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Spatial Targeting of Payments for Environmental Services in Costa Rica:

A Site Selection Tool for Increasing Conservation Benefits

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Abstract

Payments for environmental services (PES) have become an increasingly popular market-based instrument to translate external, non-market environmental services into financial incentives for landowners to preserve the ecosystems that provide the services. However, lack of spatial differentiation in the targeting mechanism may lead to potential efficiency losses. Addressing this challenge, a formal site selection tool was constructed, which takes into account three variables that vary in space: environmental services, risks of losing services, and participation costs. Using data from Costa Rica's Nicoya Peninsula, the tool's potential to increase the financial efficiency of Costa Rica's PES program is empirically tested. Results show that, given a fixed budget, efficiency increases radically if per hectare payments are aligned to landowners' heterogeneity in participation costs. Selecting sites based on environmental service potential also moderately increases efficiency. Overall additionality could in the best case be doubled but is generally limited due to low deforestation risks. To take advantage of the efficiency potentials of cost-aligned payments, cost-effective methods for the determination of participation costs would be necessary. Two possible approaches were tested deriving costs from annual land rents, and regressing easy-to-obtain and difficult-to-manipulate variables as proxies on per hectare returns. None of the approaches appeared to predict costs sufficiently well. The results raised doubts about the plausibility of the original cost estimates that were used in the targeting tool. Further tests, however, confirmed their plausibility. Considering the difficulty to determine micro-level monetary participation costs it was questioned whether estimates that are based on monetary flows in the past (as used here) and do not consider personal land holder characteristics are sufficient to explain a land holder's decision to enroll land in PES. Factors such as personal risk considerations and information access were hypothesized to be necessary to obtain a better estimate of *expected* participation costs. In addition, non-monetary values such as personal preferences may influence land use decisions. To test these assumptions, a PES adoption model was developed for hypothetical adoption decisions that interviewees made in a field survey. The model confirmed the importance of risk and information issues in explaining PES adoption. Proxies for non-monetary preferences, however, could not be shown to significantly explain decision making. In order to determine micro-level payment levels that land holders are willing to accept, inverse auction systems are proposed here as a potentially cost-effective practical approach for PES programs with flexible payment levels. In inverse auctions, all adoption determinants are potentially expressed in the land holder's bid.

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Zusammenfassung

Umweltdienstleistungszahlungen sind ein zunehmend populäres, markt-basiertes Instrument zur Umwandlung von externen Umweltdienstleistungen in finanzielle Anreize, so dass Landbesitzer die Service erzeugenden Ökosysteme schützen und erhalten. Eine unzureichende räumliche Differenzierung beim Selektieren von Schutzflächen kann jedoch zu potentiellen Effizienzverlusten führen. Hier wird daher ein Selektionsmechanismus entwickelt, welcher drei räumliche Variablen in Betracht zieht: Umweltservices, das Risiko diese Services zu verlieren und Bereitstellungskosten. Mit einem Datensatz der Nicoya Halbinsel in Costa Rica wird das Potential des Mechanismus zur Steigerung der Projekteffizienz getestet. Die Ergebnisse zeigen, dass mit einem fixen Budget die Effizienz radikal zunimmt wenn Zahlungen an die heterogenen Kosten der Landbesitzer angepasst werden. Ein Fokus der Selektion auf die Serviceleistungen der Flächen führt ebenfalls zu moderaten Effizienzgewinnen. Die Additionalität kann verdoppelt werden, ist aber insgesamt gering, da Abholzungsrisiken auf Nicoya gering sind. Für die Umsetzung der Ergebnisse in der Praxis bedarf es kostengünstiger Methoden zur Bestimmung der tatsächlichen Kosten. Zwei mögliche Methoden wurden hier gestestet: Schätzung der Kosten auf der Basis von Pachtpreisen und Schätzung der Kosten auf der Basis von leicht zugänglichen und schwer manipulierbaren Variablen wie z.B. Bodenqualität. Keine der beiden Methoden schien die Kosten ausreichend gut zu bestimmen, was auch Zweifel bezüglich der Genauigkeit der ursprünglichen Kostenschätzwerte, die im Selektionsinstrument verwendet wurden, aufkommen ließ. Zwei Tests konnten die Plausibilität der ursprünglichen Schätzungen jedoch bestätigen. Die Schwierigkeit der Bestimmung von Mikrokosten ließ auch die Frage aufkommen, ob rein monetär basierte Schätzungen ohne Berücksichtigung von persönlichen Charakteristika des Landbesitzers Landnutzungsentscheidungen ausreichend genau bestimmen können. Es wurde angenommen, dass Faktoren wie persönliche Risikoeinschätzungen und Informationsverfügbarkeit nötig sind, um den Erwartungswert der Kosten besser schätzen zu können. Außerdem könnten nicht-monetäre persönliche Präferenzen die Landnutzungsentscheidungen beeinflussen. Um diese Annahmen zu testen wurde ein PES Adoptionsmodell für hypothetische Adoptionsentscheidungen aus einer Umfrage konstruiert. Das Modell bestätigte die Wichtigkeit von Risiko und Informationsaspekten. Nicht-monetäre Werte konnten nicht als signifikant bestätigt werden. Um für PES Programme mit flexiblen Zahlungshöhen Mikrokosten günstig bestimmen zu können, werden hier als weitere Alternative inverse Auktionen vorgeschlagen, die potentiell alle relevanten Determinanten in den Geboten der Landbesitzer enthalten sollten.

