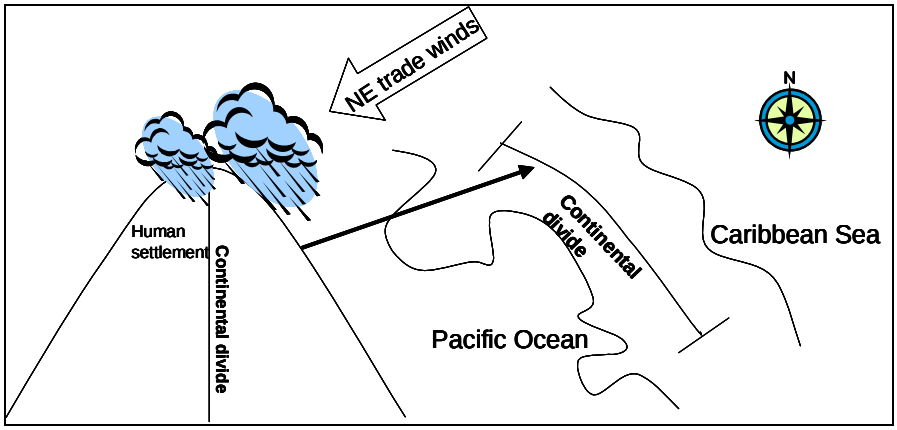
The socio-economic research selected upper catchment communities on the Pacific slope of the northern Tilarán range (Figure 3). The Caribbean slope, where there is little to no human settlement, receives the majority of precipitation from the north east trade winds that fall on the Caribbean slopes of the Tilaràn range (J. Calvo, personal communication, 2002) (Figure 4). The 'rain shadow' on the Pacific slope results in important though smaller stands of primary and secondary tropical montane cloud forest stands, whose distribution is influenced largely by the precipitation regime. The Pacific slope was selected as the location for the socio-economic research as it has been subject to significant land use change over the last fifty years. Understanding the drivers and sequence of land use change in upper catchment areas of tropical watersheds is one of the main research goals. As such, no one watershed was selected for the analysis but a configuration of upper catchment communities that had converted forested land for pasture or agriculture (see below).

Figure 3. Project location in Costa Rica

The study location, including the Arenal watershed and its extension into the Tempisque watershed, is perhaps the most strategic watershed in Costa Rica (Figure 5). The upper part of the catchment is characterised by a large area of cloud forest, extremely rich in biodiversity, which competes with other land uses, particularly livestock (dairy and meat), and agriculture. Water is stored in the Arenal reservoir, an inter-annual artificial lake created to feed into a system of three hydroelectric plants arranged in cascade (known as the *ARCOSA*[3] system), which provides over a third of the electricity produced in the country. From the hydroelectric power system, water flows through a private fish farm and an area of intensively irrigated farms, mostly dedicated to rice and sugarcane plantations, before draining into the *Palo Verde* National Park, an important wetland that hosts a large population of migratory birds. The wetland serves as a filter for water that drains into the Gulf of Nicoya, one of the most productive estuary ecosystems in the world, which accounts for approximately 20 percent of the total fisheries harvest in Costa Rica (Hazell et al., 2001, Aylward et al 1998).

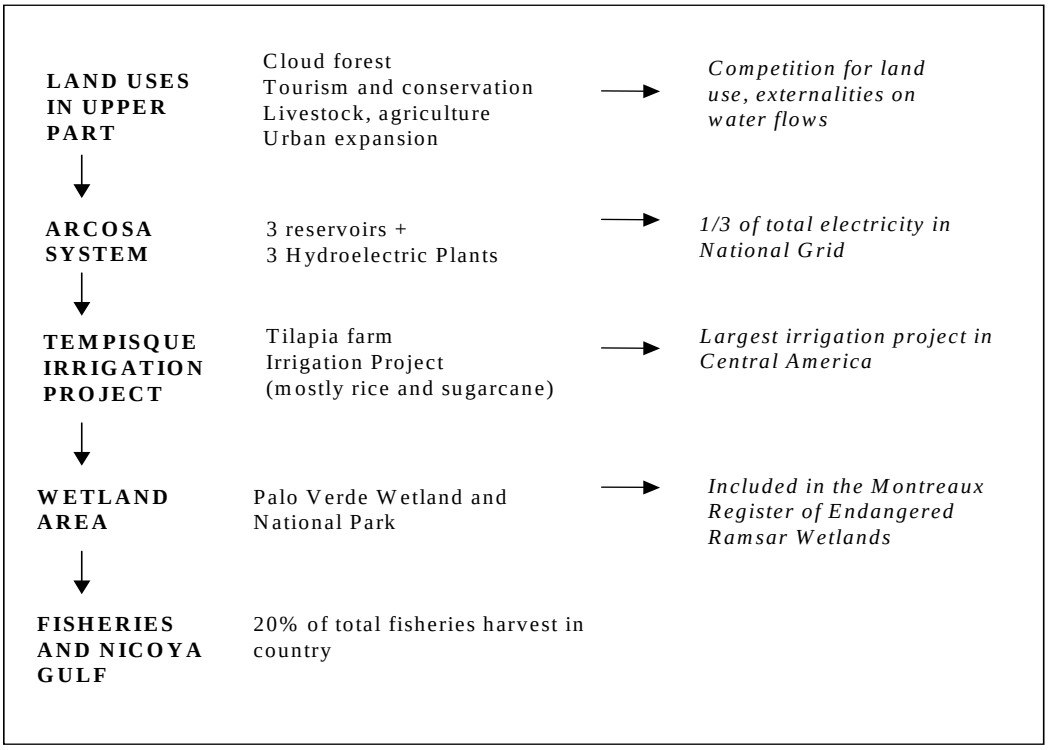
[3] ARCOSA is the name of the joint of the three dams: Arenal, Coribici and Sandillal.

Figure 4 Representation of the influence of the continental divide on rainfall in Costa Rica



The upper watershed reaches 1,800 metres above sea level, receives rainfall varying between 2,000 and 6,000 mm per year and is characterized by 90% of the upper watershed having a slope greater than 25% (Aylward et al., 1998). The majority of soils in the area are deep, sandy soils of volcanic origin possessing good natural drainage and of low fertility (CCT, 1980). Average annual maximum temperatures are 28°C with mean minimum temperatures of 19°C. Average annual humidity is estimated at around 80 percent. Wind is an important climatic and agricultural factor at the northern end of the range where there is a natural saddle between the Caribbean and Pacific zones (Aylward et al., 1998: 9-10). CCT (1980) suggest that land is primarily suited to conservation forestry (58%) or protection forestry (38%). However, the historical development of local land use patterns runs contrary to biophysical analysis.

Figure 5 Inter-linkages and value of watershed environmental services in the study location



Due to its local topography, an analysis of land use capacity (CCT 1980) suggests that the land in the region is mostly suited for forestry and forestry protection (see Table 2). Most of the Arenal Watershed is therefore suitable only for forestry production (38%) or forest protection (58%). The percent of area that should be under forest protection is significantly high in Rio Chiquito (76%), Caño Negro (82%) and Aguas Gatas (90%). In theory, approximately only 60 hectares should be under pasture and livestock production.

Table 2. Land use capacity

	Pastures	Permanent crops	Forestry production	Forest protection	Area (ha)
Upper Watershed Area:					19,108
R Chiquito	0	1.1	22.8	76	9,136
Caño Negro	1.3	0	17.2	81.5	7,248
Aguas Gatas	0	0	9.9	90.1	2,724
North and West Arenal	2.3	3.3	54.6	39.9	22,223
Total Land Watershed	**1.5**	**2**	**38**	**58.5**	41,332

Source: CCT (1980); Aylward et al (1998). Lake area is equal to 9,304 ha.

The main limitations to other land uses are linked to very high slopes, abundant humidity, easily erosionable soils, high vertical and horizontal precipitation rates, and the risk of landslides. However, topography creates several altitudinal stages where very rich ecosystems have been developed, and biodiversity and water resources are abundant.

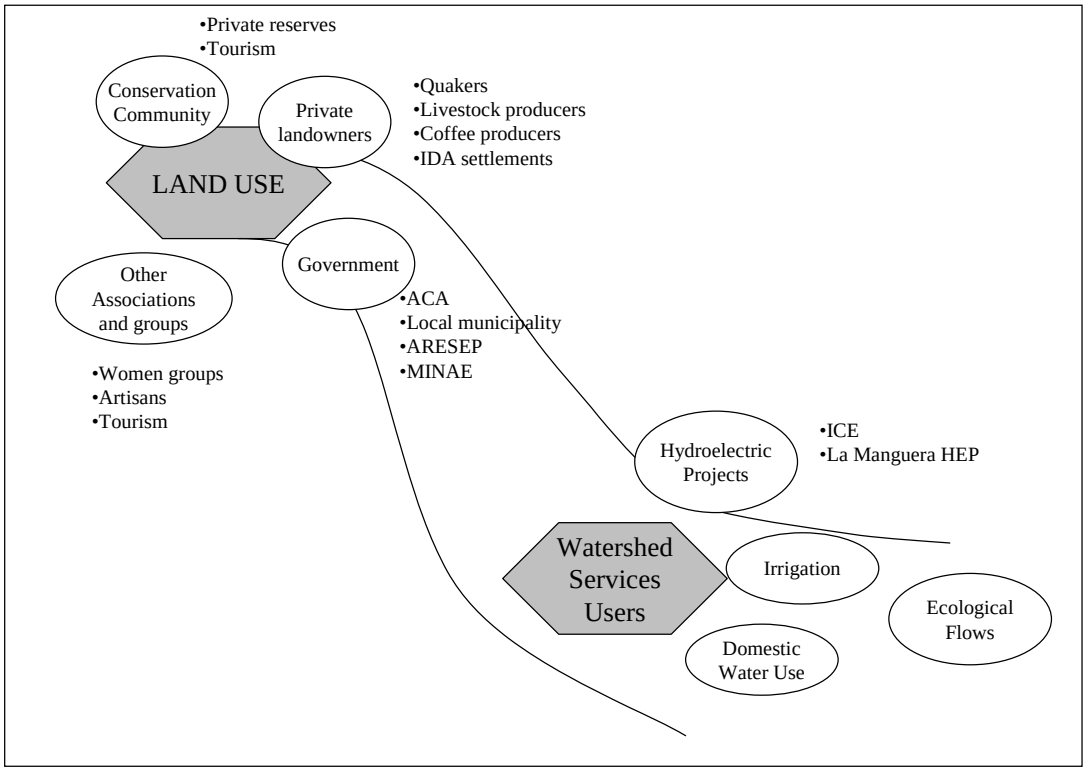
Soils in the upper watershed are the result of the chemical and physical process, which produces soils rich in organic material, high humidity and volcanic material from the Aguacate and Monteverde Formations. According to the USDA soil classification system, in Monteverde it is possible to find Andisols, Inseptisols, and Histosols.

