2011/2012

Report on

Livestock, Environmental Services and Dis-Services:

Synergies and conflicts among different incentive mechanisms in Costa Rica

---

By Sébastien COSTEDOAT

Under the supervision of:

Céline DUTILLY-DIANE,

Economist at SELMET unit,

CIRAD (FRANCE)

&

Muhammad IBRAHIM,

Leader of the Livestock and Environmental Management program,

CATIE (COSTA RICA)

Acknowledgement

First of all, I would like to thanks Céline Dutilly-Diane for her personal implication all along of my internship. I am grateful for all her advices and the way she has motivated me at every time.

I am also grateful to Muhammad Ibrahim, who has given to me many material and intellectual assistance necessary to fulfill my work. In particular, I feel honored to be invited at the policy mix workshop and the international course on payment for environmental services.

I would like to thanks all GAMMA team and people from CATIE for their daily help and kindness. It's impossible to name them all but I am sure they will recognize themselves. I address a special thanks to all the team who has accompanied me in Esparza.

I have a particular message to all the persons which have participated to one of the three restitutions I've done. As they can see, their advices have been taken into account!

I want to thanks all people working both in CATIE and CIRAD that have given to me administrative and scientific support every time I have needed it.

Finally, a special message to all the CATIE students and interns, I have spent many good times with all of you and discover with pleasure Latin culture!

¡Pura Vida!

Keywords: Costa Rica, Ecosystem Services, Ecosystem Dis-services, Payment for Environmental Services, Sylvopastoral Systems

Content

Acknowledgement 1
Content 2
Summary 4
Glossary 7
Introduction 9
I) Review of the main incentives mechanisms in Costa Rica 13
A) Generalities on Payment for Environmental Services (PES) 14
a. What is a PES? 14
b. Current status of discussion around PSE 17
B) Costa Rican National PSA Program 18
a. Creation and evolution of the national PES program (PSA) 18
b. Elements of assessment of the PSA 19
c. Evolution of participants targeting 21
d. Development of new program modalities: Agroforestry Systems 22
C) The sylvopastoral PSA(PSA- GEF) 23
a. Project presentation and PSA-GEF functioning 23
b. Main lessons learned from experience in Costa Rica 26
D) The environmental program of the Public Utility Company of Heredia (PSA-ESPH) 27
a. Project presentation and PSA-ESPH functioning 27
b. Main lessons learned from experience in Costa Rica 30
E) The sustainable livestock certification project (Rainforest Alliance) 31
a. Certification at large 31
b. Program of sustainable livestock in Costa Rica (RA) 31
F) Indirect incentives mechanisms 34
a. ICE initiative 34
b. Other noteworthy initiatives 36
G) Comparing various incentives schemes for promoting livestock sustainability 38
a. Literature 38
b. General considerations about ES provision 43
c. Services generation of livestock activities in each program 45

II) Statistical analysis of farms which have participated to Sylvopastoral Program 55
A) Background 55
a. Context of the project 55
b. Hypotheses 55
c. Methodology 56
B) Description of farms in 2003 58
a. Group repartition between 2003 and 2011 58
b. Farm characteristics by group in 2003 60
C) Land Uses change during and after the program 62
a. Evolution of ESI score by hectare 62
b. Evolution of land composition 64
D) Variation between 2003 and 2011 66
a. Production systems 67
b. Elaboration of a typology 67
E) Discussion 75
F) Policy recommendation 76
Conclusion 78
Personal assessment 81
Bibliography 83
List of figures 85
List of Annexes 86

Summary

Ecosystem services (ES) are "*the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life*» according to Daily (1997). The concept comes from ecological literature but it has been introduced in economics with Costanza *et al.* (1997). In this report, ecosystem services and environmental services are used as synonymous. These services are usually classified in 4 categories (MEA, 2005): provisioning, supporting, cultural and regulating. Agriculture and livestock activities in particular, aim at providing provision of "*food, fiber and fool*" (Zhang et al., 2007). Agriculture relies also on a set of ecosystem services, considered as production inputs. But agriculture also receive and produce ecosystem dis-services (EDS) that "*reduce productivity or increase production costs (e.g. competition for water and nutrients by undesired species)"* (Zhang et al., 2007). At the same time, agriculture creates EDS using pesticides, or enhancing soil sedimentation.

Actual debates have shown that the notion of ecosystem services in itself is not accepted by all scientists, therefore many incentives program are criticized as well. Nevertheless, productive activities have been progressively taken into account in incentive mechanisms. For example, REDD program (Reduced Emissions from Deforestation and forest Degradation) has become REDD+ after taking into account sustainable forest management and sylvopastoral practices.

The mechanisms studied in this report are environmental incentives of various types. Classic environmental policies are focused on forest conservation. New innovative mechanisms try to take into account productive activities such as livestock production in order to mitigate negative impact on environment. Among these mechanisms, Payment for Environmental Services (PES) has been introduced in Costa Rica in 1997. It's an environmental policy run by a governmental agency, FONAFIFO (National Forestry Funds). The financial resources come mainly from an earmarked tax on gasoline. If forest owners are eligible, they sign a contract containing a management plan. In exchange, they will receive an annual payment during several years (from 3 to 10 years according to different modalities). PES concept has also been used by other organizations at smaller scale. For example, a public utilities company, ESPH, has introduced a local PES which objective is to preserve forest cover in a watershed. Also, Global Environment Facility (GEF) has funded a local PES to introduce

sylvopastoral systems among small livestock farms. Two other incentives are studied: one is run by the national company of electricity (ICE) and propose training and inputs to farmers in order to improve their practices and reduce soil sedimentation. The last mechanism is a project of sustainable livestock production certification which would propose a price premium to farms with good environmental practices.

All these mechanisms are focused on specific ecosystem services or dis-services. It's necessary to understand how they improved ES provision (or EDS reduction) and which incentives are received. To do so, each mechanism is described using typologies adapted from conservation policies literature. We confirm that there are conceptual and practical differences between restrictive mechanisms and asset-building mechanisms. First ones aim at preventing some practices or land uses while second ones are in fact an investment to improve practices or land uses. Asset-building mechanisms seem to be more compatible with livestock activities: by financing a transition, they give the producers new capabilities to increase their profitability using sustainable practices. Besides, asset-building incentives are supposed to be temporary while use-restricting incentives need generally to be renewable.

We have check this hypothesis using GEF "sylvopastoral PES" data. These data contain information on land uses and socio-economic situation of farms before, at the end and 4 years after the program. Our conclusion is that most of the improvements which have occurred during the project remain stable even in the absence of incentives. In our sample, more than half of the sample has continued to improve land uses after the project. However, 15% of farms have more degraded land uses than at the end of the program. But, this group of farms has had better performance than average during the program. So, considering all farms, all of them have more sustainable land uses 4 years after the program than before.

Our second hypothesis is that incentive mechanisms don't affect farms in the same manners if we consider farms characteristics. For example, different production systems (meat, milk or double purpose) or different farm size imply different land uses. It appears that dairy farms adopt a land use able to provide more ecosystem services (in term of biodiversity protection and carbon sequestration). Indeed, these farms have a higher forest cover and a lower proportion of pasture than average, even before the implementation of the program. Considering farm size, we can notice larger farms had more degraded pasture (pasture with erosion) but not a higher proportion of forest than average before the program. Hence, larger farms have better performance during the program. In fact, they converge to average situation

in terms of ecosystem services provision but their initial situation was more degraded than average.

Data analyses have shown that 18% of farms have changed their production system since the beginning of program: they were meat producers and have become dairy or double purpose producers. This dynamic was not an aim of the sylvopastoral program but we consider this as our third hypothesis: Farms which have had the best performance during the program have invested the payment in more productive farm activities, especially milking cows. Our econometric estimation doesn't confirm this hypothesis: price ratio variation (which compares milk and meat prices before and after the program) has a significant impact on this change while program performance has no significant impact on change in production system. Moreover, initial land use has a significant positive impact on this change which means better the land use was, more probable a meat producer will change its production system.

However, a better land use doesn't mean a better impact on environment. Indeed, more farms are using concentrates to feed their herd. If we consider total ecological impact, we can't be sure that improving land uses or practices in a farm is better in terms of resources use. In terms of carbon equivalent, importing inputs could be worse than keeping intensive production systems. Indeed, a total ecological performance should be asses through a life-cycle assessment in order to take into account consequences of producer's choices in their farms as well as in all the value-added chain.

Moreover, a big issue comes from the scale of implementation of project. In ecosystem relations, farms are not necessarily the appropriate units. Ecological literature prefers analyzing ecosystem services at landscape level. Indeed, practices and land uses implemented on a farm have an impact on neighbor farms. Future incentives program could take into account this scale implementation (which is actually considered in programs focused on a watershed), as proposed by Le Coq (2011) with the notion of "*landscape labels*".

Glossary

CATIE (Centro *Agronómico Tropical de Investigación y Enseñanza):* Tropical Agronomic Center for Research and Teaching is a leading regional center involved in scientific research, education and technical cooperation on Latin American and Caribbean rural communities. It is based in Costa Rica. Its objective is to improve rural livelihoods through competitive and sustainable practices, with a focus on the interaction between natural resources and agricultural activities.

CIRAD (*Centre de coopération Internationale en Recherche Agronomique pour le Développement*) : Research Center on Agronomic for Development is a French research center involved in agronomic and development issues in developing countries.

Ecosystem Services or Environmental services (ES): The two terms are often used as synonyms (it will be the case in this report). However, Ecosystem Services refer, in biological and ecologist literature, to ecological functions furnished by vegetal and animal species. Environmental Services is more used by economists when they deal with interaction between mankind and nature, for example climate change, hydrology or forest conservation.

Ecosystem Dis-Services or Environmental Dis-Services (EDS): The notion is very recent and is focused on the interaction between agriculture and environment. EDS are ecological flows which create productivity losses in agricultural practices. This concept covers also environmental pollution created by agricultural activities.

GEF (*Global Environment Facility*): The GEF is a multinational financial organization involved in financing projects to improve global environment. It provides grants to developing and transitional countries to implement various environmental projects.

Land use: Land use refers to the typology defined in the GEF-Sylvopastoral project which describes the land cover which can be seen in the farms in the area of the project. In this report, the main difference is between land covered by trees, land covered by pasture and land covered by crops.

Sylvopastoral systems (SPS): According to Rainforest Alliance, they can be defined as "*land use practices which involve the deliberate combination of trees and animals on the same land*

management unit in some form of spatial arrangement or temporal sequence so as to have ecological and economic benefits". SPS are a component of Agroforestry systems.

Pago Por Servicios Ambiantales (PSA): English translation of Payment for Environmental Services.

Payment for Environmental Services or Payment for Ecosystem Services (PES): a PES is a contract that proposes a payment to land owners in exchange of the respect of pre-defined environmental conservation or environmental improvement. Various schemes exist all over the world, in particular in Latin America. It's important to make a difference between PES, which are contracts, and environmental or ecosystems services, which are scientific concepts. The 2 notions are not necessarily associated.

Production system: In this report, production system refers to the type of production adopted by a farmer. It can be dairy farm, double purpose farm or meat producer.

REDD (Reduced Emissions from Deforestation and forest Degradation): REDD is an international mechanism functioning on the principle that developing countries should be rewarded if they protect their forests instead of cutting them. The aim is to implement forestry project to reduce carbon emissions. The more recent version of the mechanism is REDD+ which include reduction of deforestation and forest degradation as well as forest conservation, sustainable management of forests and enhancement of forest carbon stocks.

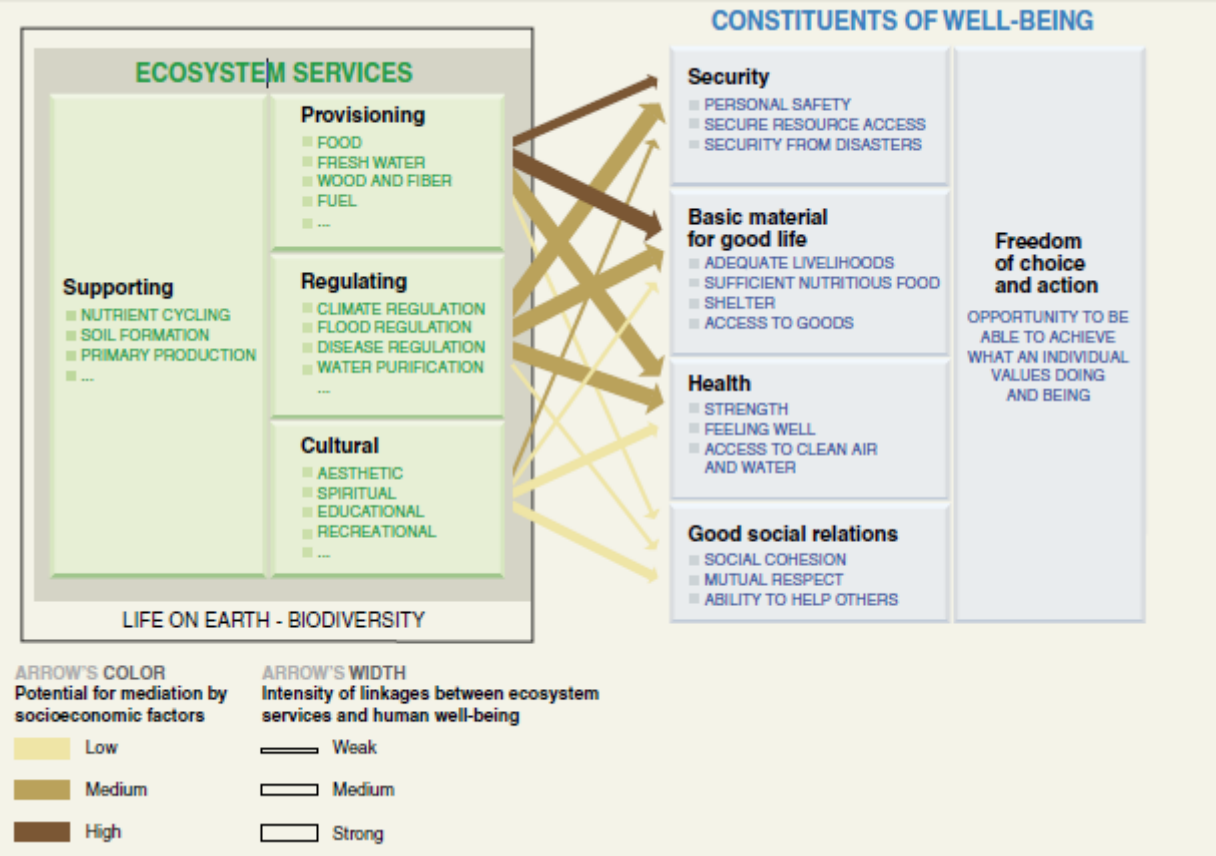
Introduction

Deforestation is a global issue: it is estimated that 20% of total greenhouse gas emissions comes from deforestation and forest degradation. However, forest policies were not taking into account in the elaboration of Kyoto protocol in 1997. This means that no financial incentives to forest could be according trough Clean Development Mechanisms (CDM). These mechanisms are in fact emission-reduction projects implemented in developing countries. The REDD initiative (Reduced Emissions from Deforestation and forest Degradation), launched at the United Nations Framework Convention on Climate Change in 2005 aims at creating markets to give a financial value to carbon sequestrated in forests. Tropical forest conservation becomes then eligible to be considered as CDM projects. Actually, according to UN-REDD program (The United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries), "*REDD+ goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks"*. The consequence is that actual financial incentives aren't exclusively focused on forest conservation but rather on sustainable use of forests.

In 1940, the forest cover in Costa Rica represented about 75% of total land. But, between 1950's and 1970's, the forest cover has dramatically reduced: according to FONAFIFO, it represented 31% of the total land cover in 1977 (and only 21% in 1987, which represent the proportion of National Parks at this time). Kaimowitz (1997) attributes this deforestation to the development of road network, to the financial incentives for livestock production and to the property regime. The authorities implemented fiscal incentives to protect forest during the 1980's in an economic context more favorable to tourism than agriculture, as pointed by Zbinden and Lee (2005). Initially, the major incentives used were income tax deductions and tax offsets, but also credits and municipal forestry funding. These programs were harmonized in the 1990's with a focus on promoting the interventions effectiveness and a major participation of small forest-owner as stated by Forestry Law (7174). Confronted to severe budget restrictionss and negotiating a structural adjustment plan in the middle of the 1990's, Costa Rica has renounced to these programs. The new Forestry Law (7575), adopted in 1996, created the National Fund for Forestry (FONAFIFO in Spanish) which was in charge on one hand of financing forest management and reforestation and on the other hand to seek funds

and finance environmental services provided by forest. This law confirms that clearing a forest is forbidden.

Figure 1: Ecosystem services and constituents of well-being

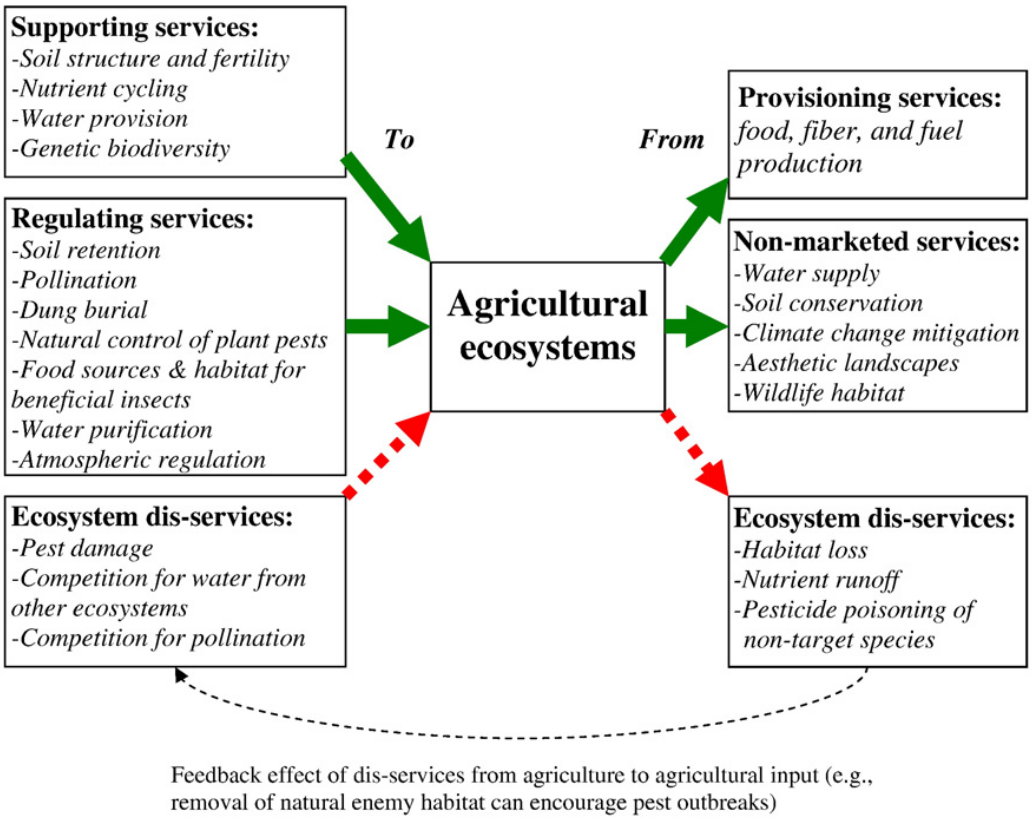


Source: Linkage between Ecosystem Services and human well-being, MEA (2003)

The notion of Ecosystem Services (ES) appears in the ecological literature with Daily (1997) who defines them as "*the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life*". This concept was introduced in economic literature after the article of Constanza et al. (1997) who tried to evaluate in economic terms the total world ecosystems services. The Millennium Ecosystem Assessment (MEA) has done a synthesis of the world's ecosystems services in 2005. MEA considers ecosystem services as "*the benefits that people obtain from ecosystems*", in particular in the aspect of Provision, Regulation, Culture and Support (figure1). The assumption is that Ecosystem Services are constituents of human well-being (Security, Basic material for good life, Health, Good social relations and Freedom of choice and action. Although the concept of ES is not stabilized, we will distinguish in this study the ES and ES following (FAO, 2007) definition: "*Environmental Services are only the services that provide welfare to humans*

without being accounted as traditional goods and services. [1] In fact, FAO definition doesn't take into account Provisioning services defined by MEA.

Figure 2: Ecosystem services and disservices to and from agriculture



Source: Ecosystem services and dis-services to and from agriculture (Zhang *et al.* , 2007)

Recently, the study of the links between agriculture and ecosystem services (figure 2) have led to the elaboration of ecosystem disservices (EDS) concept (Zhang *et al.* , 2007; Dale and Polasky, 2007; Power, 2010). Zhang considers the ecosystem disservices as ecosystem flows that "*reduce production or increase production costs*". He identifies crop pests, competition for resources (water, sunlight and nutrient resources from soil and pollination). Agriculture can as well generate disservices as habitat losses, nutrient run-off or pesticide poisoning of non-target species. Dale and Polasky are following the same perspectives when they try to study "how agriculture impacts ecosystem services, which in turn affect agricultural productivity". Power (2010) identifies the following disservices "loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species". He considers that maximizing provisioning

[1] To see a synthetic work on the historical evolution of ES in economics, refer to Meral (2010).

services from agrosystems can create trade-offs with other ES such as regulating services, which can be illustrated by the fact that deforestation reduce carbon sequestration . The key is then to develop good practices, which results from a good analysis of temporal and spatial framework that allows to reduce these trade-offs as well as to improve synergies among ES.

Among these practices, agroforestry has been seen as an adapted solution in Central America and organization like CATIE have participated in the implementation of agroforestry systems in the region (Budowsky, 1987).The aim is to maintain trees and shrubs on farmland in an integrated approach to improve the productivity and the sustainability of the land. Among these systems, "shade" coffee and live fences are usually know in agricultural practices but agroforestry systems can be also viable with livestock production if they are implemented in a way which allows positive synergy.

Our work is focused on livestock activities, and in particular bovine husbandry in Costa Rican farms. Livestock activities are generally considered as a cause of deforestation in Latin America. In the context of Costa Rica, forest cover is increasing according to FONAFIFO data (from 47% of total land cover in 2000 to 51% in 2005). Obviously, it seems difficult to increase forest cover at higher level. So, new potential for tree plantation could be among farms, with the implementation of agroforestry and sylvopastoral practices for example. Agroforestry systems (SAF in spanish) are a combination of wood resources (trees and shrubs) with agricultural or livestock activities. For example, shade-coffee plantation, trees in pasture, live fences, windbreak trees, fodder banks or sylvopastoralism. These systems could have economic impact for the producer as well as environmental benefits: they can reduce soil erosion and have a positive impact on biodiversity conservation. Moreover, they provide shade, which can have positive impact for both herd and crops.

The aim of this work is to describe different incentive mechanisms implemented or under development in Costa Rica in order to assess their capacity to improve sustainable livestock production. The description will present the context of implementation and the objectives of each instrument. Based on this description, a conceptual comparison will be proposed adapted from Wunder (2005) classification and a matrix of comparison will be built. Existing literature generally describes and compare forest conservation incentives. We will consider instruments related to Ecosystem Services provision and Ecosystems Dis-services reduction among livestock agroecosystems. Based on the comparison of mechanisms, we will formulate

hypothesis about the possible adaptation of each mechanism to specific farm profile. Indeed, we assume that incentives program don't affect farms in the same manner. If farms have different characteristics, their response to the incentives will be different. Some of these hypotheses will be tested using data from a Global Environment Facility (GEF) project implemented in Costa Rica. These data are composed of initial socio economics survey before project implementation but also land use monitoring during the project and finally data from a 2011 survey containing land use and socioeconomic information. These data will also be used to describe land use changes during and after the incentives, in order to assess their durability. We will compare evolution of land use, herd characteristics and production systems to describe relative impact of incentives and relative prices on these evolutions.

I) Review of the main incentives mechanisms in Costa Rica

Costa Rica has been a pioneer in environmental policies with the implementation of its national Payment for Environmental Services program. Nowadays, various mechanisms exist in the country. They are implemented by different organization and they are not targeting the same services. We will briefly present the concept of PES before presenting different PES and other environmental mechanisms implemented in Costa Rica. Initial mechanisms were mainly conservation policies but we will study each program modality regarding livestock activities. Livestock production has been considered as a cause of deforestation but actual policies seem to consider them as potential ES providers. We will then propose a comparison of these mechanisms using various criteria. Starting from existing conceptual and empirical comparison of some mechanisms with PES, we will formulate a comprehensive matrix on ES and EDS targeted by each programs. Next, we will propose a financial decomposition of advantages and costs implied by different programs modalities. Finally, we will elaborate some hypotheses about the adaptation of some programs with different farms typologies.

A) Generalities on Payment for Environmental Services (PES)

There are various PES mechanisms implemented in Costa Rica. We will first present conceptual aspects of these mechanisms before comparing them.

a. What is a PES?

According to Wunder (2005), PES is:

> *"(a) a voluntary transaction where*
>
> *(b) a well-defined environmental service (or a land use likely to secure that service)*
>
> *(c) is being 'bought' by a (minimum one) service buyer*
>
> *(d) from a (minimum one) service provider*
>
> *(e) if and only if the service provider secures service provision (conditionality)."*

The basic mechanism (figure 3) "*is based on the beneficiary-pays rather than the polluter-pays principle*" (Pagiola, 2008). To illustrate this definition, we can consider a region where peasants want to deforest lands in order to implement pasture. Peasants are recognized to be the owner of these lands and clearing forest will allow them to increase their income coming from livestock activities. A forest owner is considered as an ecosystem manager, and more particularly as an ecosystem services provider. It is assumed that forest provide relatively few economic benefits for the owner, who is tempted to convert his land to crops or pasture. The populations who benefit the ecosystem services, for example water services downstream if landowner is situated upstream of a watershed, are ready to pay for conserving them. The amount of calculated by taking into account the opportunity cost of converting forest to other productive land use (minimum payment to ensure the willingness to accept of the owner) and the value of ecosystem services received by population (maximum payment corresponding to the upper limit of willingness to accept of the ES beneficiaries).