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1 Introduction

The introduction is structured into the following parts: Section 1.1 defines what payments for environmental services (PES) are. This is followed by a brief comparison of PES to other conservation approaches (section 1.2). Some examples for PES programs are presented in section 1.3 while section 1.4 discusses the issues that the scientific literature has addressed in the context of PES. One of these issues, the selection of land parcels for program inclusion, is discussed in more detail and for the case of Costa Rica's PES program in section 1.5. The problems that were identified for the Costa Rican case lead to the formulation of objectives and hypotheses in section 1.6. After briefly pointing out how an approach that addresses these objectives would be different from previous targeting mechanisms (1.7), the chapter concludes in section 1.8 with an overview of the remaining chapters.

1.1 What are payments for environmental services (PES)?

Payments for environmental services (PES) have become an increasingly popular market-based instrument to translate external, non-market environmental services (ES) into financial incentives for landowners to preserve the ecosystems that provide the ES. Wunder (2005, p.3) defines PES as "a voluntary transaction where a well-defined ES (or a land-use likely to secure that service) is being bought by a (minimum one) ES buyer from a (minimum one) ES provider if and only if the ES provider secures ES provision (conditionality)". PES programs currently address four main environmental services: 1. Carbon sequestration and storage (e.g. an electricity company paying landowners for planting and maintaining additional trees to offset carbon emissions); 2. Biodiversity protection (e.g. conservation donors paying landowners for the creation of a biological corridor); 3. Watershed protection (e.g. downstream water users paying upstream landowners for adopting land uses that limit soil erosion, flooding risks, dry season water shortages, etc.); 4. Landscape beauty (e.g. a tourism operator paying a local community not to hunt in a forest being used for tourists' wildlife viewing) (Wunder 2005).

1.2 PES and other conservation approaches

PES has an emphasis on privately owned land (either individually or communally owned) and is an innovative alternative to the approaches that have so far dominated the conservation and management of ES in these areas: (i) command and control mechanisms (i.e., laws and regulations); (ii) remedial measures such as repair of the damage caused by flooding or the construction of civil works to avert flooding risks; and (iii) indirect approaches such as integrated conservation and development programs (ICDP), which take the form of either re-directing labor and capital away from destructive activities or of encouraging commercial activities that supply ecosystem services as joint products (e.g. ecotourism) (Sierra and Russman 2006).

Command and control mechanisms have often proven ineffective in privately owned areas, especially in the developing world (Sierra and Russman 2006, Engel et al. 2008). They are extremely difficult to enforce because of the spatial dispersion of land users, and they may impose high costs on poor land users by preventing them from undertaking privately profitable activities (Pagiola and Platais 2002). Remedial measures are often imperfect and usually far more expensive than preventive measures (Pagiola and Platais 2002). Indirect approaches have become the predominant approach to most large-scale conservation efforts in developing countries (Ferraro and Simpson 2002). However, indirect approaches are plagued by their ambiguous impact on conservation incentives, by their complex implementation needs, and by their lack of conformity with the temporal and spatial dimensions of ecosystem conservation objectives. As a result, many indirect conservation interventions have been reported to have had limited success in achieving their objectives (Ferraro and Simpson 2002, Engel et al. 2008).