Biophysical conditions have allowed the diversification of habitats with an immense number of species, animals and plants, many of them endemics and other in danger of extinction. Some of them are the tapir, gold toad, jaguar, and many cat's species. The cloud forests host approximately 400 species of birds, including the quetzal, 30 species of hummingbirds, 500 species of butterflies, 600 species of trees, 300 species of orchids, and over 3000 types of vascular plants (www.acmonteverde.com/especies.html).

5 Main Stakeholders in the Area

The concept of organising the Watershed as a unit in order to identify upstream and downstream relationships is not new (Mourraille, Porras and Aylward, 1995). Within the context of this study area, it would mean looking for optimal scenarios for land use management in the upper parts of the selected catchments to improve both on-site and off-site hydrological services, providing both for physical livelihood needs and potentially a source of income from market initiatives, including Payments for Environmental Services.

Figure 6. Upstream-Downstream relationships

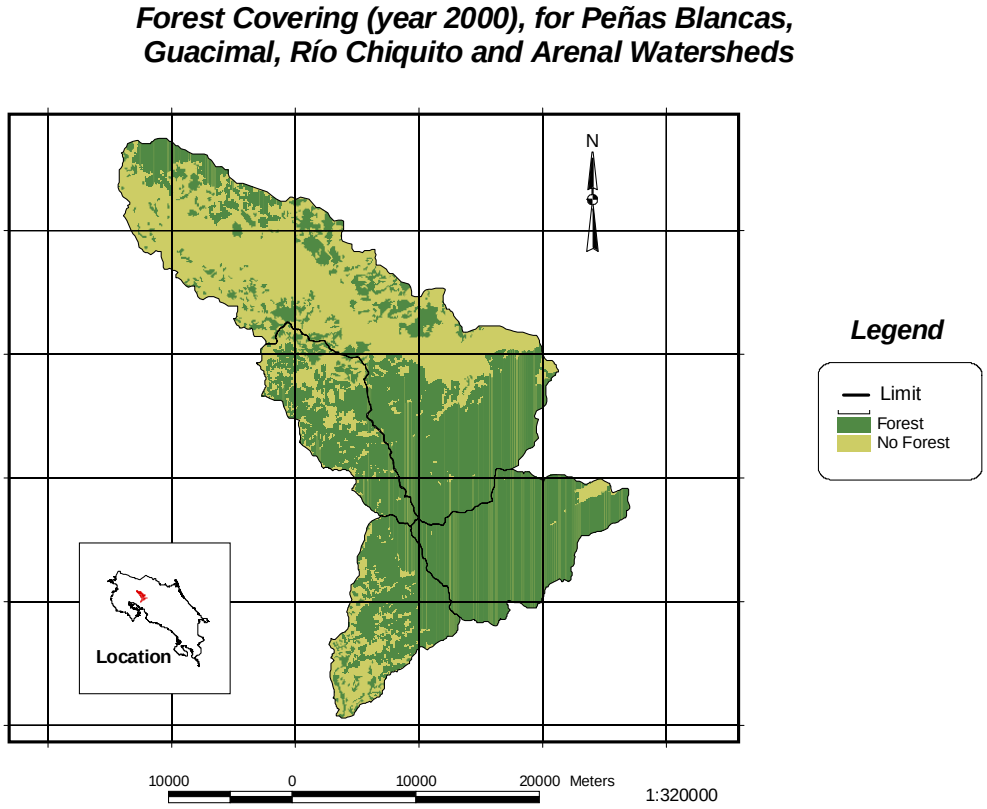


The basic relationships in the study area are summarised in Figure 6, and expanded in more detail in the Sections below. Weather characteristics in the upper parts of the catchments[4] are responsible for the existence of important areas of cloud forests, and in turn the existence of a very important conservation community and tourism activities in the area. Private reserves cover approximately 33,300 hectares, and 74% is located in the sub watersheds draining into Lake Arenal (see figure 7). Other economic activities in the area include livestock (dairy[5] and meat), small areas of agriculture, ecotourism and small patches of reforestation. The middle parts of the watershed are mostly dedicated to extensive ranching and some agriculture. Farms are mostly large and their owners live in the nearby town of Tilarán.

[4] Climate in the upper parts of the watershed is transitional, where wind patterns from the Caribbean meet those from the Pacific and create a variety of microclimates. Weather conditions are a result of a combination of global phenomenon such as polar cold fronts, tropical storms and hurricanes and local phenomenon as topographic position and winds (Lawton and Dryer, 1980). Cloud formation is encouraged on the Caribbean cost by the westerly winds. These clouds climb the eastern slope of Costa Rica's mountains, cooling as they travel, and arriving heavy with rain and mist by the time they reach the continental divide.

[5] Dairy production is sold to a local cheese factory

Figure 7 Forest Cover in the watershed draining into Arenal Lake

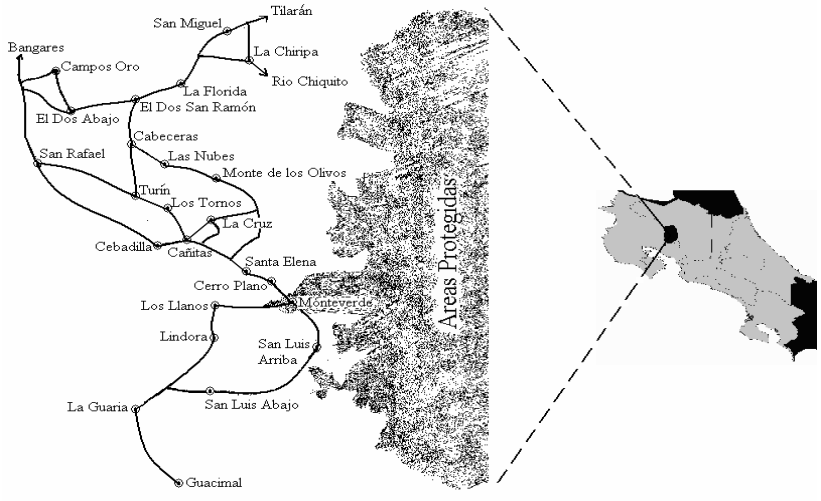


Source: Calvo, Julio

The lower basin is very isolated in terms of human habitation. There are a few landholdings, with small producers dedicated to diary farming[6] and hiring out to large ranchers. Río Chiquito, the most important population area, was a flourishing community several decades ago but was isolated with the construction of the Arenal dam. About 5 years ago the main source of employment - an open cast gold mine - was closed because of negative environmental impacts. A strong migration process has since occurred in the area, and at the moment there is only approximately 100 inhabitants in the community. Services are limited to a small primary school and one local shop. The main watershed services users in the lower part of the basins are the two Hydroelectric Projects: ICE-ARENAL and La Manguera (located on the Caribbean slope), a small private initiative. Water is also used for irrigation by the SENARA project, ending in an important area of wetlands.

[6] Milk is sold to Dos Pinos, a national cooperative for dairy products.

Figure 8. Population centers in the upper catchment areas



5.1 Private Land Uses

Most landholders in the upper part of the catchments are small or medium landholders. While the majority is dedicated to dairy activities, there are several examples of small parallel ecotourism activities at the farm-level. For instance, some families have started to rent horses to turist to ride. Others, have added sleeping rooms to theirs homes to offer loging and food as same as other basic tourist services. The areas of Las Nubes, La Cruz, Monte Los Olivos and Cañitas are dedicated mainly to pasture lands (see figure 8 for location of communities). Lower down in the catchments the climatic and soil conditions allow the inclusion of coffee production, in most cases alongside livestock. Some of the communities included here are Santa Elena, San Luis, La Lindora, El Dos, Los Tornos, Cabeceras and Turin**.** Due to the difficult access to other markets, vegetables production is mostly for household consumption, although in recent times the tourism industry has increased the demand for local produce. The main stakeholders are presented in Table 3.