This strict Wunder's definition has little direct application but is used as a theoretical framework to analyze different mechanisms aiming at reducing an environmental externality

such as deforestation, soil erosion or water pollution[2]. When we refer to PES, we are using Karsenty's definition in order to include national PES program. Indeed, a huge part of funds come from taxes, so we are not totally able to talk about a voluntary transaction. Wunder (2005) considers 3 major distinctions (figure 4) among the variety of existing PES schemes: "*area- vs. product-based schemes, public vs. private schemes, and use-restricting vs. asset-building schemes*" while Wunder (2008) affirms that the major difference is between user-financed programs and government-financed programs. If we consider the vehicle used to target Ecosystem Services, we can identify two groups of PES types: the one with focus on the area, involving for example a contract on forest conservation; and the ones related to the product, with a green premium paid by the consumer in exchange of pre-established conditions of production, for example a certified wood. In our analysis, certification and PES are two different mechanisms, so product based PES are in fact considered as a certification program.

Another difference between PES is the identification of the ES buyer: in some cases, the buyer is represented by a State (and collect taxes or grants to pay ES "managers") and in other, consumers are supposed to pay directly ES. In general, public schemes are implemented in large scale while private schemes are mainly local, for protection of local watersheds by an utility company for example. Finally, the condition to receive payment can be either to limit or prohibit land use responsible of ES gap or to establish new assets, like planting new trees in a degraded area.

[2] We can find sensitively different definition in Karsenty (2007) :"*PES is a payment to an agent for services provided to other agents (wherever they may be in space and time) by means of a deliberate action aimed at preserving, restoring or increasing an environmental service agreed by the parties*" but also in *FAO(2011):* "*A PES scheme can be put in place when:*

(a) the demand for at least one ecosystem service is clear and financially valuable to one or more 'buyers';

(b) the provision of ecosystem services is threatened, but the adoption of specific land-use/management practices has the potential to address the supply constraints;

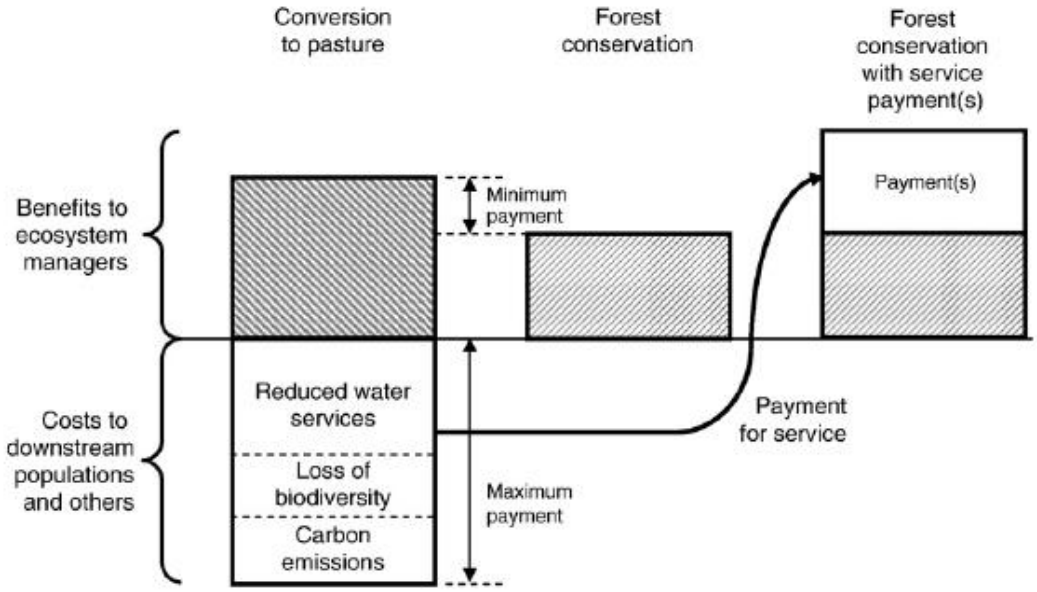
(c) a trusted intermediary is available to assist both parties in developing the negotiation and provide expertise in the PES design;

(d) clear criteria are able to be established to ensure compliance of the contractual agreement by both parties; (e) land tenure and usage rights are clear; and

(f) there is a cross-sectoral coherence between existing policies and laws and PES requirements.".

As we can see, there are various schemes possible. Indeed, PES schemes exist all over the world and are conceived to answer to a specific situation at economic, social, environmental and institutional levels.

Figure 3: Principle of PES in a context of forest conservation



Source: The logic of PES. Engel,Pagiola and Wunder (2008) adapted from Pagiola and Platais (2007)

Figure 4: Different PES types

Criterium	Difference	Specificity	Example
A: Vehicle used	A1:Area-based	land and/or ressources caps stipulated	Forest conservation
	A2: Product-based	certfied production scheme	Certified wood
B: ES buyer	B1: Public	State is ES buyer	"National" PES
	B2: Private	buyers pays directly	Local PES
C: Condition of payment	C1: Use-restricting	payment according to conservation-opportunity cost	Impeaching tree-cutting
	C2: Asset-building	restore an area's ES	Planting new trees

Source: Author, adapted from Wunder (2005)

b. Current status of discussion around PSE

According to Wunder (2008), "*numerous PES and PES-like initiatives are being implemented, at a wide variety of scales ranging from small watersheds to entire nations*." Indeed, the mechanism exists in both developed and developing countries and is implemented by different organizations: enterprises, governmental agency, NGO… They are generally conceived to respond to a specific environmental threat (e.g. water pollution or deforestation) but hey can include other objectives like poverty reduction or agricultural practices improvement (see Wunder, 2008 for some case studies in developed and developing countries). Furthermore, the institutional context and the financial resources are very different across the countries. Wunder (2008) argues many mechanisms are hybrid program and not pure PES but the actual evolution seems to show a conversion to user-financed PES in place of government-financed PES with a more targeted and differentiated approach, able to respond to local conditions. Nevertheless, the major task is to find financial resources to implemented payments and improve efficiency and effectiveness of the programs, notably by reducing transaction costs and refining monitoring.

PES programs have become very popular during the 2000's, in particular with the work of Stefano Pagiola, economist in the World Bank's Environment Department: many scientific articles have been published and a lot of project implementation has taken place. Based on numerous case studies, authors like Pirard et al. (2010) call for a critical analysis of these programs in order to increase long-term environmental benefits. Following Karsenty (2007), an innovative approach proposes to consider PES as an investment mechanism able to promote ecological intensification. Recently, FAO (2011) has analyzed the role of PES in agriculture by comparing case studies. As the notion of ES is not stabilized in itself, it's difficult to assess efficiency and effectiveness of these mechanisms. We consider them as institutional incentives aiming at improving environmental protection. But, depending of the context of implementation, they can also be used to reach other objectives such as poverty reduction or gender equality.

We will now describe different mechanisms existing or in project in Costa Rica and see how they can be adopted by livestock farmers.

B) Costa Rican National PSA Program

In Costa Rica, at least three PES programs can be found (figure 5). The initial PES program has been implemented by a governmental agency. It's a national PSA program promoting forest conservation. This initiative has been followed by two similar programs: one has been introduced by a hydro electrical company (*Empresa de Servicios Publicos de Heredia*, ESPH) on a watershed: it's a local PSA promoting forest conservation. Another one is a pilot project promoted by the Global Environment Facility (GEF): it is focused on agroecosystems and wants to promote their evolution toward more sustainable land uses.

Figure 5: Comparison of some PES programs in Costa Rica according to Wunder(2005)

	National PSA (FONAFIFO)	GEF PSA	ESPH PSA
Scale	National	Pilot (local)	Local
Vehicle used	area based	area based	area based
ES buyer	public	public	private
Condition of payment	Conservation modality :use restricting Reforestation modality : asset building SAF modality :asset building	asset building	Conservation modality :use restricting Reforestation modality : asset building

Source: Author, adapted from Wunder (2005)

a. Creation and evolution of the national PES program (PSA)

The national PES program is run by a government agency, FONAFIFO. This program wasn't created *ex nihilo* as several; incentives to reduce deforestation were in place since the 1970's (Pagiola, 2007). But the PSA program was innovative for two reasons: first, Forestry law 7575 explicitly recognizes four environmental services provided by forest: (a) carbon sequestration, (b) protection of watersheds, (c) biodiversity conservation, and (d) the provision of scenic beauty. The incentives were therefore no longer considered as a simple support to the forestry sector but were conditioned to the provision of environmental services.

The forest owners have the right to be compensated for the provision of these services. Second, FONAFIFO was funded by an earmarked tax and payment from beneficiaries and not simply by a budget allocation, it's an agency and not a simple office in a Ministry.

Initially, timber plantations, sustainable forest management, and forest conservation were the three modalities able to receive payment. The forest management modality was suppressed in 2000 because of opposition coming from environmental NGO about the efficiency of this modality. A payment for agroforestry systems (AFS) was introduced in 2003, then a payment for natural regeneration in 2005, when the knowledge about carbon sequestration was sufficient to consider these land cover as ES providers.. The resources come from an earmarked tax (3,5% of income related to national oil tax) but FONAFIFO has received a loan from the Global Environment Facility (GEF) and grant from KfW, a German agency for development. FONAFIFO has also developed voluntary participation by selling Certificates of Environmental Services (CSA in Spanish) and signing agreement with national enterprises. PSA has considerably evolved, due to the increased FONAFIFO experience and partners suggestions. The first phase is considered as experimental, with a "first come first serve" principle but it is stated that after 2001, the program is more targeted and include socio-economic preoccupation such as the participation of women or the inclusion of areas with low development index.

b. Elements of assessment of the PSA

1) Efficiency and additivity

The determination of the amount of payment per hectare is based on the opportunity cost methodology (considering the risk of conversion from forest to pasture) but the rule of calculus is not public.

Besides, it's not clear that there is a risk of deforestation in all the country, firstly because forest clearing is prohibited by law and wood selling is submitted to a legal authorization (Costa Rican State is recognized to have the capacity to enforce the law). We also have to take into account that in many parts of Costa Rica, agriculture, at least livestock production, is declining and the extensive model is not yet used by farmers (Kaimowitz, 2008).Nevertheless, cash crops like pineapple or coffee are developed quickly when international prices are high,

but these crops are planted in former pasture land, not in former forest, so actually, they can't be considered as a cause of deforestation. Also, in some part of Costa Rica (mainly in touristic areas and near San José urban area), the major threat in land use competition is likely to be urbanization more than agriculture. Therefore, is the opportunity cost methodology applied to risk of extensive pasture is appropriate? Livestock production is considered as an activity with relative low profitability, so the amount of payment can be considered as lowest that the potential level of payment. But, according to FONAFIFO, they are actually able to propose a contract to only a third of applicants, which means there are actually more people interested in receiving a payment that the budget capacity. Therefore, as proposed by Legrand (2011), increasing level of payments would produce more inefficiency (from an economic point of view). As Pagiola (2007) argues, we can't see real opportunity costs, and the concept is more used to determined low limit in the owner Willingness To Accept (WTA) than a concrete rule of determination of payment. Moreover, in the first years of PSA program, the amount of payment by hectare was very similar to the amount of payment by hectare in the previous subsidies mechanism. To synthetize, prices are too low to compete with major potential causes of deforestation but high enough to be acceptable for applicants. It could then be interesting to analyze the program as an adverse selection situation: if we consider that a farm is facing severe risk of deforestation caused by a willingness to cultivate cash crops, the payment proposed by FONAFIFO would be probably insufficient. Farms which enter PSA are the ones with limited risk of deforestation, as they don't really have opportunities to cultivate other crops. We lack of elements to conclude on this point, but as it has been affirmed, law impeaches the deforestation. So, if the main objective of the payment is to help owners to respect the law, refusing to enter the program means that costs associated to enter the program are not fully compensated by the payment itself. To summarize, the program is suspected to suffer from non-additivity problem.

2) Transaction costs

FONAFIFO works in collaboration with a network of environmental and forestry NGO (CODEFORSA and FUNDECOR are the main ones) which help owners to make a demand. Their expertise is recognized at national level as forestry regency (*regentes* in Spanish) and the procedure to follow is composed of three steps:

1) Pre-application sent to FONAFIFO with requirements specified after.

The pre-application is checked to verify legal requirements, against the national priority areas, and existence of funds for the payments. FONAFIFO had direct on-line access to the Land Register Office, which speeds up the verification.

2) FONAFIFO is bound to give a reply within ten working days.
3) A forest independent official, named *regente* is mandated (at the charge of the owner) to elaborate a technical study which include areas of forest, number of trees to be planted, geolocalisation of the forest, and a management plan.

As we can see in Annex 5, the requisites to enter the program are very important and are a limitation *de facto:* the transaction costs are relatively high for the small and medium owner. Moreover, not all the forest owners have legal titles of their property, and it could be costly to obtain it. Finally, some owners can refuse to enter the program in order to not paying land taxes. Indeed, they need a legal property title to enter the program. If they regularize their situation, they will have to pay land taxes. An easy critic of PSA program could be that a big and well-informed forest owner has a probability more important to enter the program, but based on its experience, FONAFIFO has established criteria to prioritize access to owner with more potential (and also to limit the number of potential participants). The criteria to enter are presented in Annex4.

c. Evolution of participants targeting

Following Sanchez-Azofeifa *et al.* (2006), we can distinguish 2 phases in the national PSA program. The first phase (1997-2000) was the experimented one. There were no specific criteria in the attribution of payment, which means that people who have the information were the most able to enter the program, with a "*first come, first served*" principle. The impact on deforestation was considered low. One of reason given was that the areas under contracts were not the ones threatened by deforestation. The second phase (2001-today) correspond to the implementation of Ecomarkets project with a better targeting, and social objective such as the participation of women and indigenous communities. Moreover, seven regional offices have been open, in order to be closer to rural areas.

Robalino and al. (2011) concludes that between 2000 and 2005, "*the reduction in yearly deforestation ranges between 0.6 and 0.7 per cent of the land enrolled in the program*". The

mechanism is very popular and FONAFIFO has proven it is possible to implement it in a developing country. Even if there is a large consensus on the success of the agency, there are also challenges: do they have to increase participation? But who will be able to pay? Have we reached the maximum of potential in terms of reforestation? Does the mechanism is justified if there is no proven threat of deforestation? The new additional tree cover potential seems to be inside the farms, with the implementation of agroforestry systems and in particular sylvopastoral systems.

d. Development of new program modalities: Agroforestry Systems

As we can see, PSA program is not explicitly focused on farmers. FONAFIFO was criticized during the first year of PSA implementation because only important forest owners were in fact able to participate to the program. In order to reach socio-economic objectives and to increase small owner participation, FONAFIFO has implemented a payment focused on agroforestry systems in 2003. SAF have been recognized to have the potential to generate ecosystems services and hence are able to receive payment from FONAFIFO. The main problem is that shade reduces grass density around tree but global impact on biodiversity and carbon sequestration is positive.

The payment is of 1,30 $ by tree, distributed in 3 years, the contract are for minimum 350 trees and maximum 3500. In 2010, more than 500 000 trees have been planted through this modality. The payments are not applicable to fruit trees and there are no differences according to the production system: farmers receive the same payments in grazing pasture, in cropland or in coffee plantation.

This modality is considered as a positive evolution by agricultural sector, because the initial philosophy of FONAFIFO was to consider forest and agricultural land as strictly opposite land uses. With this modality, the philosophy has changed to an interaction between forest and agricultural activities. The two activities can be complementary and with adapted incentives, livestock producers can participate to ES provision as well as ordinary forest owner. Nevertheless, we have to keep in mind that planting trees to farmers: a tree reduces superficies of land and when the tree grows, the shade impeaches sunlight to reach soil, which reduces grass density. Indeed, the tree density has to be limited, in particular in crops area. In

pastures, planting trees implies important costs associated with the necessity to protect tree in the first years, in order to not being eaten by animals. Currently, around 5% of contract signed by FONAFIFO are SAF payment.

C) The sylvopastoral PSA(PSA- GEF)

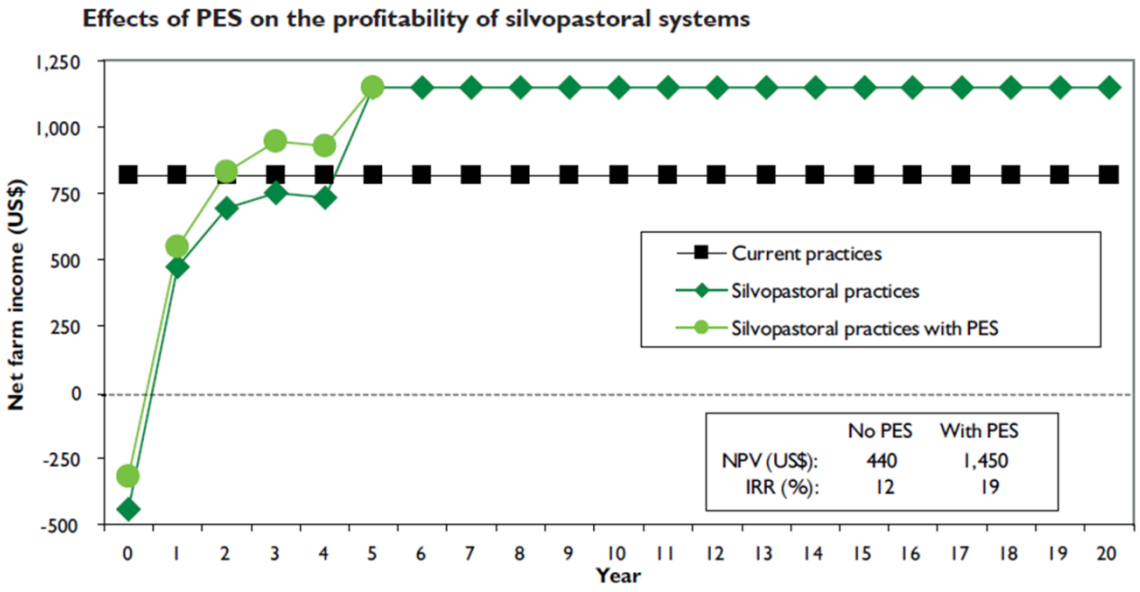
a. Project presentation and PSA-GEF functioning

The Regional Integrated Sylvopastoral Systems for Ecosystem Management Project was a pilot project administered by the World Bank and funded by the GEF. The aim was to reduce the presence of degraded pasture and implement sylvopastoral systems among livestock farms in Costa Rica, Nicaragua and Colombia. The program has been implemented between 2002 and 2008 and it's currently closed in Costa Rica. In region with intensive livestock activities, pastures got degraded due to the implementation of monoculture and due to overgrazing. The consequences are a low productivity of pasture and environment degradation (soil erosion considered as a threat to water source and biodiversity, carbon emissions). SPS are seen as a way to introduce good practices in the farm and prevent degradation of environment. At the same time, they are considered are more profitable than classic practices if pasture management is sustainable enough to have better yield in pastures and allow the farmer to produce more feed for animal in his farm (reduction of inputs use and notably labor). However, these systems are difficult to adopt because the costs are high and it's necessary to have sufficient technical knowledge to manage these systems. Indeed, as we can see on the following graph, implementing sylvopastoral practices creates initially a net loss in farmer's income because there are many costs associated to buying new seeds or reorganizing farm activities (Figure 6). Using a Payment for Environmental Services can then reduce initial income losses and be more profitable than previous practices.

The project consisted in a PES designed by CATIE. They developed an Environmental Services Index (ESI) to proxy for the biodiversity conservation and the carbon sequestration associated to with various land uses present in the project areas (Primary and secondary forest, natural pasture, live fences, annual crops,..). The Ecological Index for Biodiversity vary from 0 (degraded pasture) to 1 (primary forest). It is based on an existing index, the Biodiversity Index for Environmental Services (Saenz, 2007) but adapted and calibrated to the local context. It captures the number and diversity of species in a specific area. The

Ecological Index for Carbon vary from 0 (degraded pasture) to 1 (primary and secondary forest), as well. It compares the quantity of carbon stored by each land use. The ESI vary from 0 to 2, as it is calculated adding up biodiversity and carbon indexes, according to the land use. Consequently, each land use is associated with points by hectares (see Annex 6), so it's possible to evaluate and compare the Environmental Services provided by each farm. Based on satellite maps of farms (figure 6 bis), and reinforced by farms visits, each farm received a score corresponding to the area of each land use multiplied by the associated ESI. In the following illustration, we can see land use evolution between 2003 and 2004 in farm. The farm is characterized by plot limits. Each plot is composed of a homogeneous land use considered in the project (Annex6).

Figure 6: Estimation of net farm income in the context of usual practices and Sylvopastoral practices

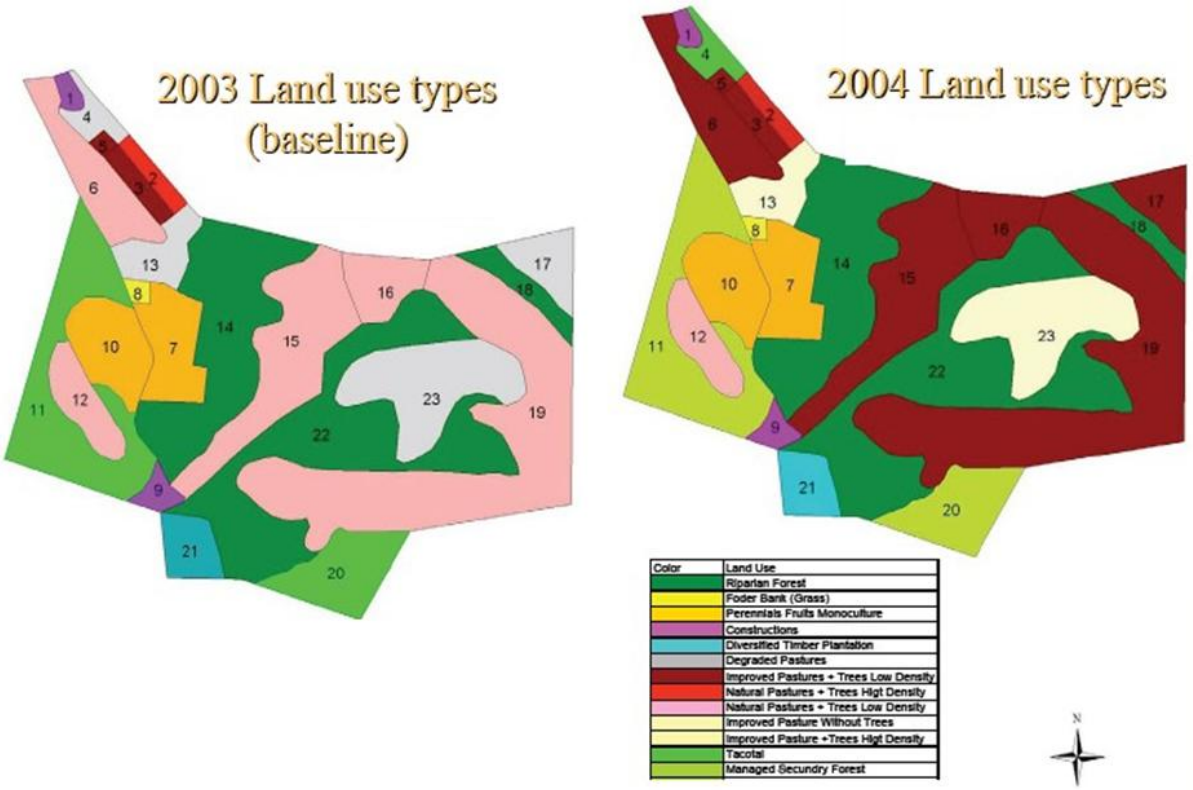


Source: Gobbi, 2005

The payment is proportional to the increasing in total score, in comparison with a baseline situation. However, farmers are also paid in year 0 (US$ 10 by point) to avoid a preliminary degradation before the project. Indeed, a farmer could have wanted to degrade his land before the project in order to maximize the potential payment received in the following years. The farm can apply to a 2 years scheme (and receiving US$ 110 by incremental point each year, group C) or to a 4 year scheme (and receiving US$ 75 by incremental point by year group B). Payments are made by FONAFIFO and farms can't receive more than US$ 4,500. During the

project, some farms have received technical assistance (group 1), and other not (group 2). A control group was included (group A), to evaluate the effect of the project.

Figure 6 bis: GIS of farms with evolution of land uses by category



Source: Gobbi, 2005

As the whole farm is under contract, no leakage should be possible at farm level, but some owners have more than one farm. Leakage can occur in Clean Development Mechanism projects when adopting good practices in the area under project creates supplementary degradation in non-contracted area. In GEF project, leakage is limited because only an increasing of ESI creates a payment, so if the owner destroys land with high ESI, he will have to compensate it by implementing other land use with high ESI. However, it's seems easier to bigger farms to increase ESI because they have more available land, so they can theoretically convert a bigger area to land with high ESI. For example, if we compare 2 farms, one having 10 ha and other 20 ha. They are both composed of 100% of degraded pasture before the program and they want to put 20% of their land in regeneration the next year. ESI for degraded pasture is 0 by ha and 1.4 by ha for regeneration shrubs (implementation of *tacotales*). Both farms have 0 points initially. A year after, small farm has 20%*10ha=2ha in regeneration and big farm has 20%*20ha=4ha. So, big farm wins 4*1.4=5,6 points while

small farm wins 2*1.4=2,8 points. Of course, costs associated to this change are supposed to be higher in the bigger farm, but if instead of converting an equal percentage, both farms choose to convert equal area, 2 hectares for example, they would have the same points but this represent a lower effort for bigger farm. Indeed, livestock activities need sufficient pasture to feed animals, so regeneration is in fact a reduction of pasture area.