Simpson and Sedjo (1996) and Ferraro and Simpson (2002) demonstrate that spectacular cost savings can be realized with direct-payment initiatives such as payments for environmental services. Apart from their alleged cost-effectiveness in conserving ecosystems and the associated environmental services, these systems are also appealing to policy makers because of their potential to improve rural livelihoods (Pagiola et al. 2002, Robertson and Wunder 2005). By 2002, close to 300 PES or PES-related initiatives could be identified worldwide by Landell-Mills and Porras (2002) and the list is likely to have increased since.

1.3 Examples for existing PES programs

Most existing PES programs are found in developed countries (Wunder 2005). In the Victorian Bush Tender program in Australia, for example, landholders are paid for the improved management of native vegetation (Stoneham et al. 2003). The Conservation Reserve Program (CRP) in the United States of America pays farmers for environmentally beneficial land retirement (Claassen et al. 2008). Among the most prominent PES programs in developing countries is the national PSA[1] program in Costa Rica which

[1] PSA (Pagos por Servicios Ambientales) refers to Costa Rica's PES program.

was implemented in 1996 and purchases carbon, biodiversity, water and landscape services by paying landholders for the conservation and natural regrowth of forests as well as the establishment of agro forestry systems and timber plantations (Pagiola 2008). China's sloping land conversion program (SLCP) is the largest land retirement/reforestation program in the developing world, having the goal of converting 14.7 million hectares of cropland to forests by 2010 (Bennett 2008). Mexico's program for hydrological services focuses on the conservation of forests in stressed watersheds (Muñoz-Piña et al. 2008). Smaller examples include reforestation projects in Ecuador where funds from Dutch electricity companies pay for the sequestration of carbon (Albán and Argüello 2004) or a turtle nesting program in Tanzania where locals are paid a fixed amount for finding and reporting turtle nests and a variable amount conditional on the nest's hatching success (Ferraro 2007).

1.4 PES Issues in Literature

Besides the already mentioned conceptual studies (Ferraro and Simpson 2002, Simpson and Sedjo 1996) much of the PES literature has so far focused on descriptive PES case studies (e.g. Landell-Mills and Porras 2002, Rojas and Aylward 2003, Pagiola 2008, Robertson and Wunder 2005, Bennett 2008, Claassen et al. 2008, Muñoz-Piña 2008). PES's potential impacts on poverty alleviation have also been given much attention (e.g. Miranda et al. 2003, Ortiz et al. 2003, Rosa et al. 2003, Rosales 2003, Muñoz 2004, Pagiola et al. 2005, Zbinden and Lee 2005). More recently, the question to what extent PES has actually led to additional provision of environmental services has gained increasing importance and various studies have contributed to clarify that issue (Sierra and Russman 2006, Sanchez-Azofeifa et al. forthcoming, Sills et al. unpublished)[2].

Targeting or the spatial allocation of payments to land parcels within a landscape is another topic of investigation. Babcock et al. (1997) classify targeting approaches for conservation programs into those that target (i) benefits, (ii) costs or (iii) benefit-to-cost ratios. Examples for benefit targeting approaches are Powell et al. (2000) and Rodrigues et al. (2003) who conduct gap analyses to identify high benefit priority areas for biodiversity conservation, and Imbach (2005) who targets multiple environmental service objectives. Chomitz et al. (2006) constitute an example for cost targeting where negative correlation between costs and biodiversity leads to low cost, high benefit solutions. Of the three targeting

[2] At least two other scholars are currently in the field to examine PES impact on deforestation in Costa Rica (A. Daniels and R. Arriagada)

classifications (i)-(iii), only the category (iii) approach ensures the maximization of environmental benefits that can be obtained from a fixed budget by purchasing those goods that offer the highest benefit-to-cost ratio until the budget limit is reached (Babcock et al. 1997). Examples of category (iii) approaches are presented in Ferraro (2003), Barton et al. (2003) and Alix-Garcia et al. (2008). Beyond category (iii) there are also approaches that target benefits and costs but not their ratio, e.g. linear scoring functions that include costs as an element of the scoring equation (Claassen et al. 2008) and non-parametric, multi-objective approaches like distance function rankings (Ferraro 2004).