Table 3. Main private stakeholders

Name	Character	Activity	Description
Private Producers			
The quaker community	Private	Dairy farming, ecoturism	Arrive in 1952 from Alabama, USA.
Monteverde Producers	Private	Cheese/dairy products	Supports sustainability by providing technical assistance on soil conservation, awarding prizes for sustainability effors and refusal to accept new producers in areas that are not suited to dairy production.
Livestock producers	Private	Dairy and met producers	Small and large producers. Represented by the Livestock Producers Association
Coffee farmers	Private	Agriculture	Agriculture (mostly coffee), associated to regional cooperatives: Coope Santa Elena and Coope El Dos.
Institute for Agrarian Development	Parastatal	Agriculture	Silvopastoral programme dealing with the resettlement of landless peasants unto smallholdings.
Foresters	Private	Forestry	Small and medium foresters (mostly for reforestation and wind-breaks), linked to a regional foresters association (AGUADEFOR)

5.1.1. Livestock

Livestock, mostly in the form of dairy farming, was introduced in the area by the Quaker community. The isolation of the region resulted in perishable fresh milk being replaced by cheese production to overcome the time-lag to markets. From the beginning the Quakers avoided unnecessary deforestation through the introduction of genetic improvement, better pastures, veterinary care and a greater use of grain feed concentrates. Livestock continued to grow in the Monteverde region when Costa Rican settlers arrived in the area. Unfortunately, most of them did not continue to implement the Quaker's environmental policies and this lead to increased deforestation (Focus Group CETAM).

Box 1. Productores de Monteverde Cheese Factory

Productores de Monteverde S.A. is a private firm created in order to industrialize milk production. Currently, there are 230 small and medium milk producers (Jorge Eduardo Herrera, pers. communication) producing 35.000 kg of milk per day. While their main product is cheese and its marketing for national consumption, the Cooperative also deals with coffee production (100% pure coffee under two different trademarks), pig farming, and inlay production. Coffee is exported by an innovative international trade system called "ant distribution". Tourists pay for their coffee in Monteverde town, but do not receive the product immediately. They give their e-mail address, and the coffee store sends it until their homes worldwide (Ramón Campos, pers. communication).

Productores de Monteverde presents a vertical integration of the cheese production, controlling all stages from milk production to sales to final consumers (Jorge Eduardo Herrera, pers. communication). Moreover, its farm has been designed to use milk residues for feeding pigs, which eventually become input for inlay production process. The existence of the Pig Farm has several local impacts: (1) it is the first production plant in Costa Rica receiving the Bandera Ecológica[7] prize during five consecutive years; (2) it generates additional income for local families by extending on the existing diary industry; (3) reduction of water pollution by reduction of residues -such as serum - thrown in local rivers; and (4) the initiative provides an example of the promotion of sustainable development and ecotourism.

Livestock activities cover approximately 100 km^2 and involve several communities in the region[8]. Dairy production takes place at altitudes above 900 meters above sea level, while beef and double purpose take place below this altitude. The only processing plant in the area is Monteverde Producers, a private association of diary farmers (see **Box 1**) who deals with all the milk production and sets strict standards to its members. Lower down in the catchment producers can sell directly to Dos Pinos. The activity, particularly dairy products, has been increasing steadily since its beginnings in 1954 (see Table 4). Most producers are relatively small, and the

[7] *Bandera Ecológica* (Ecological Flag) is a voluntary environmental certification given by the Costa Rican Ministry of the Environment. The program has been successfully running for over 7 years. It provides a credible and consistent certification scheme, which includes an independent audit. Participating firms acquire useful knowledge, which in many cases has improved their efficiency and reduced their pollution and energy use. The program, however, needs more funding and political support. Its effectiveness could also be improved by publishing a set of eco-efficiency indicators in the Internet for participating firms (for more details access http://www.minae.go.cr/sociedadcivil/bandera/categorias.htm.)

[8] These communities are: Monteverde, San Luis, Cerro Plano, Santa Elena, La Lindora, La Guaria, Guacimal, Cañitas, La Cruz, Las Nubes, San Rafael, Los Tornos, Cebadilla, Campos de Oro, San Bosco, Cabeceras, San Ramón del Dos, La Florida, La Chiripa, El Dos Arriba, El Dos Abajo, Monte de los Olivos, Río Negro, Turín y la Esperanza.

average of pasture area per associate goes from 15 ha/member in 1954 to only 5.4 ha/member in 2002.

Table 4. Dairy production and processing capacity (1954-2002)

Year	No of associates	Pasture area (Ha)	Production Kg/day	Production Efficiency (kg/ha/day)
1953	12	180	280	1.6
1985	248	3,120	10,355	3.3
1990	350	3,465	18,392	5.3
1995	483	3,000	27,955	9.3
2000	513	2,750	36,522	13.3
2002	462	2,500	35,012	14.0

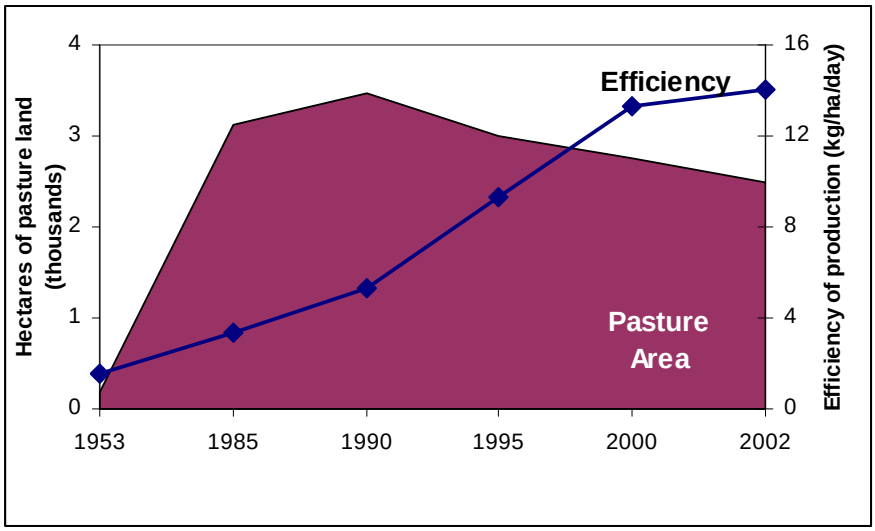
Source: Monteverde Producers Cheese Factory statistics. The number of employees in the Factory has increased from 15 in 1953 to approximately 100 in 2002. The size of the processing plant has also increased, from a small factory of 250 m^2 in 1953 to a large area of 2,800 m^2.

Figure 9 presents a summary of the Monteverde Producer's development. Both the number of associates and total area of pastures increased substantially since the factory opened in 1953. In 1990, pastures dedicated to dairy production reached its peak, it was estimated that almost 3,500 ha had been dedicated to such activity. However, by the early 2000s, the amount of land dedicated to dairy activities has begun to decrease. There are two main reasons that explain such the decline[9]: a) ecotourism activities begin to rise and b) the inclusion of technology in the dairy activities. With regards to this shift, ecotourism, represents quite a profitable market, and also involves less physical effort when compared to dairy activities. In addition, the younger population, the ones that are inheriting the land, have a broader perspective of life and are willing to take the risk of broaden their horizons. Ecotourism represents a very good opportunity for development for these new entrepreneurs.

The inclusion of new technology in the dairy activities, overall, has allowed for dairy activities to be a more efficient process. Nowadays, in the early 2000s producers require less pasture land to produce the same amount –or even a higher yield - of milk when compared to data from the early 1990s (Table. 4). The improvements in technology include better pastures as a result of windbreakers (which, according to producers, generates an increase of 20% in milk production) and also better cow herd. These technological improvements have been a necessity for the industry, not only to compete in its own market –dairy product market in Costa Rica- but also to compete for land in Monteverde. Ecotourism has been threatening producers; as a result they have had to improve their techniques and even the quality of the products.

[9] Between 2000 and 2002 , 51 members left the association of Monteverde Milk Producers.

Figure 9. Pasture Area and Efficiency of Dairy Production



Source: Monteverde Producers statistics

In 1999 Productores de Monteverde introduced new products, including sausage production using milk sub-products –for example milk serum- as inputs to feed pigs. The activity began with 34 employees, producing 900 kg/day. The introduction of better production practices and personnel (13 more employees) has resulted in an increase in production to 2,200 kg/day in only 3 years. This new activity has important positive effects, by generating additional local employment and incomes, by promoting and marketing successfully a new local produce. Additionally, with this new activity Productores de Monteverde has been able to reduce water pollution because of cheese wastes - milk serum-.

Despite their efforts to try to tackle environmental issues, one of the main problems that the industry is facing is related to pollution, in particular manure and pesticide management, which adds to the current threats to superficial waters in the area.

5.1.2 Agriculture

Agricultural activities in the region are heavily dependent on the climate. Potentially, the variability in microclimates could provide excellent conditions for a wide range of agricultural produce; however, biophysical conditions such as strong winds, steep topography, and road access have limited the development of the agriculture in Monteverde.

Growing vegetables is not a suitable economical activity for farmers in the region, but nevertheless, they harvests crops for their own consumption. Coffee production, on the other hand, is the main agricultural economic-oriented activity. During the 1970s, when there was an important livestock recession in the region, coffee was introduced by local farmer as an excellent opportunity to diversify the family's income.

Even though coffee production does not represent the main source of income for families, it is a very significant portion of their income. It is estimated that approximately 70 % of coffee producers have as their main source of income dairy activities, 10% raise beef, 8% raise crops, and 12 % generate income through some other types of activities (CoopeSanta Elena, RL. Unpubl.data, quoted by Nadkarni, et

al, 2000). Thus, once can conclude that coffee production is not the only one economic activity, but instead, these local farmers gather their income through a wide variety of activities. Moreover, coffee producers have been joining the ecotourism venture as well.