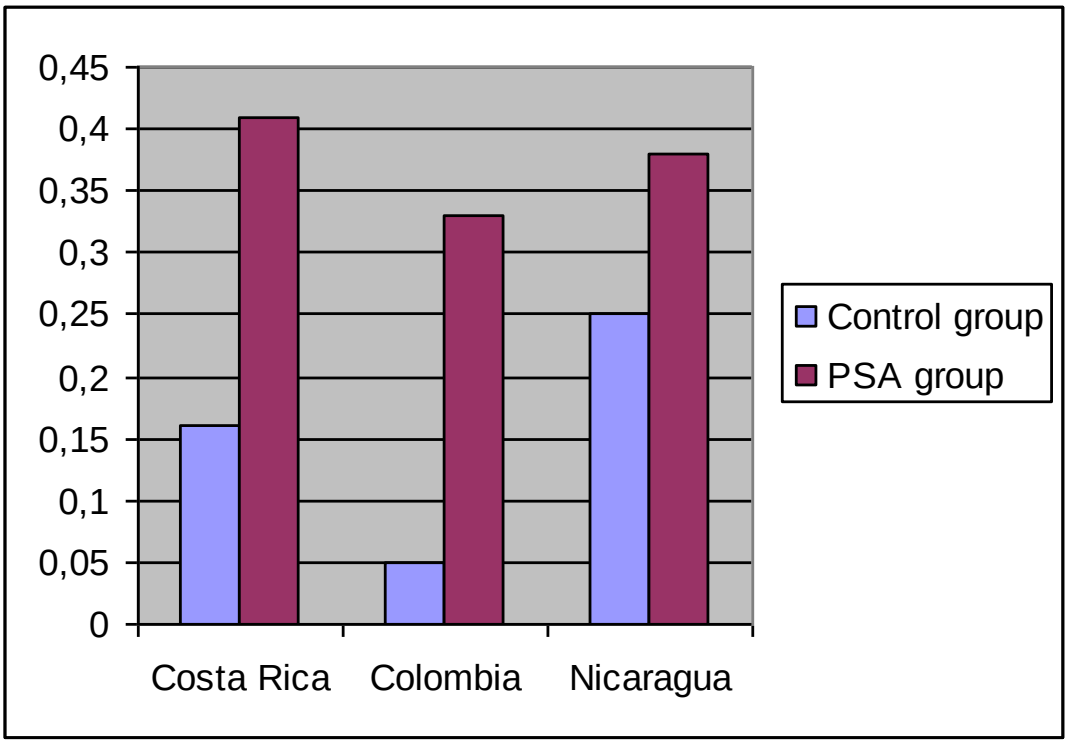
b. Main lessons learned from experience in Costa Rica

The region of Esparza is considered as low forest potential according to FONAFIFO criteria, so few people are eligible to national PSA. But it's a region with many livestock producers. This can be the sign that the national PSA program is not sufficiently targeted, as the compensation for opportunity cost regarding livestock activities would be adapted in this region. The project was successful in its objective to reduce degraded pastures by a system of Payments for Ecosystem Services (Figure 7). In costa Rica, participants farms have increase their average score by more than 0,4 points during the project. Control group only have increased its average score by 0,15 points by ha. So, PSA mechanism can be adapted to livestock activities. However, the project was not directly included in FONAFIFO modalities because it involves a methodology more complex that contractual hectares of land or number of trees. Also, it's not directly in the mandate of FONAFIFO (which is actually a forest fund, not an agricultural development agency). Moreover, technical assistance is very important in this project, and this creates many additional costs which are actually impossible to bear by FONAFIFO.

As we can see, the program methodology is public and based on a determined index. Also, several land uses are taken into account while national PSA program is considering one modality at the same time. Therefore, GEF program methodology can be considered as more flexible for the farmer: he could find a combination of forest, pasture and crops and progressively implement a sylvopastoral system. However, in the actual knowledge on ecosystem services, the provision is generally studied at landscape levels. Indeed, ES such as carbon sequestration and biodiversity protection rely on phenomenon which overpasses farm size: ecosystem services provided on a farm depends partly on ecosystem services provided by neighbor farms, but also of climatic variables such as temperature, rainfall, wind exposition…). Future programs could take into account this interdependence and condition

payments not only on single farm performance but also on general evolution of farms situated in the same geographical landscape. Institutions and contracts design should of course be based on voluntary participation but integer performances of a whole group as ES providers.

Figure7: Incremental ESI points per hectare (2003-2007)



Source: Vaessen,J. Todd,T and van Hecken G. (2008)

D) The environmental program of the Public Utility Company of Heredia (PSA-ESPH)

a. Project presentation and PSA-ESPH functioning

This program aims at protecting the upper watershed land in the region of Heredia: it is assumed that conserving tree cover will maintain water quality, as forest soils have better water infiltration capacity than pasture soils. ESPH (*Empresa de Servicios Publicos de Heredia*) is a company delivering public services (water, electricity and lighting) in 3 municipalities, which represented nearly 300 000 inhabitants. The water from Heredia Watershed has been analyzed and the results show its high physicochemical and bacteriological quality, so only disinfection process is needed to reach actual water standards.

The system has been modernized to respond to population growth: as a public services provider, ESPH must be sure that quantity, quality and continuity of water is sufficient. Nevertheless, urbanization and agriculture could represent a threat, as they are potential sources of water pollution. In particular, farms situated in strategic areas can adopt bad practices that erode soils, reject solid wastes or deforest their land. So, ESPH decide that they should receive compensation to the environmental services they propose by using a PES mechanism at local level to protect quality of water. The cost of protection would have to be paid by the final consumer, through a water tariff.

The Law of transformation of ESPH n° 7789 (1998) give the responsibility of conservation and rational use of water resources in the province of Heredia. Other Law and institutional context (after the FONAFIFO program) allow paying forest owner by using a water tariff on consumers, which is in fact a PSA mechanism at local level. They have needed a methodology to estimate the cost of forest conservation, which didn't exist at this time in order to justify the implementation of a water tariff by the public services regulatory authority. Barrantes and Castro (1999) have proposed a methodology based on opportunity costs (of maintaining livestock activities) and substitution costs (which in facts are the cost of reforestation which have been estimated by CATIE). Then, they evaluate by questionnaire the importance of forest in delivering water services, in order to determine the portion of opportunity cost which have to be compensated by the users (catch value). In a second time, they determine a recuperation value, which is the cost of reforestation, assuming water volumes that have to be produced and pondered by the portion of importance of forest according to users. Finally, they confront the monetary values that they have obtained to the estimated willingness to pay of users. Their report aimed at i) revising legal and institutional framework in order to implement a water tariff and a program of payment for environmental services by an enterprise ii) economic and ecologic evaluation of water resources in high area for 5 micro watersheds in the Province of Heredia and iii) quantification of supply and demand administered by ESPH (Solano, 2010).The value of water is based on catch value and actual selling price of water with hypotheses on demand growth and price elasticity of demand. 92% of habitants were agreeing to pay for water quality and quantity. It appears that the willingness to pay was higher that the estimated cost of protection, which proves the project, is feasible. As it was the first time this kind of tariff have had been implemented in Costa Rica, the regulator decided to fix the tariff at 1,90 C/m3 (which represent an average of 0,20 US$ of augmentation by family each month.

FONAFIFO tried to impeach the implementation of the tariff (in order to impeach parallel structures) but the regulator stated that PES mechanisms aren't an exclusive competency of FONAFIFO and as the tariff is of small amount, there is no conflict possible with the fund. Indeed, the mechanism is complementary with PSA, and FONAFIFO have no legitimacy as a tariff regulator.

ESPH concentrates its efforts on higher areas, which represent 10 000 hectares. The critical areas near the water sources are priority areas for the implementation of hydrological PSAH.

This hydric PSA is part of PROCUENCAS program, with mission to protect water sources at local level. This program is followed by a committee composed of representatives of municipalities, of ESPH. A representative of regional office of Ministry of Environment participates as legal advisor and FONAFIFO as observer. ESPH's scheme is similar to FONAFIFO. It also abides by the forestry law and the regimes for conservation and reforestation, but prioritizes its own critical areas according to the hydrogeological study that identifies areas of total protection and aquifers recharge areas.

To apply to the PSA, farmers have to ask for it. ESPH's Environmental Management Unit is in charge of studying the application and verifies the legal title, the cadastral plan and visit the farm. FUNDECOR, an environmental ONG which work as forestry official, establish maps and management plan (farmer have to pay 20% of PSA first year, 10% other years). The contract is formulated by ESPH.

The ESPH program is auto financed, they don't receive fund from other organization. The modalities are forest conservation (10 years), reforestation (15) and established plantation y regeneration (adapted from FONAFIFO). The area minimum is 1 ha. Between 2002 and 2010, 36 contracts (871 hectares), 94% conservation; 8% reforestation, 4% established plantation.

However, livestock is weak in this region but construction sector is very dynamic. ESPH have also estimate opportunity cost regarding to urbanization activities: the cost to compensate would have been considerably high to be cover by a low water tariff. As FONAFIFO program, ESPH one is voluntary. Even if the payments they propose are 2 times higher than in national PSA, there are fewer participants who want to enter than their budget would allow. The relative low level of payment in comparison with potential urban prices can be an explanation. Even, if payment is transferable if owner changes, actual owner prefers to keep free hands for their future potential transaction.

In the critical areas, close to zone of extraction, ESPH has buy property to fully control activities: 5 properties for a total of 24, 5 hectares have been bought since the beginning of the program.

Some farms are near of critical areas but don't have forest (and don't wish to have it, or don't have legal title to participate to PSA). In this case, ESPH has implemented a project to control solid waste by building biodigestors and enforcing use of organic inputs, as well as a technical assistance program. Moreover, if someone is establish in a protected area, ESPH has the right to reduce delivering of electricity and water, which could be considered as a partial Command and Control system.

b. Main lessons learned from experience in Costa Rica

This initiative has emerged few months after FONAFIFO program. As we can see, this program lays on strong technical and socio-economic studies, which are necessary to integrate a strict institutional and legal framework. We can note that in both FONAFIO and ESPH program, this institutional framework is very important, and this can be justified by the fact that environmental services can suffers from a lack in the definition of property right or at least, that they can be transferable by pure market mechanisms. They have a strong focus on transparency and try to involved many local stakeholders in their programs, which can be seen as a process of construction of norms and procedure. At the same time, we have to consider that, as in FONAFIFO program, even is the participation is voluntary, a command and control policy coexist. To simplify, bad practices are banned while good practices can receive a payment. In this case, all owners should apply to the program. Those who not enter in the program can justify it by i) the costs to enter the program ii) the condition to benefit from the program or iii) the low financial interest associated to the payment.

The scale of implementation is very interesting because watershed can be considered as a natural value added chain. If the consumers want good quality water, they have to be sure that water infiltration is made through soil with low sedimentation. In terms of ecosystem services related to water, it's generally easier to identify stakeholder because watershed are relatively reduced in size and it's possible to identify causes of pollution or sedimentation using an appropriate monitoring.

E) The sustainable livestock certification project (Rainforest Alliance)

a. Certification at large

Labels are widely popular among incentives mechanisms. They become famous in developing countries with the fair-trade philosophy. This mechanism rely on the idea that final consumer are ready to pay better prices for a product if they are sure that producers will benefits from this price premium and that production respects social or environmental criteria. Labels have been applied in tropical production such as coffee: many cooperatives were created in order to increase the value of production and reduce the number of intermediaries in the chain-value. The initial philosophy was more social than environmental, but the mechanism is exactly the same.

The labeling organization defines criteria and concludes agreements with distributors. An independent organism controls the application of criteria in the cooperative or among producers.

Labels are original mechanism as they are based on market structure, with a strong Trade-not-aid principle. Many products are labeled in both developing and developed countries. In the case of Costa Rica, certification exists for many products such as coca, pineapple, coffee and also wood.

b. Program of sustainable livestock in Costa Rica (RA)

Rainforest Alliance is a NGO involved in eco certification in tropical countries. They try to promote biodiversity conservation by encouraging good practices in farms, in businesses and among consumers. They have begun certification activities with a program incentivizing responsible practices in tropical forestry. This program, named Smartwood, was launched in 1989 and has the particularity to strongly rely on market mechanisms. The initiative was one of the base to the creation of the Forest Stewardship Council, whose RA is accredited as certifier. Encouraging by their success, they have labeled other products such as bananas, cocoa and coffee. Actually, around 20 tropical products are certified in more than 25 countries. Working with the Standard Agricultural Network (a coalition of NGO involved in tropical agriculture promotion based in San José, Costa Rica) , they have elaborated standard

to certificate sustainable farms. These standards lay on 3 pillars: "*environmental protection, social equity and economic viability*".
There are following ten principles:

"1. Social and Environmental Management System
2. Ecosystem Conservation
3. Wildlife Protection
4. Water Conservation
5. Fair Treatment and Good Working Conditions for Workers
6. Occupational Health and Safety
7. Community Relations
8. Integrated Crop Management
9. Soil Management and Conservation
10. Integrated Waste Management"

The objective of SAN is to define good practices according to the existing standards in vigor (edited by the US department of Agriculture, European Union or International Labor Office for example). To resume, SAN defines standards, which are audited each year on farms with independent authorized certification bodies. Then the farm is authorized to put the Rainforest Alliance Certified seal on their products.

The 2010 version of the standards includes ninety-nine criteria. In order to be certified, a farm must fulfill at least 50% of criteria regarding to each of the ten principles, and at least 80% of all criteria. Among the criteria, fifteen are critical criterion, which means a farm can't be certified if these criteria aren't complied. Since 2009, Rainforest Alliance and SAN try also to certify livestock production in beef, dairy or dual purpose farms. The definition of the criteria has been done in a collaboration between CATIE and SAN (Rainforest Alliance is not directly involved in the definition of criteria to avoid conflict of interests). The Sustainable Cattle Production contains 36 criteria (including 7 mandatory criteria). To be certified, farms have to fulfill Sustainable Agriculture standards and Sustainable Cattle Production Standards (Figure 8) which mean they have to be evaluated on the basis of one hundred and thirty-five criteria (including twenty-two critical ones).

The 5 principles of Sustainable Cattle production are:

"11. Integrated cattle management system

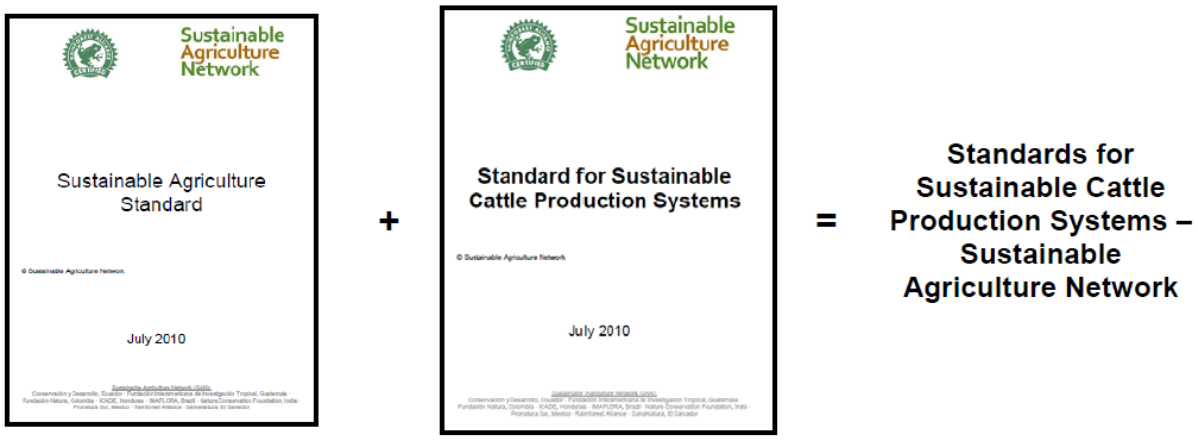
12. Sustainable range and pasture management

13. Animal welfare

14. Reducing the carbon footprint

15. Additional environmental requirements for cattle farms"

Figure 8: Document structure of SAN Standards for Sustainable Cattle Production Systems

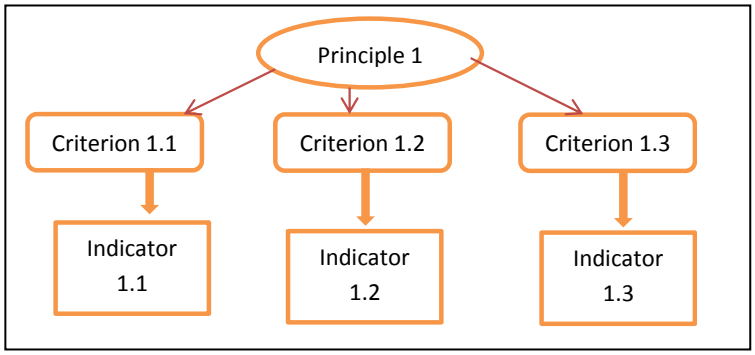


Source: Standard for Sustainable Cattle Production Systems, Rainforest Alliance (2010)

To resume the philosophy of Sustainable Agricultural Standard, we have to consider that the certification is based on the respect on some principles (elaborated by Rainforest Alliance) in the production process. In order to evaluate the degree of compliance of each principle, several criteria have been defined by Sustainable Agricultural Network. The respect of each criterion is based on a specific indicator, formulated by CATIE in the case of sustainable cattle production (figure 9).

As we can see, this group of criteria is focused on prevention of soil degradation, management of effluents and reduction of the impact on water resources. Some criteria are redundant, as they describe different aspects of a same principle, which means that various criteria can be fulfilled at the same time. Thus, we have to consider what does fulfill a criteria means. Actually, the indicators are not fully defined and are discussed among stakeholders.

Figure 9: The philosophy of Sustainable agricultural standard



Note: Each general principle is decomposed in several criteria, among them, some are critical criteria. These criteria are assessed using a specific indicator.

Nevertheless, CATIE have published a list of usable indicators (see Annex 9). This program of certification is not implemented yet. There are only pilot farms in which the feasibility of criteria is tested. Certification program is different from other mechanisms presented above. As we can see, this program is not institutionalized as PSA program or ESPH program. Indeed, in this program, the negotiations can't be at the same level, as all the mechanism relies on consumers in foreign countries. In fact, the power of negotiation of farmers is very low. It's also low in institutionalized mechanisms, but as it's occurs at a national scale, we can consider they are a potential political force.

F) Indirect incentives mechanisms

a. ICE initiative

ICE is a national hydro electrical company. During last decade, the company was hardly criticized by environmentalists and civil society because of the construction of plants and modification of rivers across the country. The company had to prove they have environmental preoccupation. We are studying a project in the Reventazon River, where a huge part of national hydroelectricity is produced.

The project was initiated in 2001 under the supervision of the Ministry of Environment (MINAET). There are representatives from Ministry of Agriculture (MAG), Costa Rican Institute of Aqueduct and Sanitary Water (ICAA), Technological institute of Costa Rica (ITCR), National Commission of Emergencies (CNE) and ICE, but also from civil society (mayors, enterprises, producers, environmentalists and development NGO). The environmental aspects have been taken into account through technical studies. Indeed, the productivity and profitability of a dam is linked to the water volume available. In order to maximize the duration of dam, it's necessary to limit sedimentation. This sedimentation can be caused by activities in upper watersheds, in particular agricultural activities such as intensive cattle production or cocoa and banana plantation.

According to IIED (2006), "*in the case of the Reventazon River, there is a comprehensive Integral Watershed Management Plan, that includes: soil conservation agroforestry and fish-farming; management of vegetation cover by: i) supporting the work of the conservation areas in the higher parts of the watershed; ii) promoting sustainable land use in the buffer zones of the protected areas, in the southerner parts of the watershed; iii) reforestation of the riparian strips and infiltration areas; iv) establishment of tree nurseries; Rehabilitation of water channels/ river beds and sediment control: i) project for flash flood control and; ii) control of erosion on roads; iii) works for rehabilitation of areas of geomorphologic instability (prone to landslides) and sediment control and; Education and Rural extension i) support of rural activities; ii) strengthening of rural social organizations and leader formation; iii) Environmental Education*."

Concerning farms in upper watershed, ICE don't propose financial incentives. The company prefers payment in kind through a contract in which farmer accepted to use better practices in exchange of input furniture. The program also includes formation curses to make farmers aware on their impact on sedimentation and explain them how to adopt environmental-friendly practices.
More than 350 farms have benefited of this program, through distribution of coffee plant, horticulture, livestock management with semi-stabulation and forage banks, water and soil management, solid effluent management (biodigestors).

ICE has also conclude an agreement with FONAFIO-ICE to plant 30 000 trees, with special requirement according to ICE preoccupation. The funds are shared between FONAFIFO and ICE.

So, we can see that the program promoted by ICE is run by corporate social responsibility and justified by profitability. They have internalized the potential profitability loss coming from high sedimentation and currently estimate the amount to pay to reduce this sedimentation.

b. Other noteworthy initiatives

1) Importance and development of agro-tourism

Agro-tourism is a sustainable form of tourism which can have a potential in Costa Rica. Indeed, the country is a very touristic one, in particular for eco-tourism, as there are many natural parks. We can distinguish 2 kinds of agrotourism projects: one is thematic tourism, like visiting a coffee plantation with explication on the production process, or horse riding in the farm. Other kind of project could be individual farms who proposed a visit to see some practices, in particular organic practices in a dairy farm. However, these kinds of project can't be implemented at large scale. Tourism is conditioned by demand and it's impossible to generalize this program: attractiveness of a farm is correlated to its specificity, and in general it's not a sufficient motive to visit. The agrotourism is more successful in area with existing tourism potential. Moreover, at the farm level, agrotourism has to be considered as a diversification of activity, it's not an activity in itself, more a cash flow activity. However, we can consider that the mechanism can remunerate farmers who have touristic potential, such as scenic beauty or specific practices that justify touristic flows. Yet, the fact there is good practices in a part of farm do not necessarily mean that these practices are implemented in the entire farm. An example of agrotourim can be found in the Region of Monteverde. In this region, there are many activities related to ecotourism such as parks and adventures activities, which mean that infrastructures are sufficient to receive foreign tourists. The region was involved in livestock activities but this system was considerably reduced during the 90's and farmers have progressively adopted coffee. However, dairy production is still high, with notably the presence of a milk cooperative. In order to diversify their activities, some farmers proposed ecotouristic activities. The visit consists in a tour with explication of the process to recycle manure using worms to produce natural compost. Moreover, the tour include visit of the farm and in particular windbreak trees and crop system which include agroforestry

practices. The tour is concluded by a degustation of cheese coming from the farm. So, the farmer has additional sources of income coming from touristic activities. This income is not sufficient and has to be considered as a complement of dairy and fattening activities. Another initiative can be found in Esparza where a farm has implemented full organic production and proposes visits to discover practices. The visit includes an explication of functioning of biodigestor and worms to produce compost. These systems aim at recycling pigs' manure to produce gas in the case of biodigestor or compost. We can also see a full integrated agroforestry system with maize mixed with trees. In this case also, the visit constitutes a diversification of activities, but income are irregular, especially because the region a low touristic potential.

2) Role of cooperatives

We have seen that FONAFIFO is interested to work with private companies but theses ones also have environmental preoccupation and this can be used as a marketing argument. For example, Dos Pinos, which is one of the leading milk and beverage cooperative in the country (the company transform 80% of national milk production), has developed an agro-environmental program which promotes rational use of resources. The idea is to visit milk producer to establish a diagnostic on impacts of the farm on hydric resources, in particular through an appropriate treatment of excrements and if the farm use appropriate techniques like organic compost or biodigestores, for example. Based on the diagnostic, a management plan is defined and the farmer can received formation to implement good practices. The program has been the first recognized by the government and actually, more than 90% of farms which works with Dos Pinos have elaborated a management plan and have started to implement new techniques. Unfortunately, we didn't have visited a farm which has participated to the program, so we will not include it in our analysis.

We have briefly presented different mechanisms existing or in project in Costa Rica in order to understand their respective objectives and details on their implementation. All of them don't have the same scope and are run by very different organizations. We can see that the concept of PES is applied to many different programs. Moreover, it's obvious that there are different scales of implementation for environmental projects. Local initiatives coexist with national policies. Studying the general coherence of this various programs will obviously be

an important challenge in the coming years. However, it's not the purpose of this report. We will now try to compare these different mechanisms using conceptual tools coming from PES literature.

G) Comparing various incentives schemes for promoting livestock sustainability

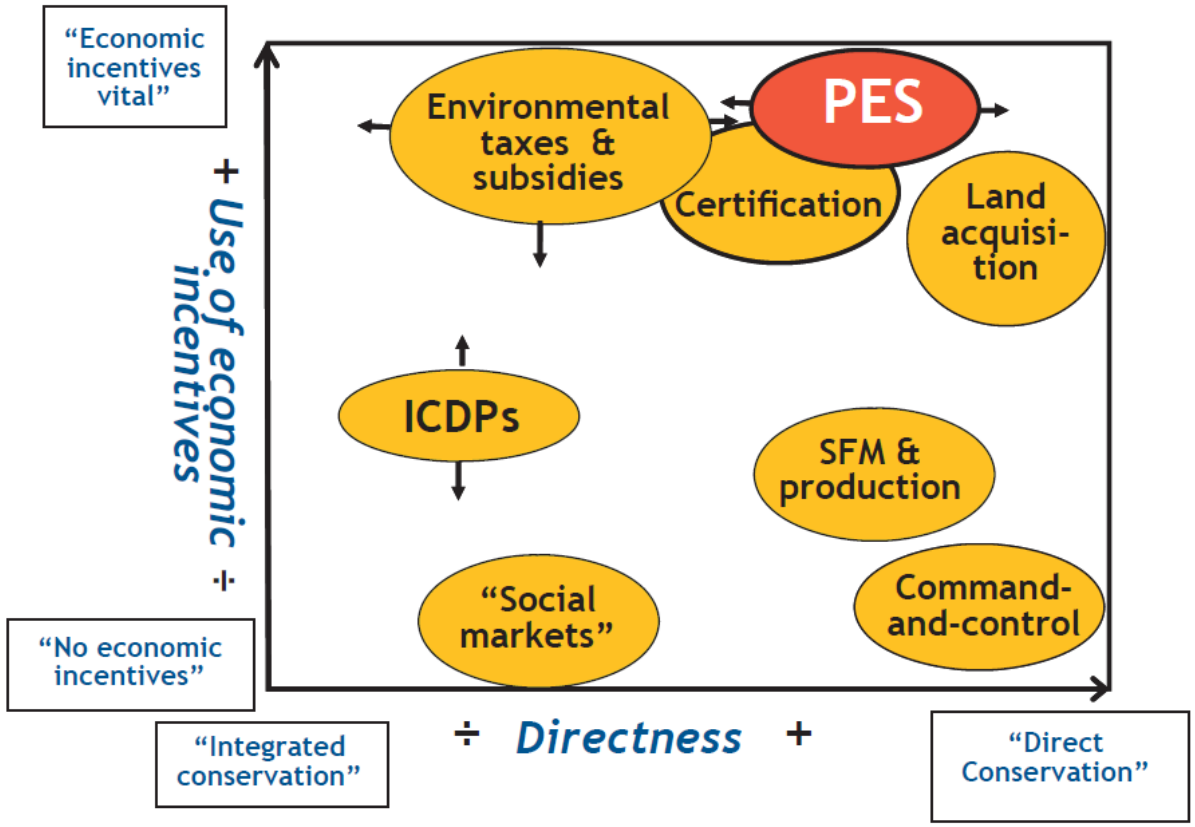
First of all, we will present existing analysis of difference between some mechanisms (respectively GEF PSA, ESPH PSA and Eco certification) and national PES program. After that, we will use Wunder's typologies and modify them to be able to compare all mechanisms altogether. We will them take into account different programs modalities to have a comprehensive vision of which ES and EDS are respectively taken into account. Newt, we will propose a financial decomposition of the benefits and costs for a livestock producer in each modality. Finally, we will formulate some hypotheses on the compatibility of some programs with specific farm typologies.

a. Literature

The main conceptualization of incentives to promote ES by natural ecosystems has been proposed by Wunder (2005) in the context of forest conservation. He compares PES to other instruments, according to the economic effectiveness they provide and if their target approach is integrated or direct. An integrated approach consists in considering various aspects involved in a specific situation, which is typical of local projects aiming at increasing social, economic and environmental situation. A direct approach wants to target exclusively a specific objective, forest cover in our case. His analysis wants to compare PES with environmental taxes and subsidies, certification, land acquisition, Integrated Conservation and Development Program (ICDP), Sustainable Forest Management (SFM) and production, Command and Control and "social markets". We can find description of each of these instruments in Wunder (2006). As we can see, command and control (C&C) approach provides few economic incentives but promote direct conservation. Typical C&C are forestry laws who prohibit forest clearing: It's important for a government to have strong institutions able to make the law enforced, which means it's necessary to control forest. An alternative could be land acquisition by public or private organization, which means buying a land in

order to protect it from commercial extraction or deforestation. At the opposite, environmental taxes and subsidies strongly rely on economic incentives, they are not targeting direct conservation areas, as they aim at modifying price structure to favor or penalize alternative activities .Integrated conservation and development project (ICDP) are local program trying to take into account various problematic in specific areas, mainly to cross forest protection to improvements in household livelihoods. Social markets are something sensitively different, which cover all traditional use of resources in particular in indigenous communities. Finally, certification proposes to pay a premium, or give access to a regulated market in exchange of specific conditions in conservation. In fact, this is very similar to sustainable forest management , and often certification are the economic counterparts of SFM, which are more to be considered as techniques to reduced impact of logging.