Besides total benefits and costs, the additionality concept gains increasing importance in conservation policy. As Hartshorn et al. (2005, p.12) state, “paying for forest protection on land that requires no protective measures is an inefficient use of scarce conservation funds”. Wunder (2005) alleges that the future of PES largely depends on the programs’ ability to demonstrate clear additionality. Additionality refers to the part of the benefits that is provided in addition to a business-as-usual scenario distinguishing ‘total’ from ‘additional’ benefits. Measures to estimate additionality are therefore part of the benefit function but are rarely used in targeting. Imbach (2005) and Alix-Garcia et al. (2008) addressed additionality in targeting studies for Costa Rica and Mexico, respectively, by incorporating measures for risk of deforestation.

1.5 Targeting in Costa Rica’s PSA scheme

Though the merits of improved targeting mechanisms have been shown in literature they are rarely implemented in practice. In Costa Rica’s PSA scheme landholders have to apply to the implementing agency, the National Fund for Forest Financing (FONAFIFO), for the enrolment of land. The program attracts applications for a land area much higher than what the program’s budget can pay for. For example, in 2006, FONAFIFO’s regional office in Nicoya received applications for approximately 12,000 ha but only had available funds for approximately 2,000 ha (J.A. Jiménez Fajardo, pers. comm., 2007). FONAFIFO therefore would be in the position to select among applicants those with the best benefit to cost ratio. However, the selection of land parcels is based on priority areas which are coarsely defined and cover nearly three fifth (29,872sqkm) of the national territory (51,101sqkm) (own calculation based on data from ITCR 2004). Although the program aims to generate carbon, biodiversity, hydrologic and scenic beauty services no attempt is made to quantify the potential delivery of these services beyond the determination of priority areas. Site differentiation therefore is limited to “inside” and “outside” these areas.

With respect to opportunity costs of service provision, Costa Rica's PSA program targets land parcels with an opportunity cost below or equal to US$40/ha/year by offering an annual per hectare flat rate that is identical across the entire country (the flat rate has been increased from US$40 to US$64 in 2006). A uniform flat rate is appealing in that it implies low transaction costs and transmits a sense of fairness and transparency among participants. Flat per-hectare payments, as in the Costa Rican PSA scheme, however, give high production rents to landowners with low-to-zero ES provision costs, while those with high provision costs are unlikely to participate in the scheme. When the opportunity costs of conservation within a target area are highly disparate, large cost inefficiencies can arise from a flat-rate payment approach. If a site is highly beneficial in terms of provision of ES, it may be worth paying more for its inclusion in the program, while sites with low participation costs would likely still participate at lower payment levels (Engel et al. 2009).

Additionality is no selection criterion in Costa Rica's PSA scheme and the program would, in fact, pay for all plots that provide environmental services if financial resources were available (Pagiola 2008). It is therefore not surprising that Pfaff et al. (unpublished) find that annually only 0.08% of the PSA contracted forest would have been cleared in the absence of payments.[3] Sierra and Russman (2006) suggest that PSA has had limited immediate effects on forest conservation in the region, and Sills et al. (2006) did not detect significant differences between PSA and non-PSA land in terms of change in forest cover on the micro-scale. In summary, it appears that the Costa Rican scheme could benefit significantly from an improved targeting approach.

Other prominent PES programs in developing countries, too, abstain from the use of improved targeting mechanisms. In China's sloping land conversion program the principal objective is the reduction of soil erosion and flooding risks. Steeply sloping, marginal croplands are being targeted for retirement and/or reforestation though exact targeting criteria vary significantly across regions. This has led, in some cases, to reforestation of areas that clearly had no significant watershed functions (Bennett 2008). Payment differentiation is only applied on a regional level, but is homogenous within regions. Since its implementation, Mexico's national forestry commission (CONAFOR, in its Spanish acronym) has much improved the targeting of payments for hydrological services incorporating numerous variables for the estimation of service benefits, and using deforestation risks as a proxy for additionality (Muñoz-Piña 2008). With respect to payment levels, however, a two tiered flat rate per-hectare payment scheme is maintained where the lower payment for general forest conservation is based on opportunity cost

[3] It is assumed here that deforestation is the only land-use change factor affecting service provision.

calculations and the upper payment is made to cloud forests which are granted a bonus for their expected higher delivery of hydrological services, independent of opportunity costs. More elaborated selection mechanisms could thus also in the latter two programs improve efficiency vis-à-vis pre-declared goals.