The impact of the coffee activity in the upper watershed (Santa Elena and San Luis) is relatively small. In 2002 the production was just over 2,200 fanegas[10], from approximately 115 hectares farmed by 90 landholders[11.] During the last decade, as the locals turn their efforts towards ecotourism, coffee production has begun a decline due to the lack of a workforce during harvest time, which is now done for the most part by migratory (mostly Nicaraguan) labour. In the middle watershed were ecotourism has not developed the same as upper watershed, coffee production remain important especially in the surroundings of El Dos town. Producers here are organized through a cooperative called COOPELDOS. Santa Elena and San Luis (see figure 8) produce approximately 15,000 fanegas of coffee per year. The 32 % of its production is sold in fair trade market (Alvares12, 2004 pers com.) Selling through fair trade has been very positive for these coffee producers. They were able to face the recent coffee international price's crisis without been on bankrupt, as it happened in others region of the country. It is important to draw attention on that 25% of coffee producers are women who are very enthusiastic about organic production. After three decades of been established, COOPELDOS obtain the certification ISO 9002. Additionally, it is working in the process for the ISO 14,001.

[10] According to ICAFE a fanega is equivalent to 0. 4 cubic meters.
[11] Coffee production areas are concentrated around Santa Elena, Monteverde, and San Luis, Cañitas, Cebadilla, El Dos and its surroundings.
[12] Alvarez , Carlos is the present manager for COOPELDOS

Box 2. Coffee Cooperatives and their local impacts

There are two main coffee Cooperatives: Coope Santa Elena and Coope El Dos.

CoopeSanta Elena was was created early during 1970s to supply agriculture inputs, household groceries and crafts. Nowadays, this cooperative concentrates mainly around coffee activities, from production, roasting, processing and marketing. Currently the cooperative has 115 associates, 75 of which are coffee producers with an average production area of 1 hectare, yielding a harvest in 2003-2004 of approximately 2000 fanegas of coffee (about 100,000 kg). While 60% of their production is exported to international markets (Montana Coffee Traders sells at US$9.5/lb) under the Fair Trade scheme, part of their produce is also sold in local markets. Additionally, the Cooperative receives an extra US dollar per pound of coffee sold in USA markets (**www.montanacoffeetraders.com**). According to Griffith *et al* (2000), coffee from this area is of very high quality, and marketed as a product grown "…in harmony with the cloud forest", helping to achieve a significant price premium. Recently, the cooperative has promoted organic coffee production, but cleaner environmental practices have been introduced for a while, such as cleaner technology practices to reduce the amount of water used, and the production of organic fertilizer from coffee pulp and organic waste (one of the most harmful residues of the production process).

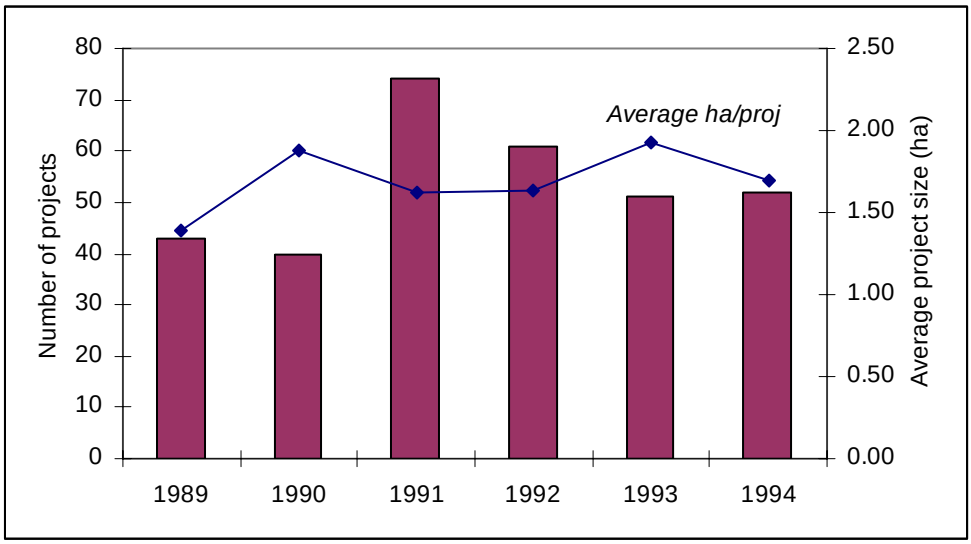
CoopeELDOS.R.L was created in 1971, by a group of 79 coffee producers. Membership has increased since then, and by 2004 the group had 580 landowners, with an average producing area of 1.5 hectares, located at 950 masl. Its main headquarters are located in El Dos, a small town of the Guanacaste province. The organisation currently produces 15,000 fanegas of coffee per year, out of which 85% is considered high quality. Coope El Dos has a strong social agenda, contributing to community development in several forms, and more recently, through the purchase and redistribution of 70 hectares to 55 producers, each with an average plot size of 1.4 ha. The environmental agenda is supported through a reforestation programme (500 hectares of native species in 12 years); maintenance of a forest nursery (75000 seedlings/year); the production of organic coffee since 1986 (currently covering 32 hectares); and an organic soil plant (8000 quintales/soil/year). In 1998, CoopeELDOS became the first coffee cooperative ISO 9002 certificated in Latin America, with an important effect of reduction of waste waters from 3000-3500 lt per fanega of coffee processed, to only 300 lt/fanega. The water is then treated before it returns to the rivers.

Source: Adapted from (www.coocafe.com/coopesantaelena.htm).

5.1.3. Reforestation

Reforestation projects are rather recent (mostly introduced during the second part of the 1980s) and isolated in the upper parts of the catchments. Early during the 1990s projects were oriented to commercial reforestation with small success causing the projects to be abandoned (Varela, O, per. comm., 2003), and to the development of windbreaks. The windbreak reforestation initiatives were more successful. The first phase begun with a small number of projects (43), reforesting an average area of 1.4 ha per project (see figure 10), reaching their maximum of 74 projects in 1991 to stabilize again by 1994 with 52 projects. In total windbreak reforestation included 321 projects for a total area of 542 hectares and an average area reforested by project of 1.7 ha. All together, the projects reached 193 farmers located in 14 communities around Monteverde.

Figure 10. Windbreaks reforestation in Monteverde



Source: Rodríguez, per.comm. (2003)

The majority of projects where windbreak barriers were introduced were dairy farms. The projects planted almost 380,000 trees of 60 different types of native species and 4 exotic ones. Each project provided free technical assistance for the farmers, who in exchange were able to continue with dairy production, as well as planting and caring of the trees, and taking part in educational and informative activities. These initiatives (alongside the creation of 3 tree-nurseries) were financiered by Canadian Cooperation, and lost continuity after 1994, when the Cooperation was over. Two of the nurseries were relocated within Monteverde[13], and the third to San Carlos in the Northern Zone of Costa Rica. However, the local capacity generated by the project has been the base for the local nursery managed by the Educational Center of Monteverde, which currently sells trees to local farmers.

The trees planted 10 years ago have reached maturity and are rated highly by the farmers. According to local farmers, milk productivity has increased at least 20% since their introduction (Focus group, La Cruz, 2002). Besides providing shelter for the cattle during wind and rain, the trees provide timber and non-timber products, such as natural insecticides, charcoal and fruits[14], as well as improving the landscape beauty and the local culture towards more environmental-friendly agricultural and dairy practices.

> "It used to be only open pastures in many places. Now, with the reforestation of windbreaks and use of shade coffee things have improved in terms of protection against wind. It is more sheltered to live here. We expect to see more benefits in years to come as trees reach maturity". El Dos Focus Group.

[13] One nursery went to Finca La Bella and the other to San Luis.

[14] According to Lampietti y Dixon (1995), the Non-Timber Forest Products (NTFPs) have five characteristics, which turn more difficult their economic valuation. These are: (1) there is not enough information about prices and quantities because there is not any market involved, (2) forest products use can not be exclude, (3) nowadays biological dimensions are not properly known, (4) a long planning horizon is required, and (5) NTFPs are both complementary goods and services.

5. 2 Environmental NGOs as key stakeholders in Monteverde Area

Contrary to other parts of Costa Rica, where the Government protects forests through the creation of National Parks, the area of Monteverde is characterized by private reserves, largely funded by international donations. There are three main NGOs involved in the protection of cloud forests: the Tropical Science Center (TSC), the Monteverde Conservation League (MCL) and the Monteverde Institute (MI). While these NGOs work independently, their main objective is the conservation of natural resources. A fourth private reserve is the Santa Elena Cloud Forest Reverse, protecting 310 hectares of forest, which belongs and is administrated by the local and public High School.

Table 5. Stakeholders: Main Cloud Forest Reserves

Name	Character	Activity	Description
Monteverde Cloud Forest Reserve	NGO	Forest Protection/ ecoturism/research	Monteverde Cloud Forest Reserve. Covers approximately 10,000 ha of cloud forests. Managed by TSC.
Monteverde Conservation League + Children's Eternal Forest	NGO	Forest protection/ ecoturism/sale of WS/research	Largest private reserve in CR (22,000 ha). Incentive programs for soil conservation and reforestation in the area adjacent to R Chiquito. Sales watershed services to La Esperanza Hydropower (incremental payments of $3 to$10 ha/yr over 5 years) – see note apart
Santa Elena Reserve	Community Reserve	Forest Protection/ ecoturism /research	Private reserve covering 310 ha of cloud forest, entrusted to the Santa Elena High School. Opened in 1992 as means to protect the forest and generate revenue for local people.