Figure 10. Classification of ES incentives



Source: Wunder (2005)

Our objective is to compare the existing mechanisms in the case of Costa Rica. If Wunder's classification (figure 10) is the bases for analysis, we will be focuses on the capacity of each of the mechanisms to increase ES provision as well as avoid generation of disservices in the

farms involved in livestock production. National PSA program, ESPH PSA and Sylvopastoral project are PES-like program where ICE program can be considered as an ICDP, even if it's run by an enterprise. Rainforest Alliance is a certification program. In general, existing literature on mechanism in Costa Rica only proposes to compare each initiative to the national PSA program run by FONAFIFO. The comparison has to be affined as the PSA program is divided in different modalities, and even if PSA-conservation is widely chosen by forest owners, all the modalities aren't following the same way of functioning. Moreover, it seems important to compare all the mechanisms altogether according to the same criteria to be able to define eventual conflict or synergies between them.

1) Comparing PSA with PSA-GEF

This comparison has been made by Ibrahim and al. (2007).Even if FONAFIFO and GEF use a PES mechanism, both of them are quite different. The sylvopastoral project explicably focused on farmer where national PSA is looking for forest owners. Moreover, the PSA pay for a predetermined amount of payment based on the superficies under contract and the modality chosen while sylvopastoral project (SPP) pays for an increment of environmental services (biodiversity conservation and carbon sequestration) generated by a change in land use. So, there is a performance objective in this case and a more precise monitoring regarding to the ES provision. Moreover, the SPP analyzes the changes that occur during the project and recompenses them only if they were positive. So, we are able to consider SSP as an asset-building scheme focused on financing the transition between a low ES land use and a high ES land use. At the opposite, PSA program (conservation modality) recompenses the situation before the project, which means a forest yet established: we have to consider it as a land use restricting scheme. The reforestation modality is more ambiguous: the trees planted are a restriction in land use but these trees have a commercial value after several years, so they can be considered as an asset. The SAF modality can't be considered as a land use restricting scheme because the farmer is free to choose his land use around the trees. In SSP case, participants are paid to improve their ES furniture with a non-renewable and time-limited contract, in the other; they are paid to keep them equal with an eventually-renewable contract. The monitoring methodology used by SPP is more complicated (based on an index) and more costly (GIS and experts are needed) than *regentes*'s certification, but we have to keep in mind

that SSP was only a pilot project at local scale, which means the methodology would surely be different if it had to be implemented at larger scale.

From a **livestock producer perspective**, the silvopastoral project is an interesting incentive: most of the changes in land use are in phase with farm production. Indeed, the establishment of forage banks furnishes additional alimentation for cattle, especially in dry season, and the adoption of improved pasture reduces the hours of labor needed on the farm. Concerning the presence of trees in pastures, sylvopastoral program have a more precise approach than SAF modality, as the program analyzes the density of trees by hectares (and not only their numbers) in pastures and propose also to take into account the implementation of live fences. Therefore, we can suppose that the interaction between livestock practices and trees is more complete that the one proposed by FONAFIFO.

2) Comparing PSA and Certification

This comparison has been made by Lecoq et al. (2011).The authors make a complete analysis of the differences between the two mechanisms at theoretical level, focusing on organic certification implemented in Costa Rica.

As we can see, the two instruments are very different. The label relies strongly on market mechanisms with a "classical" voluntary transaction between a consumer and a producer while FONAFIFO is the agency in charge of the transaction between ES providers and beneficiaries. Moreover, national PSA program is area based while certification is product based. In particular, in the case of a label such as Rainforest Alliance one, the producer lives in general in a tropical country while consumer lives in a foreign developed ones. For the national PSA program, main transaction occurs inside the country, if we consider that the major source of fund comes from the gasoline tax. Nevertheless, we have to consider that FONAFIFO try to catch new funds coming from Carbon market for example, with buyers coming from developed countries. This could have an impact on farmers, because in PSA program, people are protected by national law while in certification, a unilateral withdrawal is possible. While conservation PSA rewards a renunciation to deforest, certification reward the implementation of good practices Regarding ecosystem services, we can consider that certification is focused on limitation in the use of chemical products, control of solid waste and limitation of soil erosion.

Indeed, in our case, certification is especially adapted to **livestock production,** which means there is a stricter control on potential threat to ecosystem created by this activity. The contractual approach is different because FONAFIFO propose multiannual payments, eventually renewable while payment in certification scheme is conditioned to an annual audit.

3) Comparing national PSA and PSA- ESPH

This comparison (figure 11) has been made by Solano (2009). The two mechanisms are in fact very similar but they are not implemented at the same scale and don't have exactly the same objective. The logic could not be the same, as ESPH tried to lower its criteria to attract the maximum number of participant, according to their budget while National PSA try to have stricter criteria to be able to selection participant with higher potential. Moreover, ESPH mechanism is more transparent, as the clients know the amount of tariff, indexed in the amount of water consumption, where FONAFIFO work as a governmental agency, collecting fossil oil taxes and international loans.

Figure 11. Difference between National PSA and ESPH PSA

	National PSA	**ESPH PSA**
ES recognized	One payment for 4 ES (biodiversity, water, carbon, landscape beauty)	One payment for 1 ES (water)
Payment	32 640 C per ha (2010)	65 267 C per ha (2010)
Area minimal	2 ha	1 ha
Duration of conservation contract	5 years contract for protecting forest cover	10 years contract for protecting forest cover
Level of application demand	High demand	Low demand

Source: Adapted from Solano (2010)

Considering livestock activities, ESPH try to reduce environmental disservices (EDS) through a local PSA program . We can conclude that in both case, PSA scheme are

insufficient to address the relationship between agriculture and environment. The program seems to be targeted to unproductive lands or at least to program where the only alternatives would be keep or cut forests. Livestock activities involve a specific use of soils and a complex combination of ecosystem activities. Indeed, the interaction between agriculture and ecosystem services implies more than a choice of keeping of cutting forest: the number of cows by hectare, the crops that will be used for animals, the use of manure… We can assume that actual level of payments are insufficient to really compensate opportunity cost of livestock activities, as the amount received from PSA can't be consider as a sufficient source of income. In fact, these programs can't target small and medium livestock producers who have insufficient farm superficies to be able to choose to keep a part as forest.

b. General considerations about ES provision

Each organization which has implemented on of the studied mechanism has a specific consideration on the livestock impact on environment. For FONAFIFO, extensive livestock is seen as the major cause of deforestation while in the GEF program, livestock farms are considered as Environmental Services provider. From the point of view of hydro-electrical plants, livestock farms produce pollution and environmental degradation which have to be reduced. Finally, in Rainforest Alliance views, if livestock farms have adopted sustainable practices, they should be paid a better price. National PSA and Hydric PSA want to increase (or keep equal) tree cover and remunerate these practices according to the Ecosystemic Services they provide. Nevertheless, the impact in terms of ES are poorly analyzed, as monitoring consists in judging if tree cover is sufficient, which is logic if we consider that FONAFIFO and ESPH establish a direct relation between superficies of tree cover ES provision. Sylvopastoral PSA gives the payment according to a performance based on increasing in ES provision (correlated to specific land use). It's interesting to note that, according to ESI index, a payment for conservation of forest is not gaining any point with the year (while payment for reforestation would have a very important score). Indeed, Sylvopastoral PSA is exclusively addressed to livestock producers, so land use which is promoted are better adapted to their situation. However, we can note that Sylvopastoral project don't take into account water pollution by sedimentation. But this program aim at improving riparian forest around rivers. Obviously, livestock activities can be responsible of water pollution by using chemicals products and lacks in controlling manure evacuation. To

this end, ESPH and ICE have an adequate program, as the justification of their action is to conserve the good quality of water and to limit the presence of sediments in water. The difference is that ICE wants to preserve land erosion through reduction of soil pollution while ESPH want to increase land cover in order to have good quality water. However, ICE program is not an incentive programs because the "payments" are mainly in kind, based on a contract of adoption of good practices, while a payment in cash give more liberty in the beneficiary's practice changes. Finally, Eco-certification such as Rainforest Alliance is taking into account wide aspects related to Environmental Services (and also economic and social dimension) and can be presented as a synthesis between the other mechanisms. But, we have to keep in mind that the eco-certification is the more recent instrument analyzed in this work, and it's not yet implemented. The capacity of this program to deal with ES provision is correlated with the pertinence of indicators.

At this time, we can classify all the programs in two different groups: one is rewarding a past investment and tries to keep the practices at the same level or more (PSA conservation, ESPH PSA, certification) while other wants to incentivize a change in practices (PSA reforestation and Sylvopastoral PSA). Following Wunder (2005), the first group would be use-restricting scheme and the second asset-building scheme. We can't conclude that the first group doesn't imply additionally: indeed, it seems acceptable that practices required to enter the certification program wouldn't have been implemented without the program. To resume, we can consider that the investment is made with the idea to be able to enter to one of these programs. Moreover, another distinction comes from the degree of geographical interaction between buyers and producers of environmental services. Indeed, in the programs related to a watershed, the interaction is exclusively at the local level, which means that the distance between buyers and producers is low. In the national PSA program, interaction is more complex, but we can consider that ideally, all the interaction will occur within a national level, if we consider that the part of international loans in program finance will be reduced. We can't conclude for the GEF project, as it was only a pilot project, which means the condition of financing would be different if it has to be really implemented. Finally, agrotourism and certification rely on the interaction between Costa Rican producers and foreigners buyers. This could have a considerable consequence on the evolution of each program. Indeed, certification is based on international price movements and final consumers can stop using labeled products. The national FONAFIFO program is institutionalized and therefore will evolve following the balance of power of national stakeholder. We can suppose

that programs like ICE and ESPH evolve also with balance of power of stakeholder but only at the local level (Figure 12).

Figure 12. Classification according to Wunder (2005): PES types

	National PSA	GEF PSA	ESPH PSA	ICE	Certification
Vehicle used	area based	area based	area based	area based	product based
ES buyer	public	public/private	private	private	private
Condition of payment	-Conservation modality :use restricting -Reforestation modality : asset building -AFS modality :asset building	asset building	-Conservation modality :use restricting -Reforestation modality : asset building	use restricting	use restricting
Type of Payment	pluri-annual renewable	pluri-annual non-renewable based on perofrmance and baseline	pluri-annual renewable	training+ input furniture	price premium

c. Services generation of livestock activities in each program

Livestock production is an activity which occurs in a managed landscape. That's means an interaction occurs between agricultural activities (human action) and ecosystems: both entities affects and are affected by the other one (see Power,2010). More specifically, i) humans decide to manage landscape to allow, ii) domesticated animals (mainly bovines in our study) to live in contact with iii) domesticated vegetation (like grass, forage, trees or live fences) and iv) and other components of ecosystems (forest, river, wild animals,…). By their action, humans modify ecosystems (e.g. by planting new species, by modifying land use, by eliminating the presence of some species,…). As well, cattle are in interaction with ecosystems (by grazing, rejecting effluents, eroding soils by spreading seeds, but also by a certain positive impact on biodiversity…). Finally, ecosystems determine the conditions in which the interaction occurs: ecosystems are dynamic systems and are influenced by a lot of parameters; all are not under farmer control.

If we have to conceptualize farmer decisions according to three axes, we can considers that, first, he decides the allocation of land dedicated to forest , land dedicated to pasture and land dedicated to infrastructure. In a second time, farmer decides the land use in land dedicated to

pasture: natural or ameliorated pasture, crops, forage banks, or garden. Finally, he decides the practices he wants to adopt, which can be synthetized in extensive, intensive, sustainable or organic. We can notice that national PSA program and ESPH PSA have an influence in the first step (direct conservation), Sylvopastoral program in the second step (by proposing an amelioration of land use) and certification and ICE program in the third (obviously focused on practices improvement). Of course, these 3 steps are in fact interconnected, as a specific production system could imply a determinate land use and land allocation to allow consumption of ecosystem goods by cattle. Giving land use and land allocation, different practices (e.g use of fertilizer, use of concentrates, manure recycling…) are adopted in order to compensate natural handicaps such as low pasture availability.

At each level, the decision has an impact on ecosystems. Of course, the intensity of impact is not the same at farm level, landscape level, national level and international level. Even if we don't have many quantitative data on ES provsions, we can consider that the farmers are interested in sustainable use of soil and wood. Control of water pollution is important at local level, as we assume that consumers drink water coming from a near source. Deforestation and scenic beauty is a problem at national level. Carbon sequestration is a worldwide concern.

Forest cover is well known as a mean to improve carbon sequestration and to facilitate water infiltration. However, at farm level, the integration between forest and farms activities is not necessarily high: some owner use PSA payment to reforest area which weren't used before (e.g. field with high declivity in which it's impossible to manage pasture). In this case, we can consider that the presence of trees in the farm has no direct benefits on the farm productivity (even if it could have indirect ecological impact on other fields). In Costa Rican case, as it's illegal to change land use in forest areas, the trees are supposed remain even if there is no more payment. But, trees coming from SAF modality could be more vulnerable at the end of payment, as no law forbid to cut them. To resume, national PSA can be insufficient to fight against ecosystem disservices as it encourages forest cover in a specific period without changing production practices. At the same time, forest cover is supposed to have the stronger positive impact at the international level.

Change in land use allows reducing the presence of degraded pasture and promoting the adoption of sylvopastoral systems which have a positive impact on soils (by increasing the presence of biodiversity) and on animals, as they allows to furnish food, even during dry season. The change in land use has hence an impact on the agricultural practices. We can

assume that the change that occurred during the project remains, as they are more profitable economically that the previous land use. Indeed, the assumption behind the program is that technical assistance and payment are used to help the farmer only during the transition.

Changes in practices imply a strict control of potential negative impact on environment by reducing water pollution (by controlling effluents and chemical products) and soil erosion. It's seems more able to protect local ecosystems with low impact on the world ES provision, in particular the protection of local water resources, the quality of soil,…

We will now considering each program to compare them according to all modalities regarding to ES (figure 13). Concerning the presence of forest, the more direct mechanism is of course national PSA program in the conservation modality (and ESPH PSA which provide a very similar mechanism). However, GEF PSA gives the strongest payment by hectares for plots composed of primary or secondary forests. But, as this program pays mostly for the increment, keeping forest cover does not reduce farm performances. Finally, several certification indicators proposed by CATIE considers the percentage of tree cover on farm. Certification is the unique mechanism which takes into account the presence of native trees. In the case of reforestation, national PSA and ESPH PSA are also the more direct mechanisms and the only one to promote it, but national PSA also propose reforestation with native species in extinction. Regeneration is proposed only by ESPH and FONAFIFO, but FONAFIFO have 3 different modality of regeneration (in pasture, with productive potential and in Kyoto lands). These different modalities are justified by the fact that the agency cover all national territory and have many more partners, which allow them to diversify their program according to local land conditions.

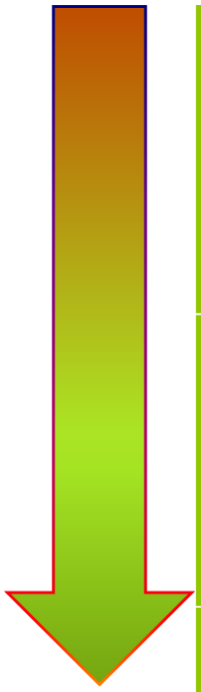
FONAFIFO, ESPH and GEF can be considered as incentives to establish plantations, the main difference is in the amount of payment receive and the duration of contract.

Looking at sylvopastoral systems, GEF program is obviously oriented at improved pastures and reduces the presence of degraded pasture. Certification aimed also at reducing pasture erosion and ICE indirectly tries to reduce overgrazing by understanding the causes of soil erosion and proposed new practices with reduced negative impact (planting fruit trees in eroded pasture for example). Only GEF program and certification take into account the presence of live fences in farms, both of them with a typology with differentiation between mono-species and poly-species fences. In terms of additional alimentation produced in the farm, GEF program proposes incentives to establish different species of forage banks while

certification indicator only take into account the fact of diversifying source of on-farm alimentation. Finally, if we consider the incentives to promote the presence of trees in pasture, FONAFIFO proposes the SAF modality, including with native species but the remuneration is based only on the number of trees. GEF PSA is stricter as the program makes a difference according to the density of trees in pasture. Also, the certification program aimed at taking into account the percentage of trees in pasture more than their numbers. For manure control, ICE as well as certification program, is very concerned about this externality and encourages for example building of biodigestores or compost practices. ESPH is the only mechanism who proposed direct buying in sensitive areas, which means the end of productive livestock activities in areas to close to sources of water. Finally, in terms of control of chemical products, ICE reduces the negative impacts by delivering inputs and establishing contracts of practices changes. Certification program only monitor the quantity of fertilizers and prohibit those which have a strong negative impact on Greenhouse Effect.

Figure 13: Decomposition of each mechanism

Land use



Practices

	PSA	ESPH	GEF	ICE	Certification
Forest cover enhancement	Conservation	Conservation	Tree cover		% of tree cover
	Reforestation	Reforestation			
	Regeneration	Regeneration	Regeneration		
	Plantation	Plantation	Timber plantation		
sylvopastoral system promotion			Improved pasture	Reduction of overgrazing	% of grass on soils
			Live fences		Live fences
			fodder banks		fodder banks
	AFS (+native species): number of tress		Density of trees in pastures		Tree cover in grazing area
Pollution control				Manure control	Manure control
		Farm aquisition			
				Reduction of chemical products use	Limitation in use of fertilizers

Note: Ecosystem services provision are promoted through different target which can be classified in three broad categories: forest cover enhancement, sylovpastoral system promotions and pollution control.

We would like to study each modality based on costs they imply. Independently from the mechanism, we will retain forest conservation, land regeneration, reforestation, forest plantation, improved pasture with trees and reduction in chemical inputs uses. Land regeneration consists in stop using a plot and let natural regeneration. This creates a land covered by bushes and eventually by trees. Reforestation refers to convert a pasture in forest without objective of future commercial extraction. Generally, reforestation refers to native trees while plantation refers to tree with commercial values such as teck plantation. To analyze these modalities, we will try to describe the costs they imply and the variation in income they creates. Karsenty (2011) identifies four costs associated to PSE mechanisms: opportunity costs, investment costs, operating costs and transaction costs. As we will focus our analysis at farm level, we won't use operating costs but we will add the payment received and the variation of future income in order to have an idea of Expected Net Present Value in each modality. The idea is not to estimate quantitative value but to compare the modalities.

Figure 14: Different costs and gains associated to each action proposed by mechnanisms

	Conservation	Regeneration	Reforestation	Plantation	Improved pasture with trees	Reduction of chemical inputs
Opportunity cost	-	- (renonciation to productive area)	- (renonciation to productive area)	- (renonciation to productive area)	0	- (lower short-term productivity)
Investment	0	0	- (seeds + protection)	- (seeds + protection)	-- (seeds+protection)	+ (reduction in input buying)
Transaction cost	- requirements	- requirements	- requirements	- requirements	-- monitoring costs are supposed to be borne by farmer	- training
Payment	+++	++	+++	++	+++	+
Δ future income	0	+ improvement in soil quality	- renonciation to productive area	+++ wood sales	++++ more productivity, less hours of labor	+ reduction of input and improved sustainable productivity
Expected Net Present Value	+	-	-	++	+++	+
Description	Land restricting	Land restricting/ Natural capital	Natural capital	Natural capital	asset building	asset building

Land use → Practices

Note: The expected Net Present Value(NPV) summaries the costs and benefits associated to the actions from a livestock producer point of view. For example, conservation has a limited but positive expected NPV: the loss of opportunity cost and the transaction costs are covered by the payment while there is no need to invest and no impact on future impact after the end of payment.

So, if a mechanism proposes to pay for conservation(figure 14), this implies that the farmer could have to renounce to opportunity costs of converting his land to pasture to make his livestock grazing. The farmer don't have to invest, because the forest already exists but if he wants to enter the program, he will have to establish legal requirements and pay an expert to elaborate a management plan. During the contract, he will receive a payment but his future income will not be modified after the payment. Therefore, considering gains and costs altogether, entering the program is interesting and generated a positive cash flow. At the contrary, reforestation can create a net loss because the farmer has to convert his pasture to forest, so he will lose a part of productive land and has to invest to buy seeds and helps tree growth. If he wants to enter a program, he will have to pay for legal requirements and elaborate management plant. Payment for reforestation is longer and more important, so he will gain more money than in simple conservation. But after the program, he won't have more a positive variation of income, because he has lost a part of pasture. In financial terms, reforestation is not interesting for the farmer. As we can notice, the more interesting modality seems to be improved pasture with tree; because the land use is similar (the idea is to convert a low productive plot in a high productive one). The transaction costs could be higher because the technology of monitoring is more complex, in particular if it's necessary to use Geographic Information System, which at the end should be paid by the farmer. If the payment is high enough (if we monetize formation and payment received), and as we know that the impact on future income is high, the net present value is very important.

We can synthetize all of these elements in order to try to determine if some programs can be more adapted to specific farm profiles (figure 15). We will consider 4 criteria to make a difference between farms. First, we will analyze different level of investment capacity. Then, we will study different type of practices among the farms. Third, we will study farm size, in terms of land area (which is in fact correlated to number of animals). Finally, it seems

important to determine if a specific production system could have an impact on the adoption of a mechanism in particular.

Figure 15. Adaptation of each mechanism to several livestock farms characteristics

Investment capacity	
Farm with limited investment capacity	PSA conservation, PSA reforestation, ICE, GEF PSA, ESPH, SAF
Farm with important investment capacity	Certification
Farm practices	
« Traditional » farm	SAF, GEF, PSA reforestation, PSA conservation
Intensive farm	ICE, ESPH
Sustainable farm	Certification
Farm size	
Small farm	ICE
Medium farm	Certification, GEF, PSA reforestation, ESPH, SAF
Big farm	PSA conservation
Production system	
Dairy farm	Certification, ESPH, ICE
Double purpose	GEF, SAF
Meat	PSA conservation, PSA reforestation

Note: In term of investment capacity, most of the programs are adapted to farm with limited investment capacity: they provide payment and training while certification usually give a payment to farms which have already implemented changes.

Investment capacity corresponds to the capacity of a farm to immobilize a capital during a period of time; this capacity is correlated to the level of income and the regularity of cash flows resulting from production activity. The farms without investment activity have to receive strong incentives in order to change their practices: a program like ICE one is perfectly adapted, as the company delivers some inputs in order to diversify farm activities, but also technical assistance to be able to elaborate this evolution. PSA reforestation sounds

interesting for this type of farms also because they guarantee a relatively important payment to plant trees (and we can consider that a farm without investment capacity doesn't have forest to put in PSA program, but have sufficient land: the farmer's choice could be either to sell a part of his land, or to enter a PSA program to receive payment).Moreover, without investment capacity, it seems difficult to put in place other strategy to improve productivity, so a payment corresponding to opportunity costs could be high enough to accept to convert pasture to forests (if the farm has few productive capacity and few capital to improve it, it seems more profitable to plant forest, with condition that PSA payment covers all the cost of maintaining trees). At short term, selling or renting a part of his land seems more interesting for the farmer, but if we consider the expected commercial value of wood, and the fact that farmers are usually reluctant to sell a part of their land, planting forest seems to become a viable alternative. Farms with limited investment capacity are also typical ones which can enter GEF PSA because we supposed they lack of knowledge to implement sylvopastoral practices and the incentives mechanism can reply to their situation to reduce degraded pasture. Also, PSA conservation and ESPH PSA can be applied to these farms that already own forest and can need complementary income coming from payment. In livestock farms, planting trees with SAF modality implies important costs: each tree requires a protection during his growth, which is costly. It seems more interesting to use SAF in cropping area during the growth and to allow cattle to graze only when trees are strong enough, but this suppose that the farmer owns sufficient plots to be able to impeach animal access during several years. As we can see, certification could only be applied to farms with huge investment capacity, because it supposes a long term immobilization of capital to allow practices change, as we suppose that the aim of certification is more to join a value-added chain than to benefit from price premium.