Though literature offers numerous solutions to targeting problems, they have not been widely adopted in practice. Hajcowicz et al. (2007), for example, note for the case of biodiversity planning that, to their knowledge, no complete set of areas produced by computer algorithms has been implemented anywhere in real-world projects. For the implementation of improved targeting not only scientific and technical challenges but also administrative, and perhaps most importantly political challenges have to be overcome. Hajcowicz et al. (2007) state it is possible that improved targeting mechanisms are not used in practice due to their complexity and reduced transparency for policy makers and project proponents. Efficiency gains also need to be compared to implementation costs of targeting (Engel et al. 2007) and may discourage implementation agencies from its use. Finally, literature has so far not offered a targeting mechanism for multiple environmental service objectives that integrates all three selection criteria, i.e. benefit, cost and additionality measures, possibly failing to address specific targeting needs of PES programs.

1.6 Objectives

Drawing on the observations that were laid out in 1.5, the principal objectives of this study are:

1. to develop and empirically apply a targeting tool for the allocation of environmental service payments considering spatially variable levels of multiple services, costs and risk (as a measure for additionality).

2. to show that implementation costs of the developed tool can be well below its potential gain in benefits and that it is possible to design an elaborated tool using simple criteria and transparent processes.

3. to identify and test approaches for the estimation of micro-level opportunity costs for the use in PES programs with flexible payment schemes.

4. to verify that participation cost is a land holder’s principal determinant for the enrolment of land in PES.

Based on the objectives it is hypothesized that (i) improved targeting can significantly increase environmental service benefits with a fixed budget, (ii) the implementation cost of such a tool is below its expected benefits, (iii) there are estimation approaches that can predict opportunity costs sufficiently well for practical implementation, (iv) participation cost of environmental service provision is the principal determinant for the enrolment of land in PES.

1.7 How this study fits into the existing targeting literature

This study contributes to the targeting literature by integrating all elements of selection into a category (iii) targeting tool for multiple objectives and explicitly considering the risk of environmental service loss as a spatial variable to determine benefit additionality. The approach is built on Imbach's (2005), but employs different assumptions for environmental service distribution, partially different data (e.g. the type of deforestation probability estimates) and, most importantly, integrates micro-level participation costs. The approach is similar to the one developed by Alix-Garcia et al. (2008) who also consider cost-benefit targeting under consideration of deforestation risks in Mexico, but use water as the only targeted environmental service. The main features and outcomes of the approach have been presented in Wünscher et al. (2006) and Wünscher et al. (2008).

1.8 Structure of this Document

The remainder of this document proceeds as follows. Chapter 2 gives an overview of Costa Rica's PSA program. Chapter 3 starts with a description of the study area and primary data collection, and continues with the descriptive presentation of the primary data that was solicited in the field survey and the secondary data sets that were used in the analyses. Moving to the main chapter of this document, chapter 4 presents the concept and empirical results of the targeting tool as well as a calculation of implementation costs. Chapter 5 examines various approaches to determine the opportunity cost of service provision. The deterministic influence of these costs and other variables upon the decision of the land owner to enroll land in PES is analyzed in chapter 6. The document concludes in chapter 7 with some final comments.

2 The PES program in Costa Rica

The Costa Rican forestry law 7575 from 1996 prepared the ground for the implementation of the Costa Rican PSA program. The first payments for environmental services were made in 1997 (FONAFIFO 2006). Payments are made exclusively to private land owners. The program recognizes the environmental services generated by forest and agro forestry ecosystems only. Specifically, four groups of environmental services are considered: carbon, biodiversity, water and scenic beauty. Payments are made in turn for land use activities which help to maintain the ecosystems and thus the delivery of their environmental services. Costa Rica's PSA program currently acknowledges four different activities to deliver forest environmental services: (i) the protection of existing natural forests, (ii) the natural regrowth of forests through land retirement, (iii) the establishment of timber plantations and (iv) the establishment of agro forestry systems. Between 1997 and 2005, most funds (80.7%) were spent on the protection of natural forests. Because of its dominance this study focuses primarily on forest protection activities. An analysis that includes natural regrowth of forests is, however, also conducted in section 4.5.