The Tropical Science Center (TSC) was established in 1962 by a group of scientists who were interested in the preservation of the tropical ecosystem, in particular the cloud forest. The TSC owns and administers the Monteverde Cloud Forest Reserve, and provides an invaluable platform for national and international scientific research, and the promotion of intensive environmental education programmes for the local communities.

The Monteverde Conservation League (MCL) was created in 1986 by a group of local and international scientists interested in the protection of forest surrounding the Monteverde Cloud Forest Reserve. The MCL administrates the Children's Eternal Rainforest[15]. They are mostly oriented to the conservation and restoration of ecosystems and biodiversity (Burlingame, 2000); and are less supportive of any type of development in the area. This policy has brought some disputes with local communities, who have nicknamed the reserve as the "eternal forest for Swedish Children, and not ours" (Watson et al 1998).

5.3 Other groups and Associations

The local social organization has contributed to build a strong social capital which has played a key role in the upper parts of the watershed, and specifically in Monteverde's development. Due to its isolated location and very bad road access, local inhabitants were forced to make decisions for themselves, and to date a very large number of

[15] This reserve was created to provide a buffer zone for the original reserve and avoid becoming an "ecologically isolated island in a sea of pastures and farms". A lot of the fundraising was done through campaigns conducted by schoolchildren in Sweeden.

local organizations were identified working in conservation and environmental improvement, education, production, services, and physical infrastructure. Non government organizations, cooperatives, scientific community, state organizations and several other groups have played an interactive role in the creation of local capabilities following sustainable development's philosophy.

Table 6 Stakeholders: Some Local Groups and Associations

Monteverde Institute	Private NGO	Education	Dealing mostly with education on environmental issues, the MVI is highly involved in local sustainable development.
Women Associations	Local group	Community issues	*Fuerza Femenina* is a strong small group of local women of all backgrounds dealing with local issues of sustainable development from a household point of view.
Association of Guides	Local group	Environmental education, guided tours	Controls the quality of certified guides within the cloud forest. Members must be local.
Tourism Chamber	Local group	Community issues	Groups together a wide variety of stakeholders to tackle community issues such as overdevelopment, and to push for regulation on the establishment of tourist activities.
Artisans Cooperative	Cooperative	Crafts	Promotes new economic activities in the form of crafts for its members (mostly women).
International Scientific Community	Various	Support	International agencies dealing with development, research, purchase of land, and new economic activities.

The Monteverde Institute. The Monteverde Institue (MVI) was established in 1986 as a non-profit educational association by Monteverde residents; led primarily by John Trostle. The MVI is not directly related to any particular natural reserve; and instead it partners up with foreign schools and universities to promote, among others, studies in tropical biology and conservation, sustainable development and sustainable design. This organization is also fully involved with issues relating to local development and conservation. For example, they work with the local representatives of AyA to tackle the problem of pollution of surface waters.

The MVI is based on the principles of peace, justice, knowledge and sustainable development. This NGO also sponsors and supports research that can be applied to local, national, and international issues of environmental degradation and the decline of biodiversity, rapid social and demographic change, and public health. As a cultural center, the MVI hosts the annual Monteverde Music Festival, music education, and the Monteverde Community Art Center.

Fuerza Femenina group. This group brings together a range of very active women. The group begun in 2000 with the sole objective of working towards sustainable development of the area. According to its members, the only requisite to joint the group is willingness to work hard in favour of the community. This group is form by a wide range of women from all backgrounds: professionals, entrepreneurs, artisans, and housewives. Their main concern at the moment is water pollution, and how to promote simple measures at household level to guarantee a safe and sustainable disposal of grey waters.

The Association of Monteverde Guides. Formed in 1996 with the objective of controlling the quality of the tourist guides, it has nowdays approximately 24 members. To become a member, each person must have been a local resident for three years and pass an examination on local biodiversity and history. The Monteverde Cloud Forest Preserve only allows members of this association to conduct guided tours within the preserve.

The Tourism Chamber (TC). The Tourism Chamber was established in 2000 to address local concerns by bringing together a wide range of local stakeholders as a united front. One of the objectives is to prevent overdeveloping of the area, and to prevent the local industry from being taken over by foreign groups or individuals.

Monteverde's Cooperative of Artisans (CASEM): This cooperative was created in 1982, by a group of women in Monteverde. It has expanded from 8 members to 150 (10 of them men), involving 21 small communities. Crafts include embroidering, painting, wood, leather, sewing clothes, felt figures and other arts using natural materials (Bonilla, M 2000). The goal of CASEM is to create an environment where the associates can work in their homes for the ecological, social and economic development of their families and the community as a whole. Accordign to many of the members, CASEM has been a way to build their self-esteem, generate extra family income, and provide a place to make new friends and discuss community issues. Crafts are produced in each home and brought to a central building for sales, and 65% of the revenues go back to the members. The cooperative begun as part of the Coffee Cooperative, but it has now become an independent organization.

International scientific community:
A large number of international agencies have been involved in the development of research programs, education, local empowered, purchase of lands for conservation, and the support of new economic activities, such as Ecotourism, or improved soil mangament. Some of the organisations include: the Canadian International Development Agency (CIDA), the World Wildlife Fund (WWF-Canada), the Department of International Development (DFID-UK), the International Institute for Economic Development (IIED),

5. 4 Government Sector

The involvement of government organizations in the area has been rather limited. In terms of conservation of forests, while the State's intervention around the country has been intense with the creation of National Parks, all the cloud forests in the catchments are protected through private reserves. The State's main role has been through the implementation of the Payments for Environmental Services Programme since the end of the nineties. The State provides basis needs for the community, such as water, electricity, communications, banking and education.

Table 6. Stakeholders: Public Sector

Name	Character	Activity	Description
Ministry of Environment (MINAE)	Government	Regulatory	Responsible for approving/assigning water concessions for hydroelectricity. Assigns permits for forest cutting and oversees violations to laws.
Arenal Conservation Area (ACA)	Government	Regulatory	Local administrative unit of SINAC and MINAE, comprising 204,320 ha of Arenal National Park, four protected areas, a national wildlife refuge and a buffer zone in which sustainable development is promoted.
Local municipalities	Government	Regulatory	Managers of local aqueducts. The Municipality of Tilarán has negotiated unsuccessfully with ICE arrangements for local people to share in the benefits of the Arenal hydropower system.
Acudectos y Alcantarillados (AyA)	Goverment	Domestic Water Provider	Provides domestic water in the Santa Elena community, and quality control advise for other local rural aqueducts.
Regulatory Authority of Public Services (ARESEP)	Government	Regulatory	Defines prices for electricity, domestic water use, irrigation, park entrance fees and other basic service tariffs.
Ministry of Health (MINSA)	Government	Regulatory	Defines policies for public health. It is the responsible for the enforcement of laws regarding to solid and water wastes disposals.
Educational sector	Public and private	Education	Community primary public schools, two secondary schools, and several language schools in the area.

5.4.1 Ministry of the Environment

The Ministry of the Environment (MINAE), originally created in 1987 under the name of Ministry of Natural Resources, Energy and Mines (MIRENEM), is the rector organization of natural resources in Costa Rica. In the mid nineties, MINAE created the National System of Conservation Areas (SINAC) with the aim of deconcentration and decentralization[16] the natural resources management. This organization has played a key role in the Payments for Environmental Services Programme. The impact of MINAE in Monteverde was invisible due to the isolation of the area and due to legimitation of the role of private natural reserves. Since the Environmental Payment Services program is growing, MINAE established last year an office in Santa Elena to implement and monitor the program as well as to put into practice the conservation policy of MINAE-SINAC.

5.4.2 Arenal Conservation Area (ACA). This government organization –within MINAE- influences Guanacaste and Tilaran range and part of San Carlos Flat lands. It is responsible for the use of the natural resources as well as its conservation. ACA is responsible for the protection and management of the Arenal watershed. It

[16] **Decentralization** involves the creation or revitalization of elected bodies at a lower level. It is unlikely to be successful unless some control over resources is ceded from the center to these elected bodies. **Deconcentration** involves a shift in operational power away from the central ministry to sub-units outside the capital. It may coincide with a redefinition of the scope of a ministry but such a change is not, in itself, an example of Deconcentration (Carney and Farrington 1998)
Academic sector CATIE and Universities

develops activities in three strategic areas: progress, control and protection of landscapes and their people. The progress area advises civilians to move towards sustainable progress by the appropriate management of the region's natural capital. The protection and control areas of ACA direct landholders and society in general to commit to control and protect the natural resources of the region.

5.4.3 Local Municipality. Monteverde area administratively belongs to Puntarenas Priovince but due to its isolation, the region grows and developed without major influence of the Municipality of Puntarenas. A local council went forward to a Municipality council since 2002. This local government is the process of capacity building for development. Since growth and development was expontaneous, the local municipality is the process of integration different sectors as well as different power forces.

5.4.4 Domestic Water Utilities:
Households in the area obtain their drinking water by a variety of ways. In Santa Elena waster is mostly provided by the State's provider Acueductos y Alcantarillados (AyA). Most surrounding communities obtain their water through rural aqueducts, with AyA providing technical assistance and quality control.