Traditional farm are farms which have few herd density regarding to the area, which eventually still use an extensive model, which means there is few risk of overgrazing and low reject of manure. All modality of FONAFIFO are adapted and even GEF PSA because there is not a huge "conflict" between forest cover and grazing. Therefore, land use improvement can be realized. At the opposite, in intensive farms, there is a risk of overgrazing and important reject of manure, so the program related to water pollution control (ESPH PSA and ICE program) are the best to correct this situation. Finally, sustainable farm are the one who can apply to certification, as they already have an important control on various potential externalities.

The difference in farm superficies has also an impact on the choice in incentive program. Small farms (limited superficies, few animals and few diversifications) are supposed to be the best to apply to ICE program, as it's the only program that furnish inputs in kind and propose courses to be able to formulate a plan to change practices. Medium farms (relative important land but relatively few animals) can apply to most of the mechanisms, because of the limited conflict between pasture and forest in land allocation, they are able to improve forest cover or land use. Finally, big farms (important lands and numerous animals) would be the best to benefit from PSA conservation, as the amount of payment is relatively more interesting in comparison to the induced costs. We consider that farms situated in a watershed have a small or medium size, because the space availability is limited. So, ESPH PSA would be adapted to medium farms.

Concerning the production system among livestock farms, main focus is about the area available as pasture for cattle and the source of animal alimentation. In a typical dairy farm, animal lives in pasture during the day and have to be put in a stable during milking process, in which they receive food and produce manure. In general, food is mainly composed of mineral complements and the farmer receives regular incomes. Farms have to use a system of manure recycle. If a farm has joined a cooperative, we can suppose that many certification requirements are already done because cooperatives usually checks animal health through milk quality. Moreover, dairy farms are generally located in upper lands, so ICE and ESPH programs could be adapted to this situation. Fattening farms need generally to add a lot of food complements and concentrates during animal growth and prefer stalling to control animal weight. These kinds of farms are supposed not to create overgrazing as the animal lives mainly in stables. They are not able to enter certification program as they don't produce the main part of animal food needed and the conditions for animal welfare are supposed to be low. This is a paradox, because the label is supposed to be applied to meat production. The certification scheme seems then to have a potential only in low-intensive fattening farms. We suppose that this kind of farms can be interested to adopt a PSA reforestation or Conservation, because they don't use their land in an extensive manner if the entire animals are in stables. Breeding and double purpose farms are supposed to have similar practices in terms of land use and animal alimentation: the main difference is that double purpose farms have more regular incomes. In these types of farms, cattle stayed all the time in pasture, so there is a need to a sustainable use. GEF program and SAF modality could then be applied to answer this situation.

This classification is of course based on hypotheses. We will test some of these hypotheses by analyzing GEF database. We have many socio economic data and land use evolution corresponding to response to ES incentives. We should then be able to find correlation between farm characteristics and specific land uses or practices.

II) Statistical analysis of farms which have participated to Sylvopastoral Program

A) Background

a. Context of the project

The GEF program has been implemented in the region of Esparza, Costa Rica (as well as in Colombia and in Nicaragua). The participation has been voluntary. Treated and control group have been surveyed before the program (2003) and a land use baseline has been established. We have socioeconomic data and land use evolution data (GIS format) between 2003 and 2007 for a hundred and twenty farms. In 2011, a new survey has been done with ninety farms out of the initial hundred and twenty. This survey contains socio economic data in order to see the evolution before and after the program and check land use composition in 2011. Unfortunately, it was impossible to monitor land use with the same precision than during the project, but we have used 2007 farm maps and ask farmers about the actual farm situation. The 2011 survey is mainly based on the 2003 survey on order to monitor evolution of variables of interest. Moreover, the questions have been discussed with the team involved in the project. Land use evolution couldn't be assessed using a satellite image in 2011 due to time and money constraints. We have then used the 2007 boundaries. So, boundaries evolution is taking into account only if it involves forest cover. Therefore, land use change between 2007 and 2011 is more a tendency than an exact description.

b. Hypotheses

The first hypothesis is that farm which has participated to the program should have continued to improve their land use after the program. This would confirm that the program can be considered as an asset-building scheme: the farmers would have learned from the program to be able to implement their own silvopastoral system further.

The second hypothesis is that farm production system (dairy, double purpose or meat farms) has an influence on the land use as well as on the change in land use during the program. For example, it seems that dairy farms have a different land use because they don't need extensive practices to feed their cows. Besides, we can assume that if farm have different land use

before the program, they will have different behavior during the program. It could be interesting then to find if there is a convergence or a divergence in terms of land use.

Our third hypothesis is that the program has enable farm with the best performance during the project could have invest the money the change their production system. For example, farms with low profitable activities and degraded land use can have implement new sylvopastoral systems and then receive important payment. So, this hypothesis can be checked by testing a correlation between program performance and change in production system.

c. Methodology

The project area has been visited two times before the 2011 survey. First visit aimed at obtain information about sylvopastoral systems and their implementation in the region of Esparza. General questions about programs have been asked to participants. Second visit has been made to test questionnaires among non-participants farms and schedule future visits. Interviews with project stakeholders such as local office of Ministry of Agriculture and Livestock but also with the local Agricultural Center have been organized. The Agricultural Center is the more important place in the region which sells agricultural inputs and provides veterinarian activities.

The 2011 survey initially aimed at providing data to perform an ex post impact assessment but we have suspected a selection bias in 2003 data. The final survey is then applied mostly to treated farm in order to describe their specific situation. Conclusions from stakeholder interviews have shown that there has been a severe impact of the global economic crisis in the region. Many farmers have sold their farms due to the low profitability of livestock production. We will then consider only farms which are still in activity. Moreover, some farms have sold a part of their land. We will not consider these plots in our analyses in order to keep farm area constant over time.

The land use database contains information for all plots which compose a farm. Each plot has an associated number and a determined area. For each year of project implementation, plots are associated to land use according to project typology. By multiplying plots area to points corresponding to land use index (see annex 6), we obtain plots score. For each farms, total Environmental Services Index (ESI) are the sum of all plots score.

The project typology considers twenty five possible land uses (and additional category for buildings, rivers and undetermined land). We will analyze only nine categories of land use in

order to simplify the analysis. Moreover, in the case of pasture, we keep only three broad categories (degraded, natural and improved pasture) while there were ten before, as the program has considered tree density in each of the broad categories.

Figure16. Land use typology

Initial GEF typology	New typology
Degraded pasture	Degraded pasture
Natural pasture without tree	Natural pasture
Natural pasture with low tree density (>30/ha)	
Natural pasture with recently-planted trees (>200/ha)	
Natural pasture with high tree density (>30/ha)	
Improved pasture without tree	Improved pasture
Improved pasture with low tree density (>30/ha)	
Improved pasture with high tree density (>30/ha)	
Fodder bank	Fodder banks
Diversified fodder bank	
Fodder bank with woody species	
Intensive Sylvopastoral System	SSP
Coffee with tree	Coffee
Monoculture timber plantation	Forest
Diversified timber plantation	
Scrub habitats (tacotales)=regeneration	
Riparian forest	
Disturbed secondary forest	
Secondary forest	
Primary forest	
Annual crops	Other LU
Semi-permanent crops (plantain, sun coffee)	
Monoculture fruit crops	
Diversified fruit crops	
Buildings and river	Non agricultural land
New live fence or established live fence with frequent	-

Note: The typology of land use has been simplified by creating broad categories.

So, our analysis is focused on land use change in terms of soil use (tree conservation, pasture and crops) more than full land use characteristics. As we can see on the following figure, we will consider timber plantation, riparian, secondary and primary forest as components of forests. Also, we will retain 3 types of pasture (degraded, natural and improved). Fodder banks are considered also as a single category and we will prefer use a dummy variable to present if this land use is present on the farm or not: as the area of these systems is small and generally represent less than 1% of farm area, the dummy seems easier to interpret and representative of a land use change. We will also use a dummy variable with intensive sylvopastoral systems and coffee plantation. The methodology to monitor live fences implementation is different (by km rather than by area) and we will not take them into account in our land use change analysis.

Each farm has different plot characteristics in terms of plots number and plots area. We will synthetize these information by giving total farm area, total farm ESI score for each year and farm composition by calculating a percentage of each land use (defined in table 16) which have been implemented in the farm for each year.

As sylvopastoral systems, coffee plantation and fodder banks represent generally a small area, we have integrated these land uses among the category "other land use". We will assess their evolution using a dichotomic variable. If a farm has implemented one of this three specific land use, the variable counts 1, 0 if the specific land use is not implemented. Therefore, the program has an impact if new farms have implemented one of these land use but not if they use more of one of this land use. For example, if a farm has 0,1 ha of fodder banks before the project and 0,15ha after the project, the variable will still value 1 for this farm.

B) Description of farms in 2003

a. Group repartition between 2003 and 2011

Among the 120 monitored farms, a control group containing 28 farms has been included. The project participants have been separated in 4 groups (Table 17). There were 2 program modalities: with payment or with payment and technical assistance. According to GEF impact assessment, Farms with payment and technical assistance have a better improvement of total ESI points during the project (+50% vs +40% for farm with payment only). But there was no significant difference between 2 years payment scheme and 4 years payment scheme.

Figure 17 Number of participants by category

Group description	Control group	Payment		Payment and Technical assistance		Total
Payment scheme	-	2 years	4 years	2 years	4 years	
Number of farms	28	14	12	33	33	120

Note: The sample has been divided in a control group and 2 different treated groups. Inside these 2 groups, a different payment scheme is applied.

Considering 2003 data, we make a statistical comparison of some characteristics for the control group (data available for 26 farms) versus the treated group (data available for 91 farms). We also make a statistical comparison of the surveyed (in 2011) treated sub sample (59 farms) versus the non-surveyed treated sample to determine if 2011 subsample is representative of all farms which have participated . If we consider the repartition of modality among subsamples of treated group (figure 18), we can see that the farms who have received payment and technical assistance during 2 years are more represented in the 2011 surveyed sample while the farms with only payment without technical assistance during 4 years are under-represented. We have done a significance test using Student t-statistic to check if there is a significant difference between original treated sample and subsample. The only significant difference is for the group who have benefited from payment during 4 years.

Figure18. Comparison of repartition of program group between treated farms and surveyed sub sample according to 4 treated groups

Repartition in %	n	Payment 2 years	Payment 4years	Payment +TA 2 years	Payment +TA 4years	Total
treated	91	13,1	15,4	35,2	36,6	100%
subsample	59	13,6	10,2	40,7	35,6	100%
ttest		ns	*	ns	ns	

Note: T-test checks if the difference between the treated group and the subsample is significantly different from 0.Levels of significance *: 10%, **: 5%, *:1%.**

But if we merge the payment groups without considering the payment scheme (2 or 4 years) and comparing repartition of farms which have receive only payment against farm which have received payment and technical assistance (figure 19), there is no significant difference between treated group and subsample. Also, there is no statistical difference between 2 years

payment scheme and 4 years payment scheme if we not take into account the payment group (with or without technical assistance) . Therefore, we can conclude that the difference of repartition identified in table 18 can't be attributed to a difference in payment group or payment scheme. But it could be more appropriate to consider payment group to assess farm evolution.

Figure 19 Comparison of repartition of program group between treated farms and surveyed sub sample according to program modality and payment scheme

		Payment vs Payment+TA			2 years vs 4 years scheme		
Repartition in %	**n**	Only payment	Payment+TA	Total	2 years	4 years	Total
treated	91	28,7	71,3	100%	48,4	51,6	100%
subsample	59	23,7	76,3	100%	54,2	45,8	100%
Ttest		Ns	ns		ns	ns	

Note: T-test checks if the difference between the treated group and the subsample is significantly different from 0. Levels of significance *: 10%, **: 5%, *:1%.**

b. Farm characteristics by group in 2003

We can see in figure 20 that there is a strong statistical difference between control group and treated group (in the 4 categories of the program), so there is a selection bias in the program. Indeed, it appears that farms in control group have already an "advanced" land use but also that there are leisure farms or bigger than treated farms. In fact, control group has been chosen in a voluntary basis with a compensation corresponding to the data needed. As we can see on the following table, these farms have significant differences in land use. First of all, the total farm area is quite different: control farms are bigger. If we consider the ratio ES points/total area, control group have a lowest score than treated group, which mean treated group have a better average land use by hectare. This is not intuitive because all the farms seems to have a similar part of forest (around 25% of total farm area) and control farms have less degraded and natural pasture but more improve pastures. Considering household characteristics and labor, we can notice that only control farms have a farm administrator and employ relative more permanent employee. Moreover, the family generally works less than in treated group. In terms of equipment, control farms seem to have generally more tools than treated farm.

They also have bigger herd size and more milking cows. So, we are not able to use this control group using impact analysis, we will prefer to analyze difference among treated group.

Figure 20 Statistical comparisons between control group, treated group, and treated subsample

		Control (n=26)	Control vs Treated	Treated (n=91)	Treated sub-sample (n=59)	Treated sample vs sub-sample
Land use						
	% forest	24,62		27,52	27,93	
	% degraded pasture	8,97	*	15,37	14,47	
	% natural pasture	29,33	**	41,21	44,42	*
	% improved pasture	30,61	***	10,28	8,96	
	% of farms with FB	26,92		27,47	25,42	
	Total area	49,16	*	32,86	33,5	
	PTS/ha	0,9	**	0,79	0,8	
Household						
	Size of hh	3,5		3,77	4	**
	Age of head	54,76		51,2	48,97	**
	years at school (Head)	7,79	***	5,57	5,77	
Labour						
	weekly familial work (h)	42,68	*	55,13	59,63	
	number of workers	0,92	**	0,25	0,2	
	majordom	0,34	***	0	0	
Livestock						
	herd size	66,23	*	38,92	40,4	
	avg milked cows in %	12,32		10,9	11,01	
Equipment	(in %)					
	back pump	0,85	**	0,6	0,66	
	water pump	0,12	***	0,01	0	
	camion	0,58	**	0,36	0,32	
	milking equipment	0,04	*	0,16	0,2	
	stable	0,19	**	0,05	0,05	
	well	0,31	**	0,12	0,1	

Note: T-test checks if the difference between the treated group and the control group is significantly different from 0 and if the difference between the treated group and the subsample is significantly different from 0. Levels of significance *: 10%, **: 5%, *:1%.**

If we compare treated surveyed subsample with other treated farms, we can notice a difference in terms of proportion of natural pasture. This is problematic in the sense that this means that our sub sample is not strictly representative of original sample but if we consider other characteristics, we can see that only notable difference is in household characteristics (sub sample farms have a larger household with a younger head) but livestock and equipment are similar. We can notice that the difference in proportion of natural pasture disappear if we remove 4 non surveyed farms which didn't have natural pasture in 2003.

C) Land Uses change during and after the program

a. Evolution of ESI score by hectare

To assess the performance of farms, we will retain the total ESI points divided by the area in hectares, which can be considered as an indicator of ecosystem services intensity in farm. This indicator varies from 0 (for a farm which is composed of 100% of degraded pasture) to 2 (for a farm which is composed at 100% of primary forest). We are using a double difference method to assess the performance of farms during the project. This method compares the evolution of difference between control and treated group during and after the program. As we can notice in table 21, the farms were significantly different before the program and the control group had better score (0,908 against 0,783).After the project, the farms are not significantly different, which means they have a similar ES intensification. A counter intuitive result is that farms from control group have significant positive evolution during the program (+0,130 points by hectares), even if it's less that for treated group (+0,328 points by hectares). The net program impact is an increase of 0,198 points by hectares, which is considerable. So, we can conclude that even if there is a general evolution to improve ecological land uses in farms, treated farms have had a better performance during the program.

Figure 21: Double difference analysis of ESI point by hectare between 2003 and 2007 (full sample)

ESI/ha	2003	2007	diff
control (n=28)	0,908	1,038	0,130***
Treated (n=92)	0,783	1,111	0,328***
diff	0,125***	-0,073	**-0,198*** **

Note: We check the significance of results using a t-test. Levels of significance *: 10%, **: 5%, *:1%.**

We can check these results using only the surveyed farms in 2011 and comparing their ES intensification in 2003, 2007 and 2011. As we can see, the subsample have better score in 2003 but also a better performance during the program, even for control group (figure 22). So, the net program impact is sensitively lower but still significant and very important. This can confirm there could be a selection bias between sub sample and original sample.

Figure 22: Double difference analysis of ESI point by hectare between 2003 and 2007 (subsample)

ESI/ha	2003	2007	diff
control (n=10)	0,923	1,068	0,145***
Treated (n=64)	0,799	1,131	0,332***
diff	0,124***	-0,064	**-0,188*** **

Note: We check the significance of results using a t-test. Levels of significance *: 10%, **: 5%, *:1%.**

If we consider the evolution between 2007 and 2011 (figure 23), we can see that all farms follow a land use improvement path, but at a lower level than during the time of project. But, there is no significant difference between control group and treated group in 2003 neither in 2011. We estimate the relative performance of farms after the program, so the result can be an indicator of the fact that farms could use their knowledge obtained during the project to continue increasing their ES intensification. But, the "net impact" of the program is not significantly different from 0 and surprisingly control group show a sensitively better performance. Besides, the evolution of control group is more than ten times lower between 2007 and 2011 than between 2003 and 2007. This can be explained by the fact that the project has had an influence in the control group, so these farms could have improved indirectly their ES performance. But, we can also consider that there is a threshold land use improvement: indeed, it's impossible to turn all pastures in forests or to plant new trees in the farm. So, probably, the ESI by hectare has a potential limit around 1,2 which is difficult to overpass in the context of a productive use of farm area.

Figure 23: Double difference analysis of ESI point by hectare between 2007 and 2011

ESI/ha	2007	2011	diff
control (n=10)	1,068	1,081	0,013
Treated (n=64)	1,131	1,143	0,012**
diff	-0,061	-0,062	**0,001(ns)**

If we consider the performance between 2003 and 2011, the results are similar to what has happened between 2003 and 2007 (figure 24).

Figure 24: Double difference analysis of ESI point by hectare between 2003 and 2011

ESI/ha	2003	2011	diff
control (n=10)	0,923	1,081	0,158***
Treated (n=64)	0,799	1,143	0,344***
diff	0,124***	-0,062	**-0,186*** **

b. Evolution of land composition

We calculate the average land use composition of farms in percentage in 2003 (baseline of program), 2007 (end of program for farms which were in the 4 years payment scheme) and 2011. As we can see in figure 25, the proportion of forest is relatively stable at each time. Major evolution is for the pasture: degraded and natural have been significantly reduced during and after the program while improved pasture have been largely implemented and continue to be implemented after the program. There is no significant difference for other land use, fodder banks (in ha) or buildings.

If we consider the proportion of farms which have implemented specific land uses (coffee plantation, fodder banks and intensive sylvopastoral systems), we find there is a significant change in the evolution of fodder banks implementation and Sylvopastoral systems (figure 26).

Figure 25: General evolution of land use composition of treated farms (n=59).

Land composition in%	2003	2007	2011
Forest	27,40	27,70	27,30
Degraded pasture	14,36	2,78***	2,18
Natural pasture	44,85	14,73***	10,99***
Improved pasture	9,11	49,8***	54,03***
Fodder bank	0,36	0,45	0,59
Other land uses	1,98	1,95	2,32
Buildings and unused land	1,5	1,44	1,39
Total	100	100	100

Note: We perform a t-test to check if difference between two dates is significant. In 2007 column, we check if 2003-2007 difference is significant. In 2011 column, we check if 2007-2011 difference is significant.

Figure 26: Proportion of farms which have implemented specific land use before, at the end and after the program.

% of farm with specific LU	2003	2007	2011	Difference (03-11)
coffee	6,8%	6,8%	6,8%	
fodder banks	25,4%	33,4%	37,3%	**
SPS	0,0%	6,8%	6,8%	**

Note: We perform a t-test to check if there is a significant difference in the implementation of specific land uses between 2003 and 2011.

However, performances have been sensibly different among farms. During the program (table 27) ,11 farms have gained less than 20% of points: these farms already have good index before the program (1,02).22 farms have gained more than 50 % of points: these farms are larger than average (40,2 ha vs 33,5 ha) but had more degraded pasture before the program (24,4% vs 14,5%).

Figure 27: Land use evolution and various performances during the program

		Land use in % of total area												
2003-2007		**conservation**			**degraded pasture**			**improved pasture**			**ESI points by ha**			**Area (ha)**
points variation	N	2003	2007	diff	2003	2007	diff	2003	2007	diff	2003	2007	diff	
<20%	11	17,1	17,2		3,8	3,6		9,1	30,3	***	1,02	1,15	***	23,3
≥20%, <50%	26	11,1	11,8		10,4	2,4***	***	10,2	52,3	***	0,86	1,16	***	30,7
>50%	22	3,5	6,1	*	24,4	2,8***	***	7,8	56,6	***	0,6	1,08	***	40,2

Note: We consider evolution of land use characteristics between 2003 and 2007 according to a typology of farms based on points variation. We check if 1) each sub group of farms has significant difference in land composition compared to group average 2) each group has a significant evolution of land composition between 2003 and 2007.

After the program (Annex 21), 9 farms have lost points: they have higher points than average in 2007 and have reduced their performance after.33 farms have gained points after the program, mainly by an increasing in proportion of improvement pasture.

We have previously assumed that the probability of a perverse effect (conversion from forest to pasture for example) during the program is limited because only the performance is taken into account. However, 2 farms have lost around 1ha of secondary forest during the program. They have gained relatively more points than other farms because they have adopted massively improved pasture. Besides, 7 farms have lost forest area (-7,3%): this is mainly due to a reduction of wood plantation.

D) Variation between 2003 and 2011

We will finally compare 59 treated farms between 2003 and 2011. If farmers have sold a plot between 2007 and 2011, this plot is not taken into account, so farm area is the same in 2003, 2007 and 2011.

a. Production systems

Based on preliminary field interview, we have known that the region of Esparza has suffer from a crisis of livestock production systems with low prices as consequence. Farms have then tried to diversify their activities and in particular have turned in double purpose or dairy farms. It seems important to take into account this evolution in production systems. Our basic assumption is that there are differences in land use according to specific production systems. Therefore, as the economic situation affects farms through changes in relative prices which lead eventually to changes in production system and then changes in land uses which are independent from the program effects.

b. Elaboration of a typology

In order to assess if there is a differentiated impact on farms, we have elaborated typologies based on production systems and farm size. Our first typology corresponds to production system. It is based on an income ratio corresponding to animal and dairy products sales. More precisely, we compare the annual incomes coming from milk and cheese to the income coming from calves and cows sales in each farm. We consider that a farm which have a ratio over 0, 75 is considered as dairy producer while a farm with a ratio under 0,75 but non null is a double purpose production. To establish a difference between farms specialized in meat, we separate small producers who own less than thirty five heads of bovines from big meat producers. We the have four categories in this typology. Our second typology corresponds to farm area. Small farms own less than twenty four hectares, medium farms between 25 and 50 hectares and big farms have more than fifty hectares. Finally, our last typology is about dynamic production system: we want to see the specific situation of farms that have change their production systems. Based on the previous production system typology, we consider the farms which have produced milk (or double purpose) in 2003 and still are doing it in 2011. Then, we consider the farms which were meat producer (small or big) in 2003 and 2011. Finally, the group of farms who turn their production from meat (small or big) in 2003 to milk (or double) in 2011. We can notice that no farms turn their production from milk to meat, this can be explained by huge investment cost of milk production and the relatively higher profitability of dairy farms.

The following table compare herd characteristic of farms according to the three defined typology. The first typology is the only one which contains an evolution of size in each group between 2003 and 2011 that means the production systems have changed. Indeed, farm area

hasn't changed (second typology) and we keep the same size for dynamic production system (third typology).

Considering the first typology, we can notice that the number of pure dairy farms have more than double (from six to fourteen farm) while the number of small meat producers have been considerably diminished (from twenty seven to seventeen). Double purpose farms and big meat producers remains relatively stable.

Figure 28 shows the "transfers" of farms according to their production systems. Among the 6 dairy farms from 2003, only 4 are still dairy farms in 2011 because two are now double purpose farms. The farms which were double purpose in 2003 even become pure dairy farms or continue to be double purpose farms. So, we can see that there is no pathway from dairy farms to pure meat production. Small and big meat producers have a more contrasted evolution and some of them become double purpose or dairy producers. So, if group average changes between 2003 and 2011, this may be cause by the transfer.

Figure 28: change in production systems

	Production system in 2011				
Production system in 2003	a	b	c	d	Total
a:Milk producers	4	2	0	0	6
b:Double purpose farms	7	9	0	0	16
c:Small meat producers	1	7	15	4	27
d:Big meat producers	2	1	2	5	10
Total	14	19	17	9	59

Note: There were 6 farms which produced only milk in 2003. Among these 6 farms, 4 are still producing milk in 2011 and 2 are now double purpose producers.

Considering the evolution of sample average (annex 16), herd size doesn't significantly vary, but the repartition is different, in particular the proportion of calves which have more than triple. This can be explained by the economic context, because if the prices are bad, farmers prefer to keep the animals and wait better prices. But, it also can be explained by a generalization of fattening methods. We can notice a significant increasing in the proportion of milking cows. So, the general evolution between 2003 and 2011 has been to use more milking cows and keep calves more time on the farm.

We will compare herd characteristics in 2003 and 2011 using the three typologies (Annex 16). The variables tested are number of bovine head, proportion of young calves, calves and cows and others animals in Tropical Livestock Units (1 pig=0,4 unit;1 goat=0,1 unit and 1 chicken=0,01). We also add the ratio of milking cows in percentage of herd: it's important to notice that even if a farm has no milk income, they can have cows and produce milk for their own familial use. For each category among each typology, we check if there is a significant difference between the category average and other farms average. For all farms in 2011, we check if there is a significant difference between average in 2003 and average in 2011. To interpret the results, we have to compare data with all farms average. As we can see, the 6sixmilk producers in 2003 have no significant differences with sample average, even if they have more cows and a ratio of milking cow higher. Nevertheless, the fourteen farms which are milk producers in 2011 have significantly less young calves but more cows and milking cows than average. But, we also know that seven farms among the fourteen that produce milk in 2011 were double purpose farms in 2003 and these farms have significantly bigger herd, so milk farms in 2011 have bigger herd than in 2003. It's interesting to compare these data with dynamic production system typology. We notice that dairy farms have in general bigger herds than average in 2003 but this difference is not significant in 2003. But, the indicator of percentage of milking cows is always significant for all categories in 2003 and 2007. For the typology based on farm area, herd size and TLU are the more significantly different: bigger farms have a bigger herd size. Considering the data which are significantly different, we can conclude that the main important indicators for production system are herd size and percentage of milking cows.