The Costa Rican PSA program was not developed from scratch but is the result of a steady history of reforestation and forest protection efforts, which began in 1969 when it was made possible to deduct expenditures for the establishment of timber plantations from the income tax (Ortiz 2002). However, because many land owners did not pay income taxes, the possibility of tax deduction did not create reforestation incentives for all. In 1986, as a reaction to this, "Certificados de Abono Forestal" (CAF) were introduced. These voucher certificates which could be cashed in or used in financial transactions were issued as a reward for investments in reforestation. They were accessible to a broader population of land owners. In 1990, in addition to the existing CAF, two new versions of forest certificates were introduced: (i) "Certificado de Abono Forestal por Adelantado" (CAFA) and (ii) "Certificado de Abono Forestal para Manejo" (CAFMA). In the case of CAFA, payments were made upfront, enabling especially small land holders to invest in reforestation when they would not dispose of financial resources otherwise. CAFMA for the first time supported the sustainable management of existing natural forest. In 1995 the family of forest certificates was further extended by the introduction of CAFMA-2000. These certificates compensated forest owners for putting a complete halt to the exploitation of natural forests and ensuring their conservation in its natural state (Ortiz 2002).

In 1997 the PES program replaced the system of forest credit certificates partly because the structural adjustment program that was signed with the International Monetary Fund obligated Costa Rica to eliminate subsidies such as the certificates. PES is not considered a subsidy because of two fundamental differences. First, the justification for payments changed from support for the timber industry to the provision of environmental services. Second, the source of financing changed from the government budget to an earmarked tax and payments that were made by direct beneficiaries. In other respects, the PES program was initially very similar to the previous incentives. Many of the details of implementation, such as the payment amounts and the scheduling of payments, were also carried over from the earlier programs. Yet, over time, the PES system underwent significant changes (Pagiola 2008).

Important changes were made to (i) the land use activities acknowledged by the program, (ii) the increased weight given to forest conservation, and (iii) a significant payment raise in 2006. Initially, the program recognized the three forest activities: ‘protection of natural forest’, ‘sustainable management of natural forest’ and ‘reforestation’ (establishment of timber plantations). Since 2003, payments were no longer made for sustainable management of natural forests. In the same year, the establishment of agro forestry systems was included into the program. In 2006, the program also included natural forest regeneration as a forth eligible activity. Compared to the forest credit certificates, the PES program shifted the focus away from timber plantations towards the protection of natural forest. Whereas from 1979 to 1997 the certificate system made payments to 129,152 ha of timber plantations, and only 22,199 ha of protected natural forest, the PES program from 1997 to 2005 supported timber plantations only on 27,096 ha, while forest protection was supported on 451,420 ha (Ortiz 2002 and FONAFIFO 2006).

In 2006, the program also experienced a substantial increase of payment levels. The flat per hectare payments that are identical across the entire country were raised by approximately 50% and were established in dollars, not as before in local currency (colones). Whereas before the effective annual payment decreased through the usually 5-year contract period due to inflation, today’s dollar payments are more stable in purchasing power. Annual payments for ‘forest protection’ contracts signed in 2005 were of 21,000 ¢/ha/year[4], which at the end of 2005 was equivalent to about US$ 42. In 2006, the payment was raised to 64 US$/ha/year (FONAFIFO 2006). Applications for program enrolment already exceeded the available PES budget threefold before the payments were raised in 2006. The drastic payment raise will probably cause even higher demand among land owners to participate in the program, but at the same time it decreases the number of hectares that the National Fund for Forestry Financing (FONAFIFO) will be able to contract with the available budget. These new circumstances increase the necessity for an

[4] Exchange rate 31.12.2005: 1US$ = 497 Costa Rican Colones (¢)

improved selection of land parcels even further in order to spend the limited budget in the most efficient manner.

For program enrolment land owners have to submit an application to the implementing agency FONAFIO which is the main actor in the program. FONAFIFO defines program areas, processes and approves applications, and monitors program abidance. The paper work and technical studies required for application can impose high transaction costs upon the applicant. A number of forestry organizations offer to take over most of the paper work and technical assistance and charge for these services a percentage that can represent up to 18% of the program payments (FONAFIFO 2005).