One identified problem that the area faces is the lack of watersheds management. The pollution of superficial waters from industry and household wastes is increasing as the population grows without control. Even though the different stakeholders are aware of this situation, little is being done to tackle it from an institutional point of view. Some private initiatives are taking place, with some degree of success. For example, the Cheese Factory and the Poultry Factory have some form of water treatment before it is deposited in the rivers -which are the main water source for downstream users. While local communities are aware and worried about water quality (see Focus Groups Report, 2002), there is still lack of personal engagement and commitment to improve household behaviour for waste management. In this respect, the Monteverde Institute is currently trying to obtain funds for household waste education.

The issue of water quality is pressing, and should be addressed by a combined effort of social organisations, communities, government utilities, the tourist sector, and other water users. Serious consecuences of not taking action today could potentially include the provision of long-term adequate water upstream, health problems for downstream water users, accumulation of harmful nutrients and chemicals in the lake, and landscape degradation with its implications for the tourism industry.

5.4.5 ARESEP. It is a public organization that defines prices for basic services as electricity, domestic water use, irrigation, national parks entrance fees and oil prices between others. There is not mayor community participation. Only in the case of the hydrological fee[17] there was a public.

5.4.6 Educational sector. The first elementary school in Monteverde was established by the Quakers. Nowadays, there are public primary schools in most communities around Monteverde, and two secondary schools, one in Santa Elena and the other in

[17] Consumer of water and electricity in San Isidro, San Rafael, and Heredia city paid an hydro fee to the utility company (ESPH) in order to protect upper watershed in North Heredia Mountain.

Guacimal. During the last years and as a result of the rapid migration into the area, a large number of private language schools have emerged, most of them for foreigners coming to learn Spanish. Higher-level education is now available through the Monteverde Institute, aimed towards foreign college students[18]. Other non-formal educational programmes, particularly environmental education, abound in the area, lead by NGOs, cooperatives and other organizations.

Box 3. The Quetzal Cam Project

The Monteverde Cloud Forest Preserve presents a fascinating example of the use of technology and education oriented to the conservation of the endangered Quetzal, through the installation of the QuetzalCam Project. This project began with the successful installation of a webcam in a Resplendent Quetzal nest and subsequent live broadcast to the web inside its natural habitat. Monteverde, Costa Rica, was selected because of the high quality of the local partners, the rich biological opportunities, and the existence of some infrastructure (offices, phones) near the forest (Cloud Forest Alive, 2003). The Internet-based project includes the fundamental objectives of demonstrating the social and ecological value of the Mesoamerican Biological Corridor's fragile ecosystems, for biodiversity and other important social purposes such as watershed management for water supply and electricity generation. This initiative has been development by the World Bank and its partners, under the auspices of the Mesoamerican Biological Corridor Initiative and with contributions from the Dutch government.

5. 5 downstream users

Table 7. Stakeholders: Main downstream water users

Name	Character	Activity	Description
Costa Rican Electricity Institute (ICE)	Government	Hydroelectricity	Control the Arenal-Corobici-Sandillar (ARCOSA) Hydroelectric complex, that feeds from waters from R.Chiquito microbasin. Supplies approximately 50% of national electricity.
La Esperanza Hydropower Co	Private	Hydroelectricity	Located on the Atlantic slopes (outside Arenal Watershed) but receives water from cloud forests in the upper parts of the watershed owned by MCL.
SENARA	Government	Irrigation	National Water and Irrigation System, feeds on water from the ARCOSA project and supplies water for the PRAT irrigation project in Guanacaste (over 15,000 ha of agriculture (mostly rice and sugar cane)).

5.5.1 The Costa Rican Electricity Institute.

Electricity and telecommunications are provided by the Costa Rican Institute of Electricity (ICE). While the role of ICE in the upper parts of the catchment has been limited to the provision of these services, their role in the lower parts of the R Chiquito catchment has included reforestation and restoration of degraded land, with the purpose of avoid erosion and sedimentation of the dam. It is important to note that instead of remoteness, any small town has at least a public phone and electricity.

[18] The MVI collaborates with universities from around the world to provide academic programs in tropical biology and conservation, sustainable development, political economy, architecture and community planning, gender studies, public health, Spanish, and Costa Rican culture.

5.5.2 National Irrigation System (SENARA). It is a public organization who handles irrigation and drain in Costa Rica. SENARA administrates several irrigation projects in the country, however, Irrigation Arenal -Tempisque District (DRAT) project is undoubtedly their main one. DRAT obtains its water capacity from ARCOSA's system, after the hydroelectricity is produced. The creation of DRAT had a social interest, where the local producers of the region could benefit from DRAT's water supply to fulfil the irrigation needs of their crops. For example, sugar cane, pasture and fruit. Several other smaller irrigation projects are being carried out by SENARA. Such as the irrigation project in the centre of the country and several drain system on the Caribbean and South West of the country.

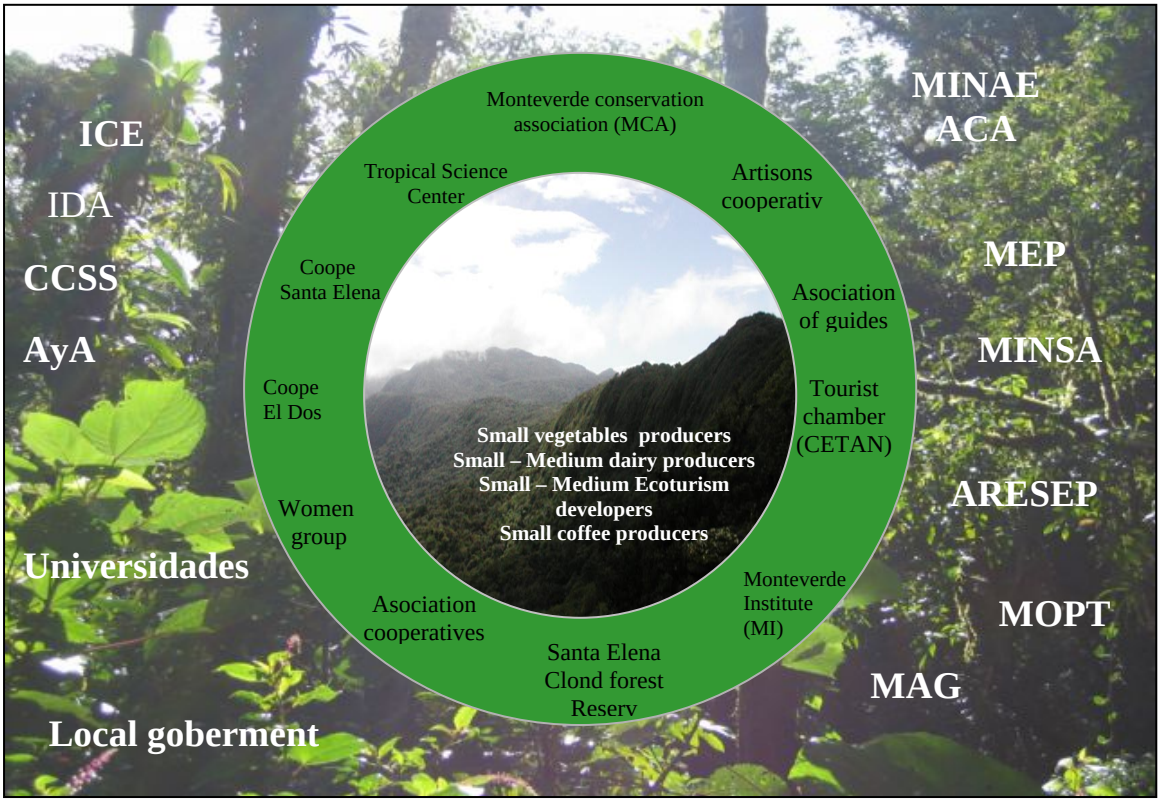
5.5.3 La Esperanza Hydropower Project is owned by Inversiones La Manguera (INMAN) a small and local hydropower company. It is a 6 MW run-of-river power plant towards North of the country. The Esperanza ´s watershed is located on the Children´s Eternal Rainforest, where ACM is highly involved in the conservation and preservation of the natural ecosystem. By the end of 1998 INMAN and ACM signed an environmental voluntary agreement to share effort in order to protect the watershed. According to the agreement ACM is responsible for the maintenance of the environmental services provided by the Childrens´s Eternal Rainforest. ACM should conserve the upper watershed of the Esperanza basin and protect the area against deforestation by illegal logging and squatting. INMAN will transfer an environmental service payment by financially rewarding ACM. The agreement included a fixed scheme. The amount of money to be paid is based on the production of the plant (Miranda, 2003).

5.6 Monteverde Stakeholders map.

From the former section we can draw an understable stakeholder's map for Monteverde´s area. Besides of local individual producers of good and services, there were identified a group of public and non public organizations. The public entities enclose all state organizations – autonomous and non autonomous – while the non public ones refer to private enterprise and NGOs without profitable objectives. Both types of organizations have specific and clear functions of local development.

Fig. 11 shows the monteverde stakeholders map. The core of the figure identifies the individual actors who offer goods and services, fallowed by the local non public organization which push and work for the local development. Finally, the out side of the figure visualizes the role of the state organization according to local perceptions.