Farms converting from meat production to milk (11 farms) have at the same time increased herd size (+43%). So, it's possible they have use the payment received during the program to invest in herd. At the opposite, dairy farms (22 farms) have reduced their herd size (-13%) but have gained other animals (+3,1 TLU). Dairy farms have a higher proportion of forest (38% vs 27% on average) they have a higher ESI score before and after the program (but lower change). Farms which change their production system gain some forest (+2,1%)and significantly lose pastures (-3,6%).

We compare herd variation for farm size and dynamic production typologies (Annex 17). As we can notice, the herd size variation is limited but others animals have been bought, so we have a huge variation of tropical livestock units. Indeed, lots of farms have started to produce pigs. The bigger farms have significantly gained milking cows but also milk producers and

farms which have change their production system. So, dairy farms have reduced their number of bovines but have increased the part of milking animals, which can be interpreted as the fact that double purpose farms have definitely became exclusive dairy producers. The farms which are exclusive meat producers have reduce their proportion of milking cows while they have increase the proportion of cows.

Figure 29: Evolution of ESI points by hectares between 2003 and 2011

Evolution of ESI points by ha		n	ESI/ha 2003	ESI/ha 2007	ESI/ha 2011	variation (%) 2003-2011	Difference in points between 2003 and 2007	Difference in points between 2007 and 2011
Production system(2003)	Milk producers	6	0,98	1,23	1,24	28,3	ns	ns
			**					
	Double purpose farms	16	0,83	1,16	1,15	44,9	ns	ns
	Small meat producers	27	0,79	1,12	1,14	50,7	ns	ns
	Big meat producers	10	0,64	1,06	1,08	80,2	**	ns
			**			**		
Farm size	Small farms	31	0,82	1,13	1,14	47,1	***	ns
	Medium farms	17	0,81	1,16	1,16	52,7	***	ns
	Large farms	11	0,69	1,07	1,11	64,0	*	ns
			*					
Farm dynamic production system	Always milk producer	22	0,87	1,18	1,17	40,4	ns	ns
			**			*		
	Always meat producer	26	0,70	1,05	1,09	64,5	**	ns
			***	***	**	**		
	Meat then milk producer	11	0,87	1,21	1,21	44,8	ns	ns
	All farms	59	0,79	1,13	1,14	51,8	**	ns

If we using the three typologies to see evolution of specific farm profile (figure 29), we confirm that dairy farms has better land use characteristic before the program, but this difference is not significant in 2011. Big meat producers have lower performance before the program but significantly improved land use during the program.

We complete our analysis with a multinomial analysis considering the four defined production systems. We use 2003 data. Based on field interview, we know that dairy farms are generally situated in upper lands, so it's important to determine the geographic situation of the farm. Unfortunately, the variable corresponding to altitude is not available for all farms, so we are using a variable which catch distance. This variable represents the distance between farm and the nearest town. Our hypothesis is the farms far away from town are supposed to be the one who produced milk, because no towns are situated in upper lands.

The list of variable used can be found in Annex 26. Household characteristic are generally key factors to explain choice in economic activities. Here, we consider the household size, so the available stock of labor force. We adds education variable, more precisely the years of education of household's head and his wife.

Then, land use variable are important variables and we have a lot of information on each farm: we will consider total farm area but also the ratio of ESI by ha in 2003. Finally, we have built a variable of relative price by village based on the price ratio of a liter of milk divided by the average price by kg of calves. As we don't have this information for all farms, we consider an average for each town.

We estimate our model using a multinomial logit to compare the influence of land use and prices factors on the probability to adopt a specific production system (Annex 27). Compared to double purpose farms, farms from other production system are situated relatively far away from towns. Meat farms are also relatively smaller than double purpose farms. Surprisingly, higher price ratio is, more farms are able to adopt meat production rather than double purpose farms. This can be explained by the difficulty to have a credit and the limited investment capacities of meat farms. Indeed, they receive income only when they sell animals. Compared to dairy farms, relative price have also an influence counterintuitive because it appears that a higher ratio is in favor of meat producers. Nevertheless, we can see that meat farms have an ES index lower than dairy farms. The difference between small and big meat producers is also

about land use performance: big meat producers have relatively worse ecological use of lands. But, as we can see, big meat producers have also larger farms.

We would like to determine the relative impact of the program on this production change. Indeed, the program has aimed at improving land use. At the same time, we have established that dairy farms have better land use according to ESI typology. Moreover, between 2003 and 2011, 11 farms have become dairy or double purpose producers. We will then estimate a triangular model composed of three equations.

First equation tries to explain determinants of points variation. The dependent variable is a binary variable valuing 1 if the farm has increased its total ESI score of more than 50%. We explain this evolution by household characteristics, farm characteristics, initial land use (ESI score by hectare before the project) and we add two dummies corresponding to the fact that farms were small or meat producers in 2003.

Second equation analyses determinants of production system change using a binary variable catching the fact of turning a meat production into milk production. We are using all the explanatory variables of previous equation but we add the variation (in %) of ESI points by hectare before 2003 and 2011 and price variables: initial price ration between milk and meat in 2003 and variation of this ratio between 2003 and 2011.

Last equation is about use of concentrates to feed animals in 2011. Indeed, dairy farms generally prefer to use concentrates during the milking process.

Our expected model (Figure 30) establishes that initial land use has a negative impact on program performance because farms with bad land uses have better opportunities to improve during the program. As program performance creates a payment, we suppose that program performance has a positive impact on the change in production system because farms could have invested money received to buy milking cows. At the same time, price variation has a positive impact on this change: if price ration is more interesting for milk, more farms would produce milk. At the same time, price variation has also a positive impact on uses of concentrates, because farms want their cows to produce more milk. Also, change in production system has then a positive impact on the use of concentrates.

We estimate this model using three probit regressions (Annex 28) and all our hypotheses couldn't be confirmed (figure 31). We estimate the three equations using a probit. Farms which have gained more points since the beginning of the project are the ones which have the

lowest ecological performance. Other variables don't have a significant impact on points gains. However, points variation has no impact on the change in production systems while initial land use and farm area have a positive impact. Price variation has a positive impact on this change. Finally, household size has an impact on change in production system, which can be explained by the available labor force.

The use of concentrates in 2011 is not determined by the use in 2003. But, the change in production system has a positive impact on the use of concentrates. Farms which were meat producers in 2003 are not the ones which use concentrates in 2011. Household size has a negative impact on use. But, price variation has a negative impact on the use on 2011. Before the project, it was difficult to change production system, even if milk was more profitable. Meat producers with poor land use have simultaneously improved their land use and change their production system to adopt milk (independently from the program). Indeed, evolution of price ratio makes dairy production more profitable. But, this price ratio has surprisingly a negative impact on the use of concentrates while change in production system has a positive impact.

Figure 30 expected model

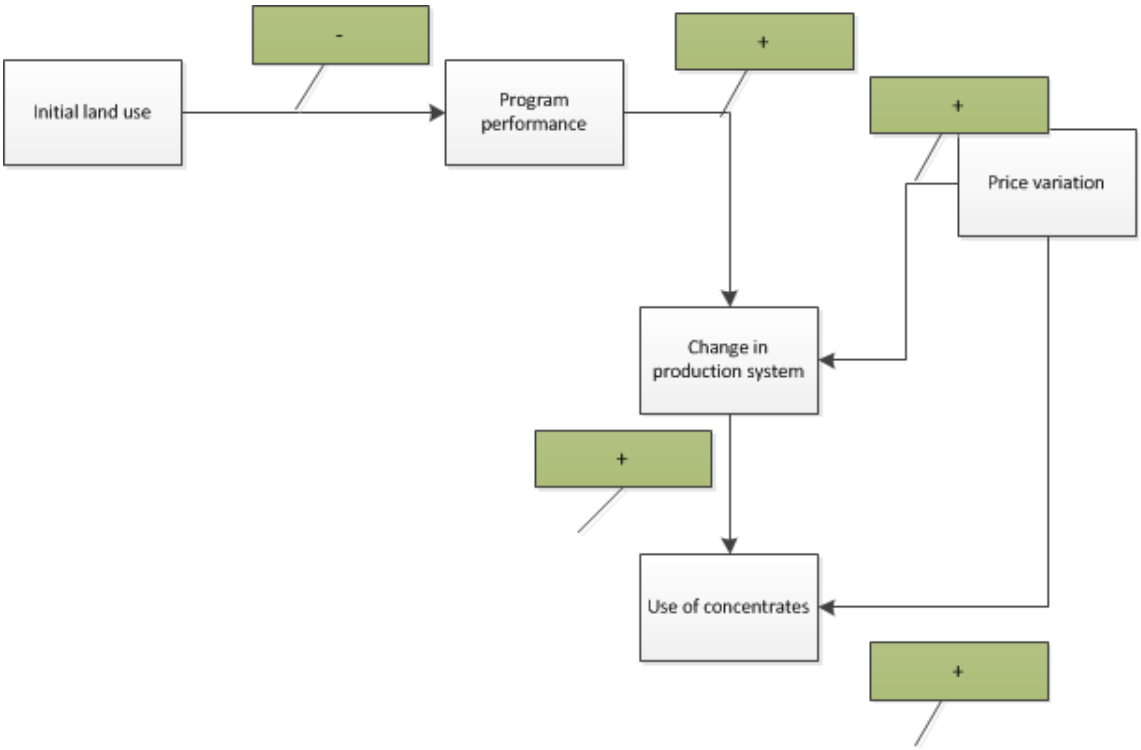
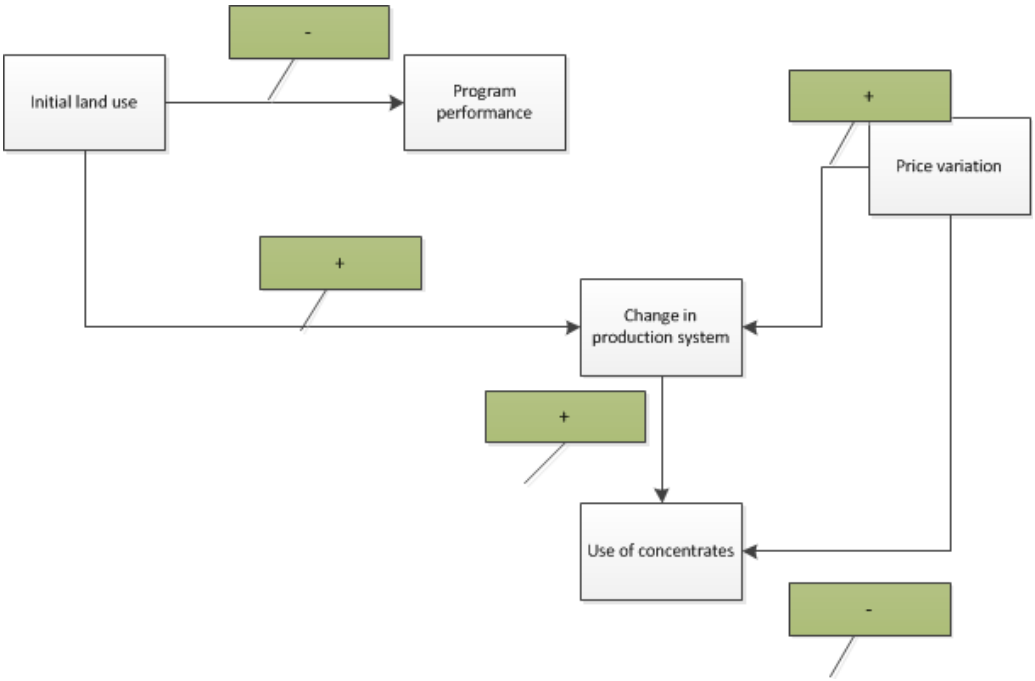


Table 31: Model according to data



So, we can't accept the hypotheses that program performance have an impact on change in production system. This change is caused by exogenous causes, which are mainly price ratio. This result could be interesting: by subsidizing products which are known to be produced in a farm with good land use, it could be possible to create an incentive to improved land uses through market mechanism. However, we know that dairy farms are generally situated in mountain areas in Costa Rica, so we can suppose that land uses would be different in other parts of the country. However, as we can see, the program has no impact on use of concentrates. So, if we are doing a lifecycle assessment of milk production, it could be possible to find that this production system emits much carbon. Moreover, as milk cows are generally closed in stables, they produce a lot of manure, which can have a negative impact on ecosystem, in particular on water resources.

E) Discussion

We have seen that most of the improvements established during the program have been conserved by farmers 4 years after the program (Hypothesis 1). Therefore, we can consider that this pilot project is a successful technological transfer program in the implementation of sylvopastoral systems. However, we have not enough elements to establish if there a clear impact on farmers' income and livelihood, but the program in itself wasn't directly targeting poverty.

Besides, we can consider that there was a different impact of the program according to production systems (Hypothesis 2). Some future programs can include this aspect of production system, by proposing different pathways according to the initial production system, for example. But, it's seems important to keep in mind that there are determinants of production systems. We have identifies price ratio as important variable but there are probably other variables (economic, geographic, familial,…) which explain that. Therefore, economic incentives are probably in themselves not sufficient to promote this change.

The fact that prices evolution has a consequence on change of behavior is a trivial result. But it's interesting to have elements to confirm that exogenous factors can have a great impact on variables which could have an influence on program performance. Nevertheless, we can't' confirm that performance during the program have a significant impact on change of production system (Hypothesis 3).

In order to give more data to analysts, it could be interesting to try to establish a control group with characteristics more similar to treated group. This statistical information could be used to assess effects of exogenous factors on performance and determine as well if these factors have the same consequence on treated and control group. We could have determined precisely what is the impact of the program on the change of production system.

Finally, we have seen the importance of using a ESI score divided by farm area in order to take into account structural inequality in land uses for different farm size. Indeed, even if it's the payment corresponds to the change compared to the initial baseline, larger farms are the more able to receive more money from the program.

F) Policy recommendation

Even if there is no consensus on the way to measure Ecosystem Services at farm level, the project has provided a scientific and coherent tool to improve and upgrade silvopastoral systems. However, the program is focused exclusively on land uses, which is in fact only a part of potential sources to reduce carbon emissions and biodiversity losses. As well, it appears interesting to define typologies of farms in order to make them participate to the program which correspond the more to their situation. For example, we have seen that the production system and the size of the farm size have an impact on the land use. However, the GEF program is not sufficient to take into account total livestock impact on ecosystems. The program has obviously a positive impact on the adoption of new land use (technological transfer) and on the reduction of degraded pasture. But it didn't aim at reducing total carbon emission produced by livestock activities. Therefore, we can consider two future pathways.

The first one is to elaborate a program which aim at reducing all (or at least more) sources of carbon emissions and biodiversity losses. This program would include land use change as well as recycling technologies and reduction of use of chemical or imported inputs and these changes can be effective through contracts involving financial incentives and training. The scheme could be a multidimensional PES, which can combine both asset building and use restricting aspects. But a certification scheme can also be a solution, in particular if they can provide training to promote change. The criteria in discussion in the Rainforest Alliance sustainable cattle production label seem to be interesting. However, as we have seen, it's important to have an incentive scheme which combine training and payment in order to reach the criteria of the label.

The second possible way is to consider a farm evolution step by step. In this aspect, land use change can be considered as a first step. Next steps would consider the whole production system and try to reduce carbon emissions and biodiversity losses implied by actual value added chain. It could be interesting in this pathway to develop new indicators in order to assess the qualitative level of land use and the potential of Ecosystem Services provision. However, this kind of program implies important costs and good framework between different level (national and regional) and institutions (Ministry of Agriculture, Ministry of Environment, NGO's,…)

Finally, as we have seen, market-based incentives have become very popular in promoting incentives to provide Ecosystem Services. State agencies such as FONAFIFO have implemented new kinds of institutional rules which are really innovative. At the same time, several pilot and local initiatives have appeared in order to try to promote particular aspects of ES provision. Different philosophies exist whether it should be the consumers of farm product (through price premium), the ecosystem services users (through voluntary contribution) or the citizens (through taxes) who have to bear the costs of these programs.

The multiplication of local projects can also create bad incentives and an assessment using policy-mix evaluation is necessary (and is actually done is some region of Costa Rica). But it seems important to design a general framework in order to take into consideration various mechanisms. As the local conditions are very different in terms of market structure and ecosystem services, many different schemes will coexist. Some mechanisms become institutionalized such as the national PES program and the ESPH program; this means that the financial scheme and the beneficiaries of the programs are well identified.

Conclusion

Environmental incentives aims at maximizing ES provision (as well as minimize emission of EDS) at both local and global level by adopting an adequate combination of land use and practices, knowing that farms have also to be considered as production unit with externalities. As we can see in some mechanisms, the people who benefits from Ecosystem Services are not necessarily ES buyers. This is obvious in the case of National PSA, where the main source of fund come from national tax on oil: even if it's logical that national inhabitants will be the first to benefits from scenic beauty, the entire world will benefits from carbon sequestration and conservation of biodiversity. At the same time, in the case of eco-labeling, the final user, consumer from a developed country is paying, based on ethical preoccupation, for the preservation of ecosystem situated in a foreign country.

We have seen that mechanisms become more and more sophisticated and become able to improve the interaction between agriculture and environment to find equilibrium acceptable from both economic and environmental perspectives. The major important point is to consider that farms are not only potential polluter but ecosystem services producers. The various incentives existing have to be considered as solution to improve bad situations. In an institutionalized mechanism like national PSA, there is a combination of instruments because payment creates incentives to better managed forest but at the same time, it's forbidden to cut forest. Moreover the literature in ecosystem services try to defend the idea that to have better ecosystem services, the scale to consider should not be a farm but a landscape, which means that the positive interaction between ecosystem occurs at larger scale that only few hectares and the practices have an impact on ecosystems even outside a specific farm. Therefore, we can consider that program proposed by hydro electrical companies are particularly important mechanism because they try to make the relation in all environmental "value chain", from the owner of soils where rain infiltration occurs to the final consumer of water and electricity. So, it's necessary to establish local institutions in order to be able to work in coordination with many local stakeholders. Finally, in the case of Costa Rica, discussion is actually made in order to implement a so-called "Second generation PSA" which could be used as a tool of rural development, with a special focus on agriculture. This is close to the vision of PES for agriculture proposed by FAO in FAO (2011): " *a new generation of PES in agriculture could*

seek the potential of a specific set of ecosystem services that can be simultaneously enhanced through appropriate agricultural practices (bundling of ecosystem services in agriculture). In this new vision, a PES labeled as PES in agriculture would be aimed at ensuring the long-term delivery of food security, a condition that will be fulfilled only when at least the subset of ecosystem services that are particularly influenced by agricultural activities are managed under sustainable and ecological criteria. In particular, a new generation of PES in agriculture for food security should:

- Be driven by a strong participatory approach;

-According to a collective vision, be implemented at community level;

-Seek to promote a model of production based on the ecological carrying capacity of agro‐ecosystems;

- Consider a bundle of ecosystem services, rather than a single one."

Livestock activities have their place in the promotion of sustainable practices because they are obviously at the interaction between economic, social and environmental preoccupation by creating wealth, assure food security and managing landscapes. If we consider that Costa Rica is near of reaching the upper limit in land to reforest (around 60% of total area), the new possibility to increase tree cover could be to plant trees in pastures. Farmers are landscapes managers able to provide ecosystem services. It seems that new generation of PES or other environmental incentives will couple conservation policies in the context of productive activity. Our work has tried to show that production system has an impact on land use but at the same time, that farmers can use payments as an investment to change their production systems to more profitable ones. However, farms are very sensitive to economic context, in particular to price variation. It's seems difficult to implement an incentive program which can also regulate this price variation during several years.

Nevertheless, giving support to small farms in order to make them implementing sustainable practices such a sylvopastoralim can have a positive impact in terms of Ecosystem Services provision. Therefore, general incentive framework could be designed as it follows:

- a strong national command and control program establishing by law which are the forbidden practices (forest clearing, use of highly toxic pesticides,…)

-local programs to preserve specific ecosystems such as watershed or protected areas

-local incentive programs to allow small producers to invest in better land uses and practices

-Organized value added chains such as in certification programs which assured the consumer products come from farms with good environmental practices.

As we can see, it's important to find equilibrium between public policy and market organization, as well as equilibrium between national and local level. However, Costa Rica is seen as a good example of developing countries which have implemented an innovative environmental policy. Environmental considerations are actually consensual among political and civil society actors. Moreover, Costa Rica aimed at becoming Carbon Neutral in 2021. The country has received international loans to finance policies design to reach this objective.

Finally, evolution of mechanism, and in particular Clean Development Mechanism and the integration of REDD+ initiative will probably give birth to new incentives programs aiming as improving Ecosystem Services provision at farm level, but also at landscape level.

Personal assessment

This internship has been a great experience to me. First of all, I have worked in to different research centers: CATIE in Costa Rica, CIRAD in France. I've been able to work and talk in three languages: English, French and Spanish. So, it was a totally international work! I quickly get used to work in different languages but it take me more time to be able to work efficiently in one place and give results at distance using electronic files.

My work has been organized in two different axes. First, I have had to compare several mechanisms and classify them. Second, I had to carry out a survey and analyze field data. It has been difficult to organize my work in order to fulfill the 2 tasks. Indeed, my internship has been dense with many meeting and 2 weeks of field works. It was hard for me to find relation between the 2 axes but finally I have better understood how to use conclusion from mechanism comparison to analyze statistical data and vice versa.

During my internship, I have used several databases, in particular GIS data. Fortunately, I have been familiar to these techniques thanks to a formation received during my master degree. But, it appears clearly that database work is not exactly the same at university and in fieldwork. I was persuaded to have sufficient knowledge on statistical and econometric techniques but I have had difficulties in practices to use it efficiently. For example, I have lost much time because I didn't know very well some agricultural and agronomic concepts. Moreover, I have lacked of hindsight with many of these concepts.

It was the first time that I have to carry out a survey: I have realized the amount of time necessary to do this! I have always have the feeling of being late during the elaboration of questionnaire and moreover in the data extraction and their analyses. I also realized how research activities are time consuming! Sometimes, I have spent three days trying to find a result without obtaining it…

I was impressed by the numbers of disciplines involved in my subjects of study: I have read articles on climate changes, ecological corridors, agronomy, public policies… This aspect is also obvious in research workshops, when different articles are presented: it appears that it's necessary to give precise definitions in order to be understood by all disciplines. As ecological economics is a relatively recent research axe, many concepts are lacking of widely accepted definition. I have discover how deeply researchers are critics about environmental policies

and ask for a better understanding of ecosystem mechanisms before designing institutional mechanism to improve some environmental aspects, maybe at the expense of other environmental aspects.

I was surprised to find that majority of articles I used are very recent, many of them have been published in 2011. Indeed, environmental policies and interaction between livestock and environment are themes intensively debated in actual literature.

To conclude, this internship was a great experience. I wanted to know how researchers work on field, I am sure I have seen many of the aspects! Even if my master degree was not directly aiming at make research, I have acquire many tools to address this task. Interesting discussions with many researchers are motivating me to pursue in this direction if I have the opportunity.

Bibliography

Budowski, G,1987. The development of agroforestry in Central America, pp. 69–88. In Steppler, H.A. and Nair, P.K.R. (Eds) *Agroforestry: A Decade of Development*. International Centre for Research in Agroforestry, Nairobi, Kenya.

Costanza, R. and 12 others, 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253–260

Daily G. ,1997. Nature's Services: Societal Dependence on Natural Ecosystems. Washington, DC Island Press.

FAO ,2011. Payments for ecosystem services and food security

Ibrahim, M., Gobbi, J., Casasola, F., Chacón, M., Ríos, N., Tobar, D., Villanueva, C., Sepúlveda, C., 2006. Enfoques alternativos de pagos por servicios ambientales: Experiencia del proyecto Silvopastoril. Paper presented at the Workshop on Costa Rica's Experience with payments for environmental services. San José, 25–26 September 2006. (in Spanish).

IIED, 2006. Costa Rica-ICE Watershed Management Units

Kaimowitz, D., 1997. *Policies affecting deforestation for cattle in Central America*

Kaimowitz, D., 2001. Will livestock Intensification Help Save Latin America's Tropical Forests? Center for International Forestry Research, Bogor, Indonesia (2001)

Karsenty ,2011. Combining conservation incentives with investment. Perspectives n°7, January 2011, CIRAD

Le Coq, J-F et al. , 2010. PES and Eco-Label. A Comparative Analysis of Their Limits and Opportunities to Foster Environmental Services

Le Coq, J-F. et al., 2010. Continuity and Inflexions of the Program of Payment for Environmental Services in Costa Rica: A Learning Process and Stakeholders' Balance of Power Perspective

Legrand,T. and Le Coq,J-F.,2011. The Efficiency of the Costa Rican Payment for Environmental Services Program under Discussion

Meral,P. ,2010. Les services environnementaux en économie :une revue de la littérature, SERENA document de travail n°2010-05

MINAE. Aplicación de incentivos a la conservación de la biodiversidad en Costa Rica

Pagiola, S. , 2007. Payments for Environmental Services in Costa Rica. *Ecological Economics,* Elsevier, vol. 65(4), pages 712-724, May.

Pagiola,S. et al. ,2007. Paying for the environmental services of silvopastoral practices in Nicaragua *Ecological Economics*, Elsevier, vol. 64(2), pages 374-385, December.

Pagiola, S. et al., 2008. Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics*, Elsevier, vol. 65(4), pages 663-674, May.

Pirard, R. et al., 2010. Upscaling Payments for Environmental Services (PES): Critical issues

Robalino, J. and al. ,2011. Assessing the Impact of Institutional Design of Payments for Environmental Services

Swinton,S. et al ,2007. Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits

Villanueva, C. et al. 2011. Ecological Indexing as Tool for the Payment for Ecosystem Services in Agricultural Landscapes

World Bank , 2000. *Forest strategy and the evolution of land use in Costa Rica*

Wunder, S. 2005. Payments for Environmental Services: Some Nuts and Bolts. Occasional Paper No. 42, CIFOR

Wunder, S., 2006. Are direct payments for environmental services spelling doom for sustainable forest management in the tropics? *Ecology and Society*

Wunder, S. et al, 2008. Taking stock: lessons learnt for the design of payments for environmental services programs. *Ecological Economics*, 65 (2008), pp. 834–852

Zbinden, S., Lee, D.R. ,2005. Paying for environmental services: An analysis of participation in Costa Rica's PSA program. *World Development* 33(2): 255-272.