Besides legal and formal requirements, only forest sites from inside predefined program areas are eligible for program entry, although exceptions are made. In the case of 'forest protection' in 2005, priority was given to: (i) officially acknowledged biological corridors (especially those prioritized in the Ecomarket Project[5]), (ii) areas under influence of the Huetar Norte Forestry Program[6], (iii) areas which serve a special function for the protection of water resources, (iv) private property within protected wildlife areas, and (v) cantons with a Social Development Index[7] (IDS, in its Spanish acronym: Indice de Desarrollo Social) of less than 40. Priority is also given to sites with expiring PES contracts (MINAE 2005). Thus, the current selection process does not distinguish the level of provided environmental services, the risk of service loss and the cost of service provision, neither within nor across priority areas.

To date, the bulk of financing for the PSA program has been obtained by allocating to FONAFIFO 3.5% of the revenues from a fossil fuel sales tax (about US$ 3.5 million a year). Since 2000, the PES program has also been supported by a loan from the World Bank and a grant from the Global Environment Facility (GEF), through the Ecomarket project. Moreover, it has also received a grant from the German KfW development bank through the Huetar Norte Forest Program (Pagiola 2008). In 2005, Costa Rica added an

[5] Project funded by the World Bank, Global Environment Facility (GEF) and Costa Rican government with main objective to strengthen forest conservation through PES within Mesoamerican biological corridors in Costa Rica.

[6] Project funded by the German Kreditanstalt für Wiederaufbau (KfW) and a 30% contribution by the Costa Rican government with the main objective to improve the net balance of CO_2 emissions through forest cover and PES.

[7] The IDS is a summary indicator which measures the social standard of regions in Costa Rica (MIDEPLAN 2001). Its value ranges between zero and 100, corresponding to the socially least developed region and the region with the best socio-demographic situation, respectively. For further details on IDS, see section 3.3.1.5.

earmarked watershed conservation fee to the existing water tariff. Once fully implemented this fee will generate an estimated US$19 million annually, of which 25% would be channeled through the PSA program (Pagiola 2008).

3 Study Area and Data

This chapter gives a brief overview of the study area (section 3.1) and presents in detail the data that was used for the study. Both primary (section 3.2) and secondary data (section 3.3) were used for the analysis.

3.1 Study Area

The study focuses on the Nicoya Peninsula in the Northwest of Costa Rica (Map 1 in Appendix I). The peninsula makes up the largest part of the Tempisque Conservation Area (TCA) which in addition also includes some islands surrounding the peninsula. For logistical reasons the islands were not included in the present study. The TCA is not a protected area, but an administrative unit in which the governmental body SINAC (National System of Conservation Areas) supervises and administers conservation activities. Nicoya has an average annual precipitation of 2,154 mm of which 90% fall during its distinct rainy season from May to October. Although rainfall is relatively high, the climate is subtropical, with average monthly temperature highs ranging from 31.7 to 35.9 °C and average monthly lows ranging from 19.9 to 21.8 °C (Instituto Meteorologico Nacional 2006). Topography ranges from 0 to 1,018 m (Cerro Azul) above sea level (SINAC 2006). The main economic activities are tourism and agriculture. The Nicoya Peninsula is part of the Chorotega region which has a long tradition of beef production and is the region with the largest extension of pasture land (375,400 ha) in Costa Rica (CORFORGA 2001). But where soils are suitable and irrigation water is accessible rice, melons, maize, beans, sugar cane and also coffee are cultivated (ADP 2005). The PSA program is well established on the Nicoya Peninsula: During 2004 alone, FONAFIFO enrolled 181 plots with an area of 12,244 ha in the Tempisque Conservation Area (FONAFIFO 2004). Of these, 96.3% were enrolled for forest protection and the remaining 3.7% for the establishment of timber plantations. The area that was enrolled in the Tempisque Conservation Area in 2004 represents 16.9% of the area enrolled at the national level (72,638 ha), where 97.9% was enrolled for forest protection and 2.1% for timber plantations.

3.2 Primary Data

Primary data was raised in a field survey in personal interviews using a structured questionnaire (Attachment II). The implementation of the field survey is described in section 3.2.1. The principal objective of the survey was to obtain data on the financial flows of the sampled farming enterprises. From these, micro-level opportunity, protection and transaction costs of forest conservation were calculated. The sum of these three components presents PES participation costs. Part of the data was also used for an econometric analysis in chapter 5 to identify the determinants of per-hectare returns, and third, for an econometric analysis in chapter 6 to identify the variables that most significantly drive a land owner to participate in the PES program. The description of primary data in this section is divided into five subsections: prices and PES participation costs (section 3.2.2), socio-economic characteristics such as age and educational level (section 3.2.3), land use and the production system (section 3.2.4), the land owner's relation with the PSA program such as acquaintance and willingness to participate (section 3.2.5), and, finally, personal attitudes of the land owner such as trust towards the state and risk behavior (section 3.2.6).