Figure 11. Monteverde Stakeholders



6. Eco-tourism activities in Monteverde surroundings

The growth of tourism was one of the major economic and social changes that occurred during the last century in Costa Rica. The fact that the country has been proclaimed itself to be one of the main nature-tourism destinations in the world developed rapidly the eco-tourism in the country and particularly in Monteverde area. The development of a tourism infrastructure in the Monteverde region began in the early 1950s with the construction of the first shelter. Initially only nature scientists visited the region, but early 1980's a BBC documental showed Montverde's exuberant biodiversity to the world. Soon after, the number of visitors to the Monteverde Cloud Forest Preserve (MCFP) rose considerably. In 2000 almost 55,000 persons visited the MCFP (Burlingame, 2000b) instead of the difficult access to the zone.

Monteverde cloud forest and its surroundings offer a fan of possibilities to nature and adventure lovers. A butterfly garden, a serpentarium, an orchid Garden and a frog Pond, an ecological farm, and several canopy tours and walks are the most prominent spin-offs of tourism in Monteverde (Acuña, Villalobos, & Ruiz, 2000). The butterfly garden, the serpentarium, the orchid garden, the frog pond and the ecological farm show specific species of flora and fauna of the Monteverde region to the tourists. They aim for environmental education and work under legal restrictions that guarantee sustainability. Aventuras Aéras offers a mechanical ride over the canopies. The Canopy Tour, Sky Trek and Sky Walk also allow tourists to experience a 'Cloud Forest adventure'. The Original Canopy Tour, the Monteverde Canopy Tour and Sky

Trek all are canopy tours that use zip-line constructions. The Sky Walk consists of suspension bridges that stretch across valleys along a circular trail (Acuña, Villalobos, & Ruiz, 2000).

The ecotourism challenge has result in growth and change to Monteverde. Population has grown-up at rapid speed since the activity has a big and varied demand for labour, from the specialized entrepreneurial to the unskilled labourer. While the 1984 population census recorded approximately 600 people living permanent in the area, the new 2001 census records 6,783 inhabitants. Part of this migratory force is local. According to the local Chamber of Tourism Entrepreneurs (CETAM), approximately 30% of people from surrounding villages have migrated to the Monteverde area, and a good 80% of the local population are related in some form to ecotourism (Torres, CETAM's representative, per.comm 2003).

The environmental, social and economic balance of ecotourism activities in Monteverde region shows both advantages and drawbacks (Miranda, 2003)[19]. The protections of nature as well as the increase of environmental awareness are the main positive environmental impact of the activity. However, the construction of infrastructure, accommodation and other tourist facilities couldn't be done without some animal disturbance, some destruction of vegetation and habitats and changes in the food chains. Moreover, the lack of sewage system and poor solid waste disposition bring pollutions problems. The net impacts of ecotourism in Monteverde are shown in Figure 11.

Figure 12. The net impacts of ecotourism in Monteverde region

Economic impact	Social Impact	Environmental Impact
+	+	±

(+) Benefits dominate (±) both benefits and drawbacks are perceived

Source. Miranda, 2003.

According to Torres[20] the economic benefits of nature-tourism are clearly perceptible in the Monteverde region. This activity has created jobs, encouraged profitable domestic industries and generated much foreign exchange with perceptible multiplier effects. The local Chamber of Tourism state that approximately the 70% of the revenues produced by eco-tourism stay in the region or at least in the country since the activity belong mainly to locals. Inflation of local prices is one of the more negative effects of tourism in the area. Apart from this, seasonal variations in the demand for ecotourism facilities cause temporary unemployment.

Positive elements on the social balance are apart from the employment effects, the support given to local culture, the improvement of infrastructure and medical care, a growing interest in education and the empowerment of women. The large influx of migrants has also caused some social problems like an increased market access to

[19] Miranda, 2003 give a wide analysis of advantages and drawbacks of ecotourism development in Monteverde region.
[20] CETAM's representative, personal communication 2003

alcohol and an increase in crime rates (Miranda, 2003). Table 6 grouped positive and negative impacts of ecotourism in Monteverde region.

Table 8. Positive and negative impacts of ecotourism in the region of Monteverde

Impacts of eco-tourism in the Monteverde Region	+	-
Economic		
Tourism may give nature an economic value	**x**	
Nature protection and economic rationality might go hand in hand	**x**	
The development of tourism might stop further deforestation and deterioration of nature by the simple fact that nature and scenic beauty motivates tourists to come..	**x**	
Tourist spending generates foreign exchange in a region and diversifies and strengthen the local economy	**x**	
Traditional agricultural economies might be supplemented by new activities as hotels, restaurants, transport systems, souvenirs, handicrafts or guide services.	**x**	
Local people might even lose their resource base for farming. Such changes in the traditional economic order may make people more dependent on developed countries.		**x**
Drops in tourist arrivals will easily result in (seasonal) unemployment.		**x**
Social		
Increase of employment offered	**x**	
Support and promotion of local culture and a further improvement of intercultural understanding.	**x**	
Improved infrastructure, (medical) facilities and communication systems may also benefit the local people.	**x**	
Stimulate the development of local-level education programs, encourage community organization and empower relatively deprived groups like women.	**x**	
Ecotourism could alienate local people from their cultural roots and degrade traditional culture.		**x**
Exclusion of local people might also be feared if tourist facilities and other advantages are not accessible or too expensive for local people.		**x**
An indirect social drawback may arise when the provision of tourism infrastructure starts to compete with the people's basic social needs for scarce public funds.		**x**
It is also possible that social problems increase because of the influx of migrants or due to the increased access to drugs, alcohol, cigarettes and sweets.		**x**
Lastly, crime rates can increase because of the presence of tourists.		**x**
Environmental		
Indirectly consciousness-raising of both tourists and the local population may result in more ecologically sound behaviour and environmental benefits	**x**	
The construction of infrastructure, accommodation and other tourist facilities can result in land clearance, erosion, visual pollution, disturbance of animals, the destruction of habitats, changes in food chains and finally in a loss of biodiversity		**x**
The dumping of waste and discharges of wastewater may damage soil and water systems		**x**
Water shortage might occur due to an increased extraction of consumption water.		**x**
Among these indirect environmental drawbacks are the increases in air pollution and CO_2-emissions caused by transport and travel and the seasonal changes in population dynamics, which can be a source of extra stress on the environment		**x**

7. Reflections

Even though Monteverde region has advanced and is on the way of sustainable progress undoubting it has several challenges to face. Sustainable progress introduces a new thinking to the common understanding of sustainable development. Sustainable progress is a wider concept. Moreover all principles of sustainable development, sustainable progress refers to manageable society. It includes a process of change by trial and error in a multi-actor context (Miranda, 2003). Sustainable progress is a real participatory process. Different actors must be involved in diverse ways. Stakeholders must be present; they must have political incidence at local and national level.

Monteverde people are very proud about their spontaneous development and growth. At the moment even most local stakeholders group and civilians are proud of it, it is necessary to draw attention about several challenges that must face to continue going towards sustainable progress direction. Monteverde people have environmental, social and economic challenges to face. Environmental challenges are embedded in the identification of ecological limits and risks; if environmental risks are crossed social impacts appear immediately. Social challenges deal with how environmental and economic risks will be distributed among local and national society. Economic challenges are related to how quality of the physical environment could influence the market.

Environmental challenges. Monteverde has based its development and growth mainly on the richness of its natural capital and its scenic beauty. Because of that, it is important to draw attention to several environmental risks that were identified during the exploratory work. To mitigate and dismiss environmental risk is a challenge for Monteverde authorities as same as to different group of stakeholders and civilians. The main challenges could be grouped as fallow: preserving pristine and secondary cloud forest, to recuperate degraded cloud forest landscapes, to protect biodiversity and others landscapes than cloud forest, to ensure water for the different uses, to guarantee potable water to locals and tourist. To built a sewage system in order to warranty public health to locals and tourist. In general, Monteverde and its surroundings have to avoid environmental degradation in order to continue forward sustainable progress.

Social Challenges. One of the most important social challenges is to continue the process of interiorize in locals their social responsibility with nature. Monteverde is very rich in water resources but water pollution is a risk. There is a lack of waste disposal. Most of the restaurants, hotels, and any kind of business, dispose their wastes directly into creeks and rivers channels. Society in general must take awareness about its own responsibility with the environment. Visitors characterize Monteverde as a paradise where environment is part of every day live for every one but in reality it is not true due to lack of water disposal and sewage system. This social challenge transpasses its limits and become an economic challenge. The main advantage to achieve this social goal is that it is not an isolate activity. It is part of a process of building capabilities for sustainable progress. Public and not public stakeholders must coordinate and develop a participatory approach in order to go

forwards this challenge. To improve social and life conditions of locals is a shared responsibility.

Another social challenge for Monteverde is to avoid the lost of local culture. Local authorities must work very hard to maintain and enrich local life stile. External influence is very fast adapted for young people. Besides, general social problems related with economic growth must be taking into account in order to avoid major problems later.

Economic challenges. The main economic challenge for Monteverde authorities is to diversify its economy. It is excessively risky having ecotourism as the most import source of employment. External situation – like September, 11, 2001 – could origin an economic crisis in the area. Water markets could be an additional source of income for farmers placed upper Arenal Watershed but this kind of market have not been widely developed. Only a few landowners access the Environmental Services Payment. Through a participatory approach stakeholders must respond the following questions: What oriented changes in economic system are not only necessary but also feasible?, What kind of technology it is smart to develop? How technology must be develop, What kind of economy the community want?, How to encourage or discourage land use changes?, How to deal with negative externalities?, How to take advantage of positive externalities?, and How will markets develop. All together is a huge economic challenge for Monteverde people.