List of figures

Figure 1: Ecosystem services and constituents of well –being

Figure 2: Ecosystem services and disservices to and from agriculture

Figure 3: Principle of PES in a context of forest conservation

Figure 4: Different PES types

Figure 5: Comparison of some PES programs in Costa Rica according to Wunder(2005)

Figure 6: Estimation of net farm income with usual practices and Sylvopastoral practices

Figure 6 bis: GIS of farms with evolution of land uses by category

Figure7: Incremental ESI points per hectare during PSA-GEF (2003-2007)

Figure 8: Document structure of SAN Standards for Sustainable Cattle Production Systems

Figure 9: The philosophy of Sustainable agricultural standard

Figure 10: Classification of ES incentives

Figure 11: Difference between National PSA and ESPH PSA

Figure 12: Classification according to Wunder (2005): PES types

Figure 13: Decomposition of each mechanism

Figure 14: Different costs and gains associated to each mechanism

Figure 15: Adaptation of each mechanism to several livestock farms characteristics

Figure16: Land use typology

Figure 17: Number of participants by category

Figure18: Comparison of repartition of program group between treated farms and surveyed sub sample according to 4 treated groups

Figure 19: Comparison of repartition of program group between treated farms and surveyed sub sample according to program modality and payment scheme

Figure 20: Statistical comparison between control group and treated group, and subsample

Figure 21: Double difference analysis of ESI point by hectare between 2003 and 2007 (full sample)

Figure 22: Double difference analysis of ESI point by hectare between 2003 and 2007 (subsample)

Figure 23: Double difference analysis of ESI point by hectare between 2007 and 2011

Figure 24: Double difference analysis of ESI point by hectare between 2003 and 2011

Figure 25: General evolution of land use composition of treated farms (n=59)

Figure 26: Proportion of farms which have implemented specific land use before, at the end and after the program.

Table 27: Land use evolution and various performance during the program

Figure 28: change in production systems

Figure 29: Evolution of ESI points by hectares between 2003 and 2011

Figure 30: Expected Causal model

Figure 31: Causal model according to data

List of Annexes

Annex 1: National PSA modalities

Annex 2: Distribution of Payment in each PSA modality

Annex 3: Amount of payment by hectares or by trees by modality in national PSA

Annex 4: Priority criteria to apply to PSA program

Annex 5: Legal requirements to enter national PSA

Annex 6: Ecological index for different land uses in Sylvopastoral PSA.

Annex 7: Description of the 10 principles of the Sustainable Agriculture Standard

Annex 8: Standard for sustainable cattle production systems

Annex 9: Summary list of proposed indicators

Annex 10: Differences between National PSA and Sylvopastoral PSA

Annex 11: Differences between National PSA and Rainforest Alliance Label.

Annex 12: Juridical comparison between mechanisms

Annex 13: Financial comparison between mechanisms

Annex 14: evolution of average land use composition among treated farms

Annex 15: Evolution of prices in GEF project area

Annex 16: herd characteristics according to defined typologies

Annex 17: Herd variation according to farm size and dynamic production system typologies

Annex 18: Land composition in 2003

Annex 19: Land composition in 2011

Annex 20: Evolution in the implementation of specific land use

Annex 21: Different performance during and after the program

Annex22: Land use evolution of farms with forest losses

Annex 23 Index evolution for farms with forest losses

Annex 24: Evolution in the use of inputs

Annex 25: Evolution in the use of tools and infrastructure

Annex 26: List of variables used in models

Annex 27: Excerpt of multinomial estimation of determinants of farm production systems

Annex 28: Excerpt from econometric estimation of causal model

Annex 1: National PSA modalities (2011)

1. Forest protection

The projects in forest are native or indigenous, intervened or not ecosystems, occupying an area of five acres to three hundred hectares per year, characterized by the presence of mature trees of different ages, species and size varied, with one or more canopies covering over seventy percent (70%) of the surface and where there are more than sixty trees per hectare of fifteen or more inches in diameter , according to the definition of forest established in the Forestry Law No. 7575 .

2. Water Resource Protection

These projects are established in forest areas with aquifer recharge potential, which occupies an area of two to three hundred hectares per year in areas where infiltration occurs that feeds particular water areas of importance identified by the Department of Water and FONAFIFO, or other instances of Ministry of Environment.

3. Protection of Protected Areas

They are found in forested land in private sites located within established protected area. The project size is of two to three hundred hectares per year.

4. Protection of Forest in Conservation area

Private sites located within Protected Areas and Biological Corridors, or on private land outside of Protected Areas and Biological Corridors, but have great biodiversity value. The project areas of two to three hundred hectares per year, except the indigenous territories which can recruit up to a thousand hectares per year.

5. Forest Management

On farms that have management plans approved by the State Forestry Administration, in an area two to three hundred hectares

6. Reforestation

Project set in grounds of one to three hundred hectares, cultivated by one or more forest species in sites with high productive potential for forest plantation development to the capacity of land use, giving particular priority to projects that use genetic material improved. Also must have a density of eight hundred and sixteen trees per hectare.

7. Reforestation with native species to extinction

In a land of three hundred acres, cultivated by one or more species contained in the decrees of closed and threatened or endangered areas.

8. Reforestation in Protection Areas

Projects which are established on land from one to three hundred acres, cultivated by one or more tree species. The sites selected must be degraded or buffer zone permits the development of forest plantations.

9. Second Harvest

These projects are made in area of three hundred hectares, cultivated specifically for Tectona grandis and Gmelina arborea. They begin from the final harvest of the plantation established on the site, with evidence of appropriate management earlier.

10. Natural regeneration in Kyoto Land

In areas with pasture and grazing in an area of two to three hundred acres and can be made only in areas defined as Kyoto lands, according to the provisions of the Kyoto Protocol.

11. Natural regeneration in Pastures

In denuded land suitable for forestry in an area of two to three hundred acres, to regenerate into forest site conditions that have a low potential for regeneration.

12. Natural regeneration with Productive Potential

Land with secondary succession stages of forest potential to regenerate to forest, for project area of two or more hectares which are in area of abundant regeneration of seedlings and saplings of commercial species.

13. Agroforestry Systems

All those in which agricultural production is based on a tree species polyculture with other herbaceous nature with a minimum of three hundred fifty five thousand trees (Coffee Agroforestry Systems, Species in Agroforestry Systems with Extinction, Agroforestry with Species in Extinction)

Annex 2. Distribution of payment in each PSA modality

Distribución de los Pagos de los Servicios Ambientales del periodo 2011, por Modalidad

Modalidades	1er año	2do año	3er año	4to año	5to año
Protección de Bosque	20%	20%	20%	20%	20%
Protección dentro de Áreas Silvestres Protegidas	20%	20%	20%	20%	20%
Protección de Recurso Hídrico	20%	20%	20%	20%	20%
Protección en Vacíos de Conservación	20%	20%	20%	20%	20%
Regeneración en Potreros en Tierras Kyoto o Carbono	20%	20%	20%	20%	20%
Regeneración en Potreros	20%	20%	20%	20%	20%
Regeneración con Potencial Productivo	20%	20%	20%	20%	20%
Reforestación	50%	20%	15%	10%	5%
Reforestación en Áreas de Protección	50%	20%	15%	10%	5%
Reforestación con Especies en Vías de Extinción	50%	20%	15%	10%	5%
Segundas Cosechas	50%	20%	15%	10%	5%
Manejo de Bosque	20%	20%	20%	20%	20%
Sistemas Agroforestales	65%	20%	15%	-	-
Sistemas Agroforestales en Café	65%	20%	15%	-	-
Sistemas Agroforestales con Especies en Vías de Extinción	65%	20%	15%	-	-
Sistemas Agroforestales con Especies Nativas	40%	15%	15%	15%	15%

Annex 3. Amount of payment by hectares or by trees by modality in national PSA

Montos Asignados por Hectáreas y/o Árboles para el Pago de los Servicios Ambientales por Modalidad, Año 2009

Año	Modalidades de PSA								
	Protección de Bosque	Protección Dentro de Áreas Silvestres Protegidas	Protección de Recurso Hídrico	Protección en Vacíos de Conservación	Reforestación	Regeneración en Potreros en Tierras Kyoto o Carbono	Regeneración en Potreros	Regeneración Natural con Potencial Productivo	Sistemas Agroforestales (árboles) *
2009**	320.00	320.00	400.00	375.00	980.00	320.00	205.00	205.00	1.30

Fuente: Decreto Ejecutivo

(**) El monto está fijado en dólares

Annex 4. Priority criteria to apply to PSA program

N° de criterio	Forest Protection Priorities	Puntos para priorizar
1	Forest located in Conservation Gaps and also in national protected wild areas (ASP); Forest located in Conservation Gaps and Biological Corridors; Forest protecting the water resourse (with a note of ASADA; AYA or municipality) or FONAFIFO or MINAET where is established the importance of protecting the forest ; forest in the indigenous territories.	80
2	Forest located in Conservation Gaps and out of the national protected wild areas and Biologival Corridors; Forest located inside national protected wild areas ASP and out of Conservation Gaps; Forest located in ASP and still have not been purchased or expropriated by the State.	75
3	Forest in private Farms in Biological Corridors and out of Conservation Gaps.	70
4	Forest with contracts in the modality of Forest Managment and are applying for the forest protection modality as long as they fulfill all the requirements on the manual of procidures and the contract concludes the same years that they are applying.	65
5	Forest outside of the previous priorities mentioned	60
I	Forest for conservation on the farms that fulfill one the requirements listed above that have constracts for forest protection in PES in the previus years, as long as they fulfill all the requirements on the manual of procidures and the contract concludes the same years that they are applying. The validity of the new contracts will begin the day after the due date of the previous contract.	5 puntos adicionales
II	Forests located on districts with a Social Development Index lower than 40% according with the established by MIDEPLAN (2007).	5 puntos adicionales
III	Forest in any of the previous priorities listed above, with application for PES in areas smaller than 50 has.	10 puntos adicionales
iv	Applicants who show their interest of applied this year, after applied the previous year and it was not processed, as long as they fulfill all the requeriments	5 puntos

Source: Fonafifo (2011), Oscar Sanchez's presentation.

A farm has to to fulfill criteria in order to have be above 85 points to be able to enter in PSA program

Annex 5: Legal requirements to enter national PSA

Landowners who wish to participate in the program have to provide the following documents:

a) Application form to the regional MINAE office;

b) Proof of identity or statutes of an organization;

c) Proof that they hold a legal title to the land. If applicant only have possession rights then other official requirements are necessary: proof of sale, three independent witnesses, description of the property and its limits, proof that there are no conflicts over the property, etc. All of these have to be publicly authorized by an official lawyer (*notario público*).

d) Proof that they have paid local taxes;

e) An official cadastral map of the property;

f) Verification of the size of the area by a professional topographer;

g) (Copy of) a cartographic map on a scale 1:50.000 to indicate location of the area;

h) Legal authentication of representative;

i) For sustainable forestry activities, a Forest Management Plan drafted by a professional forestry engineer and approved by the National Conservation Areas System (SINAC). Reforestation can only be financed after additional official approval by the
Ministry of Agriculture;

j) Priority areas for approving projects are selected every year through a decree.

Annex 6. Ecological index (ecological points per hectare) for different land uses in Sylvopastoral PSA.

Land use	Biodiversity index	Carbon sequestration index	Environmental services Index (ESI)
Annual crops	0.0	0.0	0.0
Degraded pasture	0.0	0.0	0.0
Natural pasture without trees	0.1	0.1	0.2
Improved pasture without trees	0.4	0.1	0.5
Semi-permanent crops (plantain, sun coffee)	0.3	0.2	0.5
Natural pasture with low tree density (<30/ha)	0.3	0.3	0.6
Natural pasture with recently-planted trees (>200/ha)	0.3	0.3	0.6
Improved pasture with recently-planted trees (>200/ha)	0.3	0.4	0.7
Monoculture fruit crops	0.3	0.4	0.7
Fodder bank	0.3	0.5	0.8
Improved pasture with low tree density (<30/ha)	0.3	0.6	0.9
Fodder bank with woody species	0.4	0.5	0.9
Natural pasture with high tree density (>30/ha)	0.5	0.5	1.0
Diversified fruit crops	0.6	0.5	1.1
Diversified fodder bank	0.6	0.6	1.2
Monoculture timber plantation	0.4	0.8	1.2
Improved pasture with high tree density (>30/ha)	0.6	0.7	1.3
Diversified timber plantation	0.7	0.7	1.4
Scrub habitats (*tacotales*)	0.6	0.8	1.4
Riparian forest	0.8	0.7	1.5
Disturbed secondary forest (>10 m^2 basal area)	0.8	0.9	1.7
Secondary forest (>10 m^2 basal area)	0.9	1.0	1.9
Primary forest	1.0	1.0	2.0

Pagiola et al(2007).

Annex 7. Description some principles of the Sustainable Agriculture Standard

Principle 2: Ecosystem Conservation. "Natural ecosystems are integral components of the agricultural and rural countryside. Carbon capture, crops pollination, pest control, biodiversity and soil and water conservation are just some of the services provided by natural ecosystems on farms. Certified farms protect these natural ecosystems and conduct activities to restore degraded ecosystems. Emphasis is placed on restoring natural ecosystems in areas unsuitable for agriculture, for example by reestablishing the riparian forests that are critical to the protection of water channels. The Sustainable Agriculture Network recognizes that forests and farms are potential sources of timber and non-timber forest products that help to diversify farm income when they are managed in a sustainable manner."

Principle 3: Wildlife Protection. "The farms certified under this standard are refuges for resident and migratory wildlife, especially species that are threatened or endangered. Certified farms protect natural areas that contain food for wild animals or habitats for reproduction and raising offspring. These farms also carry out special programs and activities for regenerating and restoring ecosystems important to wildlife. At the same time, the farms, their owners and employees take measures to reduce and eventually eliminate the number of animals in captivity, despite traditional practices of keeping wildlife as pets in many regions of the world."

Principle 4: Water conservation. "Water is vital for agriculture and human existence. Certified farms conduct activities to conserve water and avoid wasting this resource. Farms prevent contamination of surface and underground water by treating and monitoring wastewater. The Sustainable Agriculture Standard includes measures for preventing surface water contamination caused by the run-off of chemicals or sediments. Farms that do not have such measures guarantee that they are not degrading water resources through the implementation of a surface water monitoring and analysis program, until they have complied with the stipulated preventative actions."

Principle 8: Integrated crop management. "The Sustainable Agriculture Network encourages the elimination of chemical products known internationally, regionally and nationally for their negative impacts on human health and natural resources. Certified farms contribute to the elimination of these products through integrated crop management to reduce the risk of pest infestations. They also record the use of agrochemicals to register the amounts consumed, and work to reduce and eliminate these products, especially the most toxic ones. To minimize the excessive application and waste of agrochemicals, certified farms have the procedures and equipment for mixing these

products and for maintaining and calibrating application equipment. Certified farms do not use products that are not registered for use in their country, nor do they use transgenic organisms or other products prohibited by different entities or national and international agreements."

Principle 9: Soil Management Conservation. "One of the objectives of sustainable agriculture is the long-term improvement of the soils that supports agricultural production. Certified farms carry out activities that prevent or control erosion, and thus reduce the loss of nutrients and the negative impacts on water bodies. The farms have fertilization programs based on the crop requirements and soil characteristics. The use of vegetative ground cover and crop rotation reduces dependency on agrochemicals for the control of pests and weeds. Certified farms only establish new production areas on land that is suitable for agriculture and the new crops, and never by cutting forests."

Source: Rainforest Alliance (2010)

Annex 8. Standards for sustainable cattle production systems

11. INTEGRATED CATTLE MANAGEMENT SYSTEM

Certified farms plan their land use respecting the conservation of ecosystems and vulnerable areas. Farms keep track of animals and have herd health and nutrition programs respecting SAN prohibited substances. The cattle feed is produced on farms and pests in farm's structures are controlled with Integrated Pest Management techniques.

11.1 The farm must have a land use plan, which identifies and maps areas for:

a. Cattle: pastures and other feedstock;

b. Ecosystem conservation and restoration;

c. Restricted and vulnerable areas;

d. Other land use.

11.2 *Critical Criterion*. The farm must demonstrate that:

a. The cattle were born and raised on a SAN certified farm; or

b. It purchases cattle born and raised on non-certified farms that do not violate the following SAN criteria:

i. Destruction of a high value ecosystem after November 1, 2005 (critical criterion 2.2);

ii. Child labor (critical criterion 5.8);

iii. Forced labor (critical criterion 5.10);

iv. Discrimination (critical criterion 5.2);

v. Mistreatment of animals (critical criterion 13.3);

c. Cattle purchased from these non-certified farms must stay a minimum of six months on the certified farm.

11.3 *Critical Criterion.* The farm must implement an individual identification record system of its cattle from birth or arrival, until sale or death.

11.4 *Critical Criterion*. The presence of transgenic or cloned animals on certified farms is prohibited.

11.5 The farm must implement a feeding plan to ensure animal nutrition conforming with cattle's wellbeing, physiological and production requirements.

11.6 The farm must supply water suitable for cattle consumption in sufficient quantity and continuity. The water supply system must include:

a. Measures to protect the water sources from damage and pollution;

b. Maintenance activities.

11.7 *Critical Criterion.* The following products must not be supplied to cattle:

a. Products or by-products prohibited by national livestock feeding laws or regulations.

b. Any animal by-product originating from mammals or birds or animal excrement.

11.8 The farm must implement a cattle herd health program endorsed by veterinarians or authorized veterinary service providers or professionals, including vaccinations required by animal health regulatory authorities.

11.9 *Critical Criterion*. All medications must be administered strictly according to label instructions, including withdrawal periods and expiration dates. Dosage variations are permitted only when approved by veterinarians or authorized veterinary service providers or professionals.

11.10 *Critical Criterion.* The farm must only use cattle medications approved by and registered with the respective animal health regulatory authorities. Use of the following substances is prohibited:

a. Substances for pasture management included in SAN's Prohibited Pesticide List;

b. Organochlorinated substances;

c. Anabolics to promote weight gain;

d. Hormones to stimulate higher production;

e. Antibiotics as preventive medication, except for surgery;

f. Clenbuterol, Diethylstilbestrol (DES), Dimetridazole, Glicopeptids, Ipronidazole;

g. Chloramphenicol, Fluoroquinoles, Furazolidone.

11.11 The farm must manage a reproduction program including records of reproduction periods and activities. The farm must avoid inbreeding within their reproduction herds.

11.12 The farm must implement an integrated pest control management program for its buildings and infrastructure.

12. SUSTAINABLE RANGE AND PASTURE MANAGEMENT

In tropical regions, sustainable pasture management is a key element to ensure maximum yield in cattle ranching operations. Pastures are selected and managed by the farm based on agro-ecological parameters, characteristics such as resistance to pests, nutritional value and production rates to ensure optimum growth, availability and avoid pasture degradation.

12.1 The farm must implement and document a range and pasture management plan.

12.2 Farms must produce most of their feed and fodder on farm, except when impossible due to atypical adverse conditions.

12.3 The farm must select forage species for sustainable cattle production that avoid those that negatively affect other ecosystems and include consideration of:

a. Agro-ecological conditions;

b. Production rates;

c. Nutritional value;

d. Resistance to pests or adverse climatic conditions.

12.4 The farm must prevent pasture degradation including consideration of:

a. Quantity and quality of vegetative cover;

b. Reducing soil erosion, particularly on crossing areas and steep slopes.

12.5 Grazing on slopes steeper than 30 degrees is permitted only where there are no signs of soil erosion generated by cattle. Otherwise, grazing pressure must be reduced.

13. ANIMAL WELFARE

The farm practices responsible animal husbandry through an animal welfare program including safe transportation. The farm and its handling facilities do not mistreat the cattle. Animals are provided

with shelter, food and water in sufficient quantity and quality to ensure good health and productivity. Farms have adequate physical facilities for the responsible management of cattle.

13.1 The farm must document its animal welfare program including provision of space, prevention of disease, avoidance of hunger and thirst, and minimization of fear, stress and pain.

13.2 Cattle handling facilities must minimize animal stress and the risk of accidents, including:

a. Sufficient and clean space;

b. Isolation of injured or sick animals;

c. Natural ventilation;

d. Protection from sun and rain.

13.3 *Critical Criterion*. The farm must not mistreat animals, including:

a. Use of sharp objects;

b. Misuse of irritating substances, including potash for branding;

c. Moving animals in a pain inflicting way.

13.4 Animal identification techniques must minimize animal suffering and must be done by trained personnel.

13.5 The farm must perform swift and accurate euthanasia on incurable animals.

13.6 The farm must guarantee that newborns get fed with colostrum. Calves must consume milk until their development allows for their digestion of fodder or other food sources. Weaning practices must be unstressful.

13.7 Castration must be done at the earliest age possible to minimize pain and only using surgical methods or emasculation. Animals castrated after two months of age must be treated with pain relief medication.

13.8 Calves under five months of age may be dehorned by chemical or hot iron processes. If older, only tipping of horns is permitted.

13.9 When artificial insemination is practiced and identification of cows in heat is required, detection methods must not negatively affect animal wellbeing.

13.10 There must be an inspection by competent personnel before an animal is deemed fit to travel. Except for emergencies and medical treatment, animals with the following conditions must not be transported:

a. Sick or severely injured animals, including those with open surgical wounds;
b. Females separated from their offspring less than 48 hours after birth;
c. Cows in the last month of pregnancy.

13.11 The animal loading and unloading structures must ensure animal safety.

13.12 Farm transport vehicles and procedures and those contracted externally must ensure animal safety and wellbeing.

14. REDUCING THE CARBON FOOTPRINT

Certified cattle ranching operations seek to reduce greenhouse gas emissions through improved diet, optimized productivity, manure and urine processing, and agroforestry systems.

14.1 The digestibility of feed and fodder must be improved and feeding practices must be changed to reduce methane emissions from cattle's enteric fermentation.

14.2 Cattle effluents produced in farm installations must be controlled, contained and treated to reduce methane emissions.

14.3 Where a natural climax ecosystem has a tree cover of less than 20%, the farm must have land set aside for conservation or recovery of natural ecosystems that equals no less than 20% of its cattle production area. In all other ecosystems, the farm may meet this requirement by providing a 20% tree canopy cover on all its pastures.

15. ADDITIONAL ENVIRONMENTAL REQUIREMENTS FOR CATTLE FARMS

Certified cattle farms minimize the access of cattle to ecosystems and establish a balance between the presence of wildlife and cattle. Farms dispose hazardous waste without negative impacts on human health and the environment.

15.1 Cattle's negative impact on aquatic ecosystems must be effectively reduced by ensuring that cattle receive adequate water and feed within pastures and that
there are physical barriers between cattle and aquatic ecosystems. Routes where cattle cross aquatic ecosystems must be selected and managed in ways that minimize damage.

15.2 The risk of predators attacking the cattle must be minimized through the proper placement of cattle and collaboration with local environmental authorities or specialist groups.

15.3 Medications must be stored safely to minimize risks to human health and the environment and in compliance with original label instructions.

15.4 The farm must lawfully treat and discharge its bio-infectious waste through labeling, physical separation in identified sites and restricted access. It may choose to deliver it to an authorized recollection system. The farm must treat dead animals by prompt burial or incineration to eliminate the risk of contamination.

Source: Rainforest Alliance (2010)

Annex 9: Summary list of proposed indicators according to SAN(2010)

SOIL AND WATER QUALITY

% of total linear km of protected water bodies that flow through the farms

If natural water bodies are present on the farm, are cattle crossings through these aquatic ecosystems regulated and supervised?

% of grazing area under bare soil land cover

Are there slopes greater than 30° without any vegetative cover?

% of farm affected by symptoms of erosive processes, such as landslides, exposed roots, washed up superficial layer, etc.

For semi-confined systems, does wastewater (effluents) receive any treatment?

TREE COVER AND CONSERVATION AREAS

% tree cover (canopy) on grazing areas

% of tree cover accounting to native species

Linear density of live fences in pasture areas

Are live fences within the farm simple (2 or less species) or complex (more than 2 species)?

# of live fence prunings, per year

Areas under conservation

% of farm area under conservation

SUSTAINABLE LIVELIHOODS

Total # of employees (broken down by men/women, full time/part time, local/non-local).

% workers receiving more than minimum wage established by the country?

Do all workers have access to clean water (suitable for human consumption)?

% of school-aged children (of farm workers) that attend school full time?

# of serious accidents in the last 12 months

% of workers with access to health services (government-operated or otherwise)?

PRODUCTIVITY/SUSTAINABLE MANAGEMENT

% of feed coming from farm

Amount of certified product sold in the last 12 months

Total milk and/or meat production in the last 12 months

Interval between births (average for all cows)

CARBON FOOTPRINT

Average monthly consumption of fossil fuels

Any measures taken to treat solid or liquid wastes, such as the use of biodigesters, composting or similar?

Amount of fertilizers and pesticides used by the farm, in the last 12 months

Average weight gain per individual

ANIMAL WELL-BEING

Average # of hours that animals graze freely in open pasture, per day

Does the farm have a well-documented animal welfare program?

Average distance between water troughs

How often are water troughs checked for sufficient water availability?

On a scale from 1 to 5, five being best, how would you judge the infrastructural conditions of premises where cattle frequent, in terms of cattle welfare impingement?

Is there an area exclusive for treatment of sick or injured animals?

Body inspection for physical condition on 10 randomly selected animals

# of wild animal attacks against cattle in the last 12 months

How often are animals checked for injuries, abnormal behavior, etc.