Finally, it is necessary to stress that for sustainable progress there are systemic as well as process prerequisites. Government and society have to be open to work and learn together. It is a social learning process that is not spontaneous or easy. Social learning is a process that is positive through interaction and communication between stakeholders with independence among them.

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8.1. Appendix: an Annotated Literature Review

Livelihoods and watershed protection markets

Although there have been a considerable number of watershed markets in several countries (Landell-Mills and Porras, 2002), little is really known and reported about the effect of these markets on local livelihoods and poverty reduction. Some of the possible benefits that are referred in the literature include income generation for suppliers, employment in watershed businesses, cost savings obtained from improved watershed protection and pollution control, direct benefits in the form of more stable hydroelectric services and spin-offs for forestry, agriculture, fishing and recreational activities. There are also some potential costs associated to watershed markets, particularly related to direct costs of providing watershed protection, transaction costs and opportunity costs associated with forgone land uses.

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> A census questionnaire to landholders in R Chiquito, applied by Aylward *et al* (1997) reported an average parcel size of 65 hectares, where property owners have been engaged in livestock production for an average of 14 years in their properties.

On average, the holdings had been converted to pasture starting 32 years earlier (i.e 1963). Land tenure can be classified as landowners (69.9%), farm managers (17.3%), renters (1.5%) and others (11.3%, which includes members of the owner's family, previous owners, or neighbours).

In general, respondents had a low socio-economic level of development, and relatively few of them have completed primary education. Thirty seven percent of the holdings surveyed had people living more or less permanently on the farm. There is a clear distinction between small landholders living on or near their property and those larger landholders (average holdings of 150 ha) living outside the area.

Livestock production include beef ranching (54% of holdings), dairy farming (18%) and a dual purpose operation that attempts to produce both (24%). The economic analysis of net returns to the activities varies substantially: returns to ranches over 80 ha in size come to $1,055/ha (in 1998 US$), while returns for those with less than 80 ha averages *minus* $581/ha. Most of the returns of beef ranchers were negative. Dairy farming was the most profitable activity, with an private opportunity cost of $1,020/ha and an economic opportunity cost[21] of $1,570/ha. Dual purpose returns were $308 and $551, respectively. A review of the location of the ranches show that the larger, more profitable ones, are located in the lower watershed, and a large number of the smaller and less profitable operations located in the interior of the watershed.

Water and resource degradation

According to Aylward and Tognetti (2001), the main concerns of stakeholders in the area were:

- erosion of landholdings due to livestock, having an effect in livestock stocking rates, productivity and profitability;
- sediments reaching the Arenal Reservoir, which can affect the dead storage volume and have subsequent effects on hydroelectricity and the irrigation project downstream;
- sedimentation of the lake caused by geologic factors (such as earthquakes); and
- diminished water supply from springs for productive and domestic uses (perceived to be a consequence of deforestation).

During the Initiation Workshop of this project (29 August 2002), one of the main problems that local stakeholders[22] perceived in relation to water was in terms of both water availability and quality for drinking purposes. Nitrate concentrates and the potential harms of uncontrolled urban expansion were signalled as some of the main threats to water in the region. Very little concern was expressed by the local stakeholders for sediments or soil erosion problems.

Aylward, B., Echeverria, J., Fernandez Gonzales, A., Porras, I., Allen, K., and Mejias, R. (1998) Economic Incentives for Watershed Protection: A Case Study of Lake Arenal, Costa Rica. Collaborative Research in the Economics of Environment and Development (CREED), IIED, London.

[21] Economic opportunity cost (also referred as shadow prices) includes adjustments for transfers, such as taxes and duties.

[22] Stakeholders include both producer and consumer groups: coffee, dairy, civil society (undifferentiated), womens groups, tourist board, cheese factory, plus more formal organisations and institutions, including local municipality, water board, ICE, FUNDECOR, FONAFIFO, PRAT, MINAE etc

Water is not generally included as a formal production system for landholders, rather they enter the equation as costs related with the maintenance of waterworks located in their landholdings.

When asked about land degradation and conservation efforts, half of the 120 holdings engaged in livestock production indicated that they felt the productivity of their land has declined over time, with the main declines being: wind (reported by 45% of respondents), dryness or drought (30%), growth of weed species (28%) and problems with soil fertility (25%). When asked whether they were undertaking any soil conservation measures, only eight respondents indicated that they were protecting existing forest areas as means of breaking the wind or protecting water supplies, while 45 respondents indicated that they had installed live fences and/or windbreaks. In general, disturbance to water availability was not really perceived as a problem related with livestock production.

Local scientific studies point out that pastures seem to contribute to higher levels of erosion and sediments in the watershed, however, the magnitude of the effect is not a common figure for all studies (see studies below). In relation to water yield and land use, there has been very little research done in the area, and relatively fewer series of reliable, long term data.

CCT. 1980. "Estudio Ecológico Integral de las Zonas de Afectación del Proyecto Arenal". Report prepared for ICE. San José, Centro Científico Tropical.

An ecological study of the areas affected by the Arenal Dam, commissioned by ICE. Estimates of erosion and sediments for forests, permanent crops, and pastures (2, 2, and 65 tons/ha/yr respectively). Results suggest that 96% of the calculated erosion is derived from pasture which is just under 50% of the total area. A second study using a different estimation method, also done by CCT, presents results for forests, permanent crops, pasture and annual crops (1.4, 18.2, 109, and 840 tons/ha/yr).

Hydroconsult, A.B. 1993. "El Embalse Arenal: Condiciones Generales, Problemas y Propuesta para un Programa de Estudio". Report prepared for ICE. Uppsala: Hydroconsult.

This study was done by A.B. Hydroconsultant, a Swedish firm, in collaboration with ICE, using information on run-off and suspended sediment yield. Results are presented for the micro-watersheds R Chiquito, Caño Negro and Piedras Negras, with resulting suspended sediments averages of 2.36, 0.98 and 0.81 ton/ha/yr respectively. This document reports a rather low figure for the R Chiquito watershed, and are considered rather conservative due to problems with data management.

Calvo, J. and Quirós, O. 1996. "Modelos de Predicción de Carga Media Anual de Sedimentos en Suspensión en Cuencas Rurales de Costa Rica". CREED Costa Rica, notas Técnicas #4. San José. CCT/CINPE/IIED

Commissioned by the CREED-CR project, 24 rural watersheds in the Atlantic and Pacific Zones of Costa Rica were selected and studied. The average erosion (tons/ha/yr) rated by land use in Arenal were estimated as: forests (3.7), pasture (11.63), perennial crops (85.32), annual crops (233.88) and denuded (992.14). A new estimate by micro-watershed presents average SSY (in ton/ha/yr) for: R Chiquito (3.8), Caño Negro (1.1), Aguas Gatas (1.7) and Arenal NW (6.8).

Vásquez A.; and Rodríguez, C. 1995. “Análisis de Erosión en la Cuenca del Río Chiquito”. Report prepared for CREED-CR. San José, Centro Científico Tropical.

Also commissioned by CREED-CR, using both predictive equations and fieldwork to assess erosion rates in R Chiquito. Results are (average tons/ha/yr): Forests (3.08), pasture (35.21) and tacotal (7.92). The authors also performed a field sampling of soil depth in adjacent pasture and primary forest sites, and conclude that USLE might not be an accurate tool for the simulation of erosion from sites with different slopes.

Jansson, M. 1996. “Investigations in the Arenal Drainage Basin: Subject Report No. 1 of the Arenal Reservoir Project”. Report prepared for SIDA, Uppasala: AB Hydroconsult.

Revision of Suspended Sediments Estimates for R Chiquito. The author critiques the methods used by ICE and using additional sampling campaigns and adjustments, and her results suggest a ten-fold increase for R Chiquito and a six-fold increase for Caño Negro over the suggested by Hydroconsultant (1993).

Saborío, J. and Aylward, B. 1997. “Análisis Espacial de Erosión y el Transporte de Sedimentos en Tres Micro-Cuencas de Arenal, Costa Rica”. CREED Costa Rica. Notas Técnicas #7. San José: CCT/CINPE/IIED.

Spatial model for sediment prediction in Arenal, By using the CALSITE model, to calculate erosion and suspended sediment yields, the authors estimate average values for the micro watersheds, and for pasture, primary forests and disturbed forests.

Fallas, J. 1996. “Cuantificación de la Intercepción en un Bosque Nuboso, Monte de los Olivos, Cuenca del Río Chiquito, Guanacaste, Costa Rica”. CREED Costa Rica, Notas Técnicas #6.

Horizontal precipitation in R Chiquito, Commissioned by CREED-CR, the study selected four sites in the upper watershed area of R Chiquito to establish monitoring plots for a yearlong experiment. Results suggest that forest fragments act as natural collectors of atmospheric moisture that would not have been obtained by these parcels in the absence of the forest. Due to the additional layers of understorey maintained by high forests, it appears that low forests are more efficient collectors. This study, however, does not quantify horizontal precipitation per se, but provides a measure of total interception.

Calvo, J. 1996. “Efecto del Uso de la Tierra y Estudios de Balances Hídricos para Cuencas Tropicales: con particular referencia al Embalse Arenal”. Report prepared for CREED Costa Rica. San José, CCT/CINPE/IIED.

Statistical analysis of water regime in R Chiquito and R Caño Negro. Using the TURC and Holdridge methods Calvo’s study concludes that with existing rainfall maps it is not possible to develop an understanding of the potential contribution of horizontal precipitation to run-off in Arenal.