How many animals have died in the last 12 months? Also cite the cause

Annex 10: Differences between National PSA and Sylvopastoral PSA

	National PSA	Sylvopastoral PSA
Focused on	Forest and wood plantations	Agricultural landscape
Objective	Forest conservation and reforestation	Convert degraded pasture in agricultural environment
ES targeted	Carbon capture, Biodiversity conservation, Hydric resources, scenic beauty	Carbon capture, Biodiversity conservation
Receivers of payment	Land owner	Livestock producers
Duration of payment	5 years renewable for conservation, 10 years non-renewable for reforestation, 3 years in SAF, non-renewable	2 or 4 years, non-renewable
Amount of payment	Annual and fixed payment by hectare according to compensated land use. Payment is distributes following a determined percentage each year .	Annual payment with a land use change index-based rule.
Monitoring	Annual certification by forestry officials	Annual, by visiting farms to determine land use change index
Emission of ES	a land use emits or not ES	there is different level of emissions
Leakage	No monitored	Monitored only at farm level (many producers have more than one farm)
Baseline	In forest cover (conservation modality)	In land use

Source:Ibrahim(2007)

Annex 11. Differences between National PSA and Rainforest Alliance Label.

	National PSA	**Eco label**
Principle	ES provision associated with specific land use	ES provision associated with final product
Source of funding	Final ES beneficiary in theory	Final consumer
Nature of funding	Earmarket tax+ internation fund in the case of Costa Rica	Price premium
Scope of focus	Focused on determined ES	Multidimensional (social economic, environmental)
Price setting limit	WTP of ES beneficiairies	WTP of consumers
Institutional context	Defined by rule and institution	Defined by existing markets and economic conditions
Stability of payment	Contract guarantee multi years level of payments	Fluctuation according to quantity and quality of production
Transparency threat	Payment based on stakeholder negotiation more than in opportunity cost	Risk of bad transmissions of premium price
Monitoring cost	deduced from payment received	suported by the farmer
Limitation in participation?	Limitation of access due to fund availability	Market condition
Impact on ES	Debate on impact on reduced deforestation but lack of information on ES emission	Change in practice noticeable but lack of information on ES emission
Additionality	debated	Not clearly adressed
Leakage	variable	Not adressed
Efficiency	Could be superior to traditional conservation policy	Depending on the premium transmission, the number of intermediaries, transaction costs
Access limitation of the poors	Lack of property title	Poors can't invest to reach the criteria

Adapted from Lecoq (2010)

Annex 12. Juridical comparison between mechanisms

	National PSA	GEF PSA	ESPH	ICE	RA
Institution in charge	FONAFIFO	GEF+ Universities	ESPH	ICE	Rainforest alliance
Juridic entity	governemental agency	research center+ international organization	private enterprise	public enterprise	ONG
Legal framework	Forestry Law	international project	Public services regulator	Public services regulator	non profit
Target	forest owners	livestock producers	owners of land in critic area	owners of land in critic area	livestock producers
ES protected	carbon sequestration+ water ressources+ biodiversity+ scenic beauty	biodiversity and carbon sequestration (soil improvement)	water ressources by increasing forest cover	water ressources by controling erosion and effluents	pest control, soil protection, water protection
Source of Fund	earmarked tax+ international funds	international funds	hydric tariff	?	price premium
Area of implementation	all country, in regions with forest potential	Canton of Esparza	Watersheds in Heredia Province	Watersheds in Turrialba Province	all country, in livestock production region?
Associated organism	MINAE, ONG, enterprises, international donors	MAG, CACE	MINAE, municipalities, watershed management organisation	?	Sustainable Agricultural Network (SAN)
Documentation available	FONAFIFO data	CATIE data	ESPH Data (SOLANO 2010)	ICE data	SAN criteria
Studies available	Robalino (2011), Pagiola (2007)	Ibrahim 2008	Barrantes and Gamez 2006	?	CATIE tesis

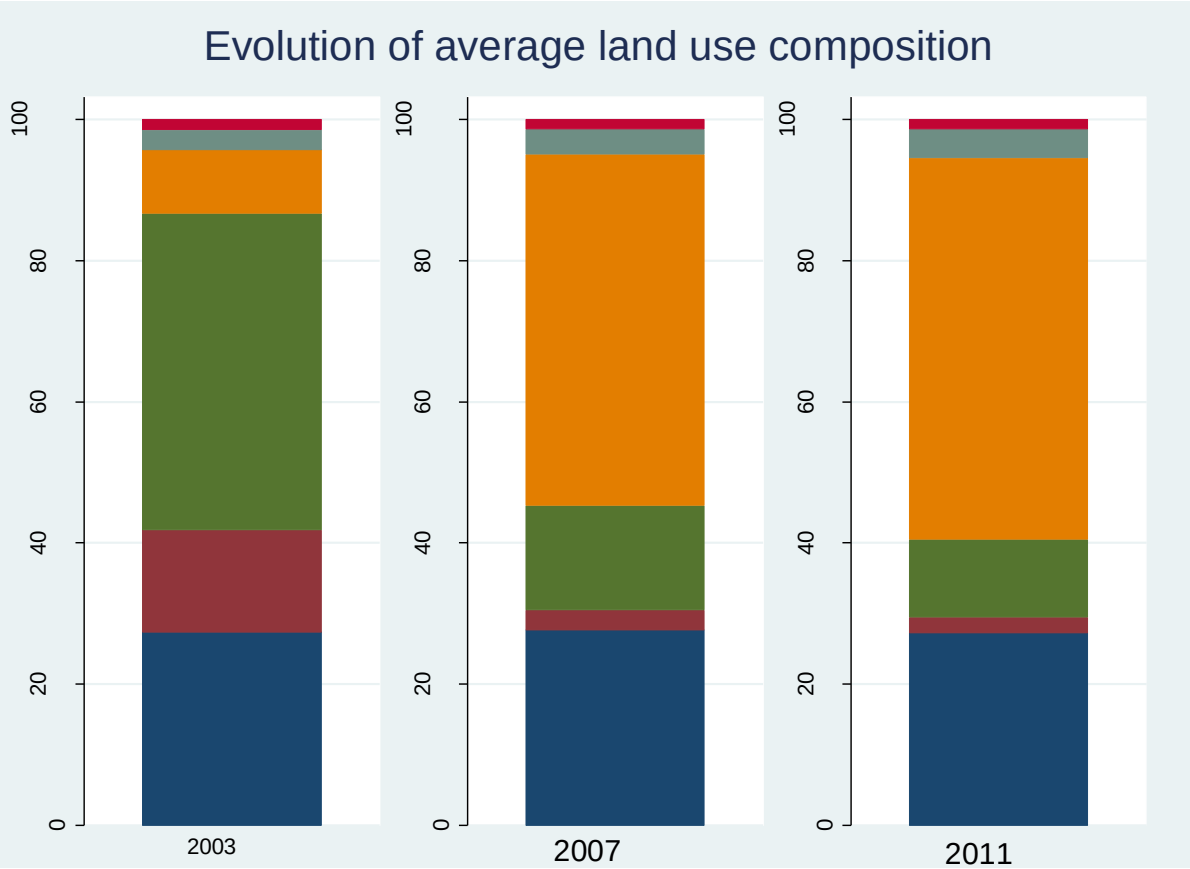
Annex 13A Financial comparison between mechanisms

	PSA-conservation	PSA-reforestation	PSA-SAF
payment	to conserve existing forest	to convert pasture to forest	improve number of trees in the land
ES	carbon sequestration + scenic beauty (not mesurable)+ biodiversity (but no control of practices)+ water	carbon sequestration + scenic beauty (not mesurable)+ biodiversity (but no control of practices)+ water	carbon sequestration + scenic beauty (not mesurable)+ biodiversity (but no control of practices)+ water
juridic transaction	contract: selling of ES in exchange of payment	contract: selling of ES in exchange of payment	contract: selling of ES in exchange of payment
Price setting	opportunity cost of agricultural practices	opportunity cost of agricultural practices	?
nature of payment	determined amount of cash	determined amount of cash	determined amount of cash
promotion of change in practices	by keeping forest	by planting forest	by planting trees
investment	major costs already suported	major cost during the reforestation	major cost during first years of tree development
future revenue	increasing in land value, commercial value of wood	increasing in land value, commercial value of wood	indirect by increasing sustainability of land

Annex 13B Financial comparison between mechanisms

	GEF	ESPH	ICE	Certification
payment	to improve environmental index	convert pasture to forest?	no payment	premium as a recompense to adoption of good pratices
ES	in favor of biodiversity, soil improvement, carbon sequestration	water	no	pest control, soil protection, water protection
juridic transaction	contract: payment according to evaluation of land use	contract: selling ES in exchange of payment	contract: adopt better practices in exchange of input furniture	contract: premium in exchange of respect of certification criteria
Price setting	Correlated with ESI incrementation	opportunity cost of Livestock production	varying with each farm situation	according to quantity of certified product sold
nature of payment	amount of cash based of land use change	determined amount of cash	in kind	cash
promotion of change in practices	by using SSP, eventually technical assistance	by planting or conserving forest	effluent control and reduction of soil erosion, technical assistance	more focus on practices and their consequences
investment	seed, maintaining cost, fertilizant	major cost already suported	cost during the implementation of practices	all changes have to be done before certification
future revenue	indirect by increasing sustainability of land	increasing in land value, commercila value fo wood	diversification of activities	increasing in production selling prices

Annex 14 evolution of average land use composition among treated farms



Annex 15 Evolution of sales prices in GEF project area

price (Colones/kg)			
	average	min	max
calves 2003	**471,1**	330	666,6
calves 2011	**586,2**	225	800
young bulls 2003	**394,6**	333	450
young bulls 2011	**664**	500	850
butchery 2003	**318,3**	207	400
butchery 2011	**559,8**	250	850
milk (Colones/L) 2003	**94,8**	70	120
milk (Colones/L) 2011	**205,2**	130	240
cheese (Colones/Kg) 2003	**870**	800	1000
cheese (Colones/Kg) 2011	**2188,8**	1650	3000

Annex 16: herd characteristics according to defined typologies

		2003							2011						
Typology		N	Herd size	% of young calves	% of calves	% of cows	TLU	% of milking cows	N	Herd size	% of young calves	% of calves	% of cows	TLU	% of milking cows
Production system	Milk producers	6	34,3	49,8	0	47	0,4	30	14	48,6	39,9 *	10,6	45,9 *	3,7	30 ***
	Double purpose farms	16	68,1 ***	56	4,8	35,8	3,2	21,7 ***	19	45,6	51,3	12,7	32,5	2,9	22,3
	Small meat producers	27	20,9 ***	60,9	2,9	32,4	0,6	3,1 ***	17	17,6 ***	52,9	8	33,4	0,7	3,3 ***
	Big meat producers	10	52,4	59,5	4,1	32,8	2,8	3,5 **	9	64,6 **	68,3 *	4,1	25,3	0,7	1,8 **
Farm size	Small farms	31	23,4 ***	60,4	4,4	31 *	0,5 *	10,5	31	22,5 ***	48,5	11,6	35,6	0,6 **	17,2
	Medium farms	17	38,8	52,1	2,6	42,4 **	1,8	11,3	17	40,2	58,8	5,6	33,1	1,6	16,6
	Big farms	11	90,9 ***	61,5	1,4	34,1	4,5 **	12,1	11	94,3 ***	52,5	9,9	35,3	7,4 ***	14,9
Farm dynamic production system	Always milk producers	22	58,9 ***	54,3	3,5	38,9	2,4	24,2 ***	22	51,5	44,7	13,3	39,9	4,5 **	28,3 ***
	Always meat producers	26	30,8 **	61	3,1	31,8	0,6	3,3 ***	26	33,9	58,2	6,6	30,6	0,7	2,8 ***
	Meat producers then milk producers	11	26,2	59,6	3,6	34,2	2,6	2,8 **	11	37,5	50	9	37,7	0,8	25,8 *
	All farms	59	40,4	58,2	3,3	34,9	1,6	11,00%	59	41	52,2	9,6*	34,8	2,1	16,6%**

Annex 17: Herd variation according to farm size and dynamic production system typologies

Variation (in %) 2003-2011		Herd size	% of young calves	% of cows	TLU	% of milking cows
Farm size	Little farms	-1,27	-5,23	14,39	158,33	7,41
	Medium farms	-0,69	20,37	-21,18	44,19	10,37
	Big farms	21,97	-13,47	57,87	438,45	144,66 **
Farm dynamic production system	Always milk producer	-11,3 *	-3,01	6,73	327,96	90,98 *
	Always meat producer	5,8	6,63	12,46	103,4	-24,94 **
	Meat producer then milk producer	26,2 *	-6,4	31,7	49,77	58,5
	All farms	3,22	0,61	13,35	357,26	33,85 **

Annex 18 Land composition in 2003

			Forest					Pasture						**Total**
	Land composition in 2003	n	% conservation	% wood	% riparian	% regeneration	**% forest**	% of degraded	% of natural	% of improved	**%pasture**	% of other use	% of non agricultural land	
Production system(2003)	Milk producers	6	17,9	1,0	16,8	3,0	**38,64**	3,9	40,5	10,5	**54,9**	2,0	4,5	**100%**
							**						***	
	Double purpose farms	16	11,0	1,0	16,9	0,9	**29,77**	10,8	45,1	10,4	**66,4**	1,9	0,9	**100%**
	Small meat producers	27	6,9	0,5	14,7	3,1	**25,20**	13,3	49,0	8,6	**71,0**	1,5	1,4	**100%**
	big meat producers	10	8,3	0,4	13,4	0,8	**22,85**	29,1	35,7	7,6	**72,4**	3,4	0,9	**100%**
								***						
Farm size	Small farms	31	8,9	0,4	13,5	1,7	**24,45**	9,6	51,5	9,8	**70,9**	2,1	1,6	**100%**
							*	**	***					
	Medium farms	17	11,8	1,1	17,5	2,4	**32,75**	16,7	38,0	8,3	**63,0**	2,0	1,5	**100%**
							*		*					
	Large farms	11	7,1	0,7	17,0	2,7	**27,48**	24,2	36,5	8,5	**69,3**	1,7	1,3	**100%**
								**						
Farm dynamic production system	Always milk producers	22	12,8	1,0	16,9	1,4	**32,19**	9,0	43,9	10,4	**63,2**	1,9	1,9	**100%**
							**	*						
	Always meat producers	26	4,7	0,5	13,6	3,0	**21,81**	17,9	47,8	8,1	**73,8**	2,2	1,6	**100%**
			**				***							
	Meat then milk producers	11	13,4	0,3	16,1	1,2	**31,06**	16,8	39,8	9,0	**65,5**	1,6	0,5	**100%**
	All farms	59	9,4	0,7	15,3	2,1	**27,40**	14,4	44,9	9,1	**68,3**	2,0	1,5	**100%**

Annex 19 Land composition in 2011

			Forest					Pasture						Total
	Land composition in 2011	n	% conservation	% wood	% riparian	% regeneration	**forest**	% of degraded	% of natural	% of improved	**pasture**	% of other land use	% of non agricultural land	
Production system(2003)	Milk producers	6	18,0	1,0	16,5	3,6	**38,5**	1,5	4,1	49,2	**54,8**	1,5	4,3	**100%**
							**				**		***	
	Double purpose farms	16	9,5	1,2	17,3	1,4	**28,8**	0,8	11,9	53,9	**66,6**	1,9	0,9	**100%**
	Small meat producers	27	9,7	0,3	14,8	1,6	**25,6**	2,9	11,6	53,8	**68,3**	2,7	1,3	**100%**
	big meat producers	10	8,4	0,4	13,1	1,3	**22,7**	3,0	12,0	57,7	**72,7**	2,4	0,8	**100%**
Farm size	Small farms	31	10,4	0,3	13,9	0,7	**24,8**	0,8	11,5	56,8	**69,1**	3,0	1,4	**100%**
						**		*						
	Medium farms	17	11,4	1,1	16,8	3,2	**31,5**	4,2	11,9	47,5	**63,6**	1,4	1,4	**100%**
						**								
	Big farms	11	8,4	0,9	17,2	2,1	**27,7**	3,1	8,1	56,2	**67,3**	1,9	1,3	**100%**
Farm dynamic production system	Always milk producers	22	11,8	1,1	17,1	2,0	**31,4**	1,0	9,8	52,6	**63,4**	1,8	1,8	**100%**
							*							
	Always meat producers	26	7,3	0,4	13,6	1,4	**22,0**	3,7	12,6	55,9	**72,1**	2,9	1,3	**100%**
							***				**			
	Meat then milk producers	11	14,3	0,3	16,2	1,9	**31,7**	1,0	9,7	52,5	**63,2**	2,0	0,6	**100%**
	All farms	59	10,3	0,6	15,4	1,7	**27,3**	2,2	11,0	54,0	**67,2**	2,3	1,4	**100%**

Annex 20 Evolution in the implementation of specific land use

% of farm with specific LU			% of farms with coffee			% of farms with fodder banks					% of farms with SPS		
		n	2003	2007	2011	2003	2007	2011	diff 03-07	diff 03-11	2003	2007	2011
Production system (2003)	Milk producers	6	0,0%	0,0%	0,0%	0,0%	33,3%	33,3%			0,0%	16,7%	16,7%
	Double purpose farms	16	6,3%	6,3%	6,3%	37,5%	37,5%	43,8%			0,0%	6,3%	6,3%
	Small meat producers	27	11,1%	11,1%	11,1%	14,8%	29,6%	33,3%	**	**	0,0%	3,7%	3,7%
						*							
	big meat producers	10	0,0%	0,0%	0,0%	50,0%	51,6%	40,0%			0,0%	31,6%	10,0%
						*							
Farm size	Small farms	31	9,7%	6,5%	6,5%	19,4%	32,3%	35,5%		*	0,0%	6,5%	6,5%
	Medium farms	17	5,9%	11,8%	11,8%	35,3%	35,3%	35,3%			0,0%	5,9%	5,9%
	Big farms	11	0,0%	0,0%	0,0%	27,3%	36,4%	45,5%			0,0%	9,1%	9,1%
Farm dynamic production system	Always milk producers	22	4,5%	4,5%	4,5%	27,3%	36,4%	40,9%			0,0%	9,1%	9,1%
	Always meat producers	26	3,8%	0,0%	0,0%	26,9%	34,6%	38,5%			0,0%	7,7%	7,7%
				*	*								
	Meat producers then milk producers	11	18,2%	27,3%	27,3%	18,2%	27,3%	27,3%			0,0%	0,0%	0,0%
				***	***	*							
	All farms	59	6,8%	6,8%	6,8%	25,4%	33,9%	37,3%			0,0%	6,8%	6,8%

Annex 21 : Different performance during and after the program

2007-2011		conservation				degraded pasture				improved pasture				ESI points by ha				area
points variation	N	2003	2007	2011	diff	2003	2007	2011	diff	2003	2007	2011	diff	2003	2007	2011	diff	
negative	9	15,3	16,7	14,2		8,4	0,22	1,6		8,2	48,7	50,7		0,91	1,23	1,18	**	21,9
no change	17	7,3	8,1	8,1		14	0,28	0,28		9,4	55,7	55,7		0,8	1,16	1,16		32,7
positive	33	8,8	10,3	10,3		16,2	4,8	3,3	**	9,2	47,1	54,1	***	0,76	1,09	1,21	***	35,2

Annex22: Land use evolution of farms with forest losses

	All farms (N=59)			Farms with conservation losses (N=2)			Farms with deforestation (N=7)		
	Land composition in 2003	Land composition in 2007	Variation	Land composition in 2003	Land composition in 2007	Variation	Land composition in 2003	Land composition in 2007	Variation
% conservation	9,4	10,7	+13,8	7	4,3	-38,6	11,2	10,7	-4,8
% wood	0,7	0,7	0	0,1	0,1	0	2,0*	1,0	-51,3
% riparian	15,3	15,4	+0,7	20,1	20,1	0	17,3	16,6	-4,2
% regen	2,1	1,6	-23,8	0	3,5	/	0,6	2,5	+315,9
Sub total forest	27,4	27,7	+1,1	27,2	24,5	-9,9	31,1	28,8	-7,3
% of degraded	14,4	2,8	-80,6	45,1***	0,8	-98,2	15,3	3,3	-78,5
% of natural	44,9	14,7	-67,3	20,7*	4,8	-76,8	38,6	9,0	-76,6
% of improved	9,1	49,8	+447,3	4,3	63,5	+1376,7	9,7	51,9	+435,8
Sub total pasture	68,3	67,3	-1,5	70,1	69,1	-1,4	63,6	64,2	+1,0
% of other land use	2,8	2,9	+3,6	1,7	1,8	+5,9	3,2	5,4	70,8
% of non agricultural land	1,5	1,4	-6,7	1,1	1,1	0	2,2	1,5	-29,5
Total	100%	100%		100%	100%		100%	100%	
% of farms with Fodder banks	25,4%	33,9%	+33,4	100%	100%	0	57,1%	71,4%	+25,0

Annex 23 Index evolution for farms with forest losses

	N=59	N=2	difference	N=7	difference
farm area	32,9	51,5	ns	31,9	ns
ESI by ha 2003	0,8	0,56	ns	0,8	ns
ESI by ha 2011	1,13	1,08	ns	1,15	ns
variation ESI by ha (in %)	49,7	124,6	*	24,6	ns
points incrementation	11,7	24,5	ns	11,7	ns

Annex 24: Evolution in the use of inputs

	2003	2011	ttest
seeds	3%	27%	***
compost	2%	12%	**
pesticide	3%	3%	
salt/mineral	95%	92%	
herbicide	98%	71%	***
fertilizer	20%	22%	
medicament	90%	63%	***
cereal	17%	8%	
barbed wire	75%	17%	***
concentrates	32%	78%	***
stubbles	2%	0%	

Annex 25: evolution in the use of tools and infrastructure

	2003	**2011**	**difference**
use of			
back or motor pump	98%	96%	
animal traction	24%	12%	**
tractor	2%	5%	
water pump	0%	3%	
Vehicle or truck	53%	56%	**
pasture grinder	19%	32%	*
chain saw	61%	53%	
stable	5%	8%	
milking room	7%	10%	

Note: In 2003, 19% of famrs used pasture grinder and 53% in 2011. The evolution is significant at 10%.

Annex 26: list of variable used in models

Household	
# members	Number of people in the household
Education Head	years of education of household head
Education Wife	years of education of household head's wife
Farm	
Distance	Distance in km between the farm and the nearest village
Farm Area	Total farm area in ha
Land use	
ESI/ha 03	ratio Ecosytem Services Index score divided by farm area (in 2003)
Δ ESI/ha 03-11	Evolution (in %) of the ratio Ecosytem Services Index score divided by farm area between 2003 and 2011
Price	
Price ratio 2003	Ratio of relative sell price between a liter of milk and a kg of meat by village in 2003
Price variation	Evolution (in %) of price ration between 2003 and 2011
Production system	
Milk	Dummy variable 1 if farm is a milk producer
Double purpose	Dummy varibale: 1 if farm is a double purpose farm
Small Meat	Dummy variable: 1 if farm is a meat producer with less than 35 bovines
Big Meat	Dummy variable: 1 if farm is a meat producer with more than 35 bovines
Change in prod° system	Dummy variable: 1 if farm has change its production system from meat producer to dairy or double purpose farm
Variation of milk cows	Evolution (in %) of the number of milking cows between 2003 and 2011
Use of concentrates 2003	Dummy variable: 1 if the farm use concentrates in 2003
Use of concentrates 2011	Dummy variable: 1 if the farm use concentrates in 2011

Annex 27 Excerpt of multinomial estimation of determinants of farm production systems

VARIABLES	Milk vs double	Small meat vs double	Big meat vs double	Smalle meat vs milk	Big meat vs milk	Big meat vs Small meat
Household						
# members	0.0526	0.201	0.568	0.148	0.515	0.367
	(0.183)	(0.723)	(1.494)	(0.565)	(1.342)	(1.139)
Education Head	0.247*	0.0298	0.0579	-0.218	-0.190	0.0281
	(1.652)	(0.209)	(0.438)	(-1.236)	(-1.160)	(0.238)
Education Wife	0.0446	0.0656	-0.0169	0.0210	-0.0615	-0.0825
	(0.316)	(0.632)	(-0.150)	(0.178)	(-0.455)	(-0.797)
Farm						
Distance	1.083**	0.861*	0.906*	-0.222	-0.177	0.0449
	(2.173)	(1.852)	(1.923)	(-1.251)	(-0.923)	(0.374)
Farm Area	-0.0158	-0.111***	-0.0484*	-0.0952***	-0.0326	0.0626***
	(-1.008)	(-3.327)	(-1.757)	(-3.425)	(-1.601)	(2.809)
Land use						
ESI/ha 03	4.265	-1.713	-5.283*	-5.977*	-9.548***	-3.570*
	(1.511)	(-0.643)	(-1.788)	(-1.956)	(-2.908)	(-1.888)
Price						
Price 03	-3.591	56.04**	72.21**	59.63**	75.80***	16.17
	(-0.145)	(1.990)	(2.537)	(2.206)	(2.749)	(1.260)
Constant	-7.942*	0.193	-2.357	8.135**	5.585	-2.549
	(-1.905)	(0.0664)	(-0.766)	(2.020)	(1.298)	(-1.230)
Observations	59	59	59	59	59	59

Annex 28 Excerpt from econometric estimation of causal model

VARIABLES	Point gains	Meat to Milk	Use of concentrates 2011
Household			
# members	-0.103	0.469**	-0.532*
	(-0.718)	(2.456)	(-1.912)
Education Head	-0.0125	-0.144*	-0.0418
	(-0.131)	(-1.778)	(-0.467)
Education Wife	0.0507	0.0215	-0.0936
	(0.778)	(0.227)	(-1.470)
Farm			
Distance	0.0591	-0.0892	-0.0774
	(1.091)	(-1.094)	(-1.266)
Farm Area	0.00567	0.0307	0.0493**
	(0.789)	(1.517)	(2.324)
Land use			
ESI/ha 03	-9.522***	6.816**	2.360
	(-3.993)	(2.391)	(1.011)
Δ ESI/ha 03-11		-0.000267	0.0128
		(-0.0327)	(1.156)
Price			
Price ratio 2003		-5.237	-13.86
		(-0.533)	(-1.478)
Price variation		0.0112**	-0.00958*
		(2.296)	(-1.787)
Production system			
Small Meat	0.492	9.392***	-0.800
	(0.760)	(3.172)	(-1.192)
Big Meat	0.613	9.566***	-0.210
	(0.763)	(3.635)	(-0.210)
Change in prod° system			3.007**
			(1,961)
			(2.248)
Variation of milk cows			0.00218
			(0.571)
Use of concentrates 2003			0.560
			(0.901)
Constant	6.292***	-17.36***	1.341
	(2.760)	(-3.984)	(0.514)
Observations	59	59	59