3.2.1 Field Survey implementation

A simple random sample was applied to a frame population from a list of livestock holders in Costa Rica. The list is maintained by the screwworm eradication program 'Gusano Barrenador' and is believed to be the most complete documentation of livestock holders in the country. For the Nicoya Peninsula Gusano Barrenador has a record of 4,266 livestock holders. Those with no exact location specified as well as those with land plots smaller than three hectares were excluded from the list leaving a frame population of 3,879. From the random sample, 178 livestock holders or 4.6% of the frame population were interviewed in personal, structured interviews. The spatial distribution of the sampled land properties is depicted in Map 2 of Attachment I.

Table 1 presents the distribution of interviews across the six cantons[8] of Nicoya Peninsula. Most interviews were conducted in Santa Cruz (28.1%) and Nicoya (27.5%) and the least interviews were conducted in Carrillo (6.7%) and Hojancha (9.6%). The distribution of the sample reflects relatively well the distribution within the frame population where most of the land owners are also situated in Nicoya (32.3%) and Santa Cruz (22.6%), and the least land owners are to be found in Carrillo (7.4%) and Hojancha (7.3%). The sample represents 3.9% to 6.0% of the land owners in the cantons, and the entire sample represents 4.6% of the frame population.

[8] Regional administrative units in Costa Rica from large to small: Provinces, cantons, districts.

Table 1 Distribution of land properties across cantons

Canton	# Sample	% Sample	# Population	% Population	%Sample in Population
Carrillo	12	6.7	286	7.4	4.2
Hojancha	17	9.6	284	7.3	6.0
Nandayure	20	11.2	459	11.8	4.4
Nicoya	49	27.5	1253	32.3	3.9
Puntarenas	30	16.9	721	18.6	4.2
Santa Cruz	50	28.1	876	22.6	5.7
Total	178	100.0	3879	100.0	4.6

The interviews were conducted from February 24th 2005 to April 21st 2005 by three interviewers. Reference year for the interviews was 2004. The mean duration of the interviews was 55.3 minutes and ranged between 29.0 and 120.0 minutes (S.D.:14.9). If farmers could not be localized or encountered after several attempts, the surveying policy was to find and interview a nearby living farmer. In a total of 71 cases (39.9%) the original land owner from the sampling list was interviewed and in 107 (60.1%) cases a neighbor had to be interviewed instead. Being an extensive study area of 5,147 km^2 with substantial distances between interview sites, interviewers traveled separately in motorized vehicles. Interviewers carried a GPS-tool and took coordinates of each land property at the time of the interview. If the interview was conducted outside the property the coordinates were localized on a 1:50,000 map with the help of the property owner.

Three pre-tests of the questionnaire were conducted, each with twelve to twenty interviews. After each pre-test the questionnaires were adapted to newly encountered, locally specific circumstances. The interviewers took part in the pre-testing phase and were thus thoroughly accustomed to the interviewing technique, local conditions and the specific challenges of the questionnaire. Interview guidelines were distributed and discussed with the interviewers and final mock interviews were conducted as part of the interview training. In the field, participating land owners were supplied with a letter which described the main purpose of the interview, asked for their collaboration and offered contact details of the person in charge.

3.2.2 Prices and PES participation costs (opportunity, transaction and protection costs)

This section presents the survey results for input and output prices (3.2.2.1) as well as the calculation and results for opportunity, transaction and protection costs.

3.2.2.1 Prices

Price information (input and output prices) was used primarily for the calculation of opportunity costs of forest conservation on pastureland.

Input Prices. Table 2 presents the most common inputs used in cattle production and pasture management on Nicoya Peninsula and their prices as reported in the field survey. Minimum and maximum prices can differ quite substantially. In the case of goods such as cattle, price differences occur due to heterogeneity in size and quality. Other inputs such as herbicides, fence staples or molasses show price variability due to the scale of purchase and possibly access to markets. Fence staples, for example, can be bought in boxes of 1kg, but also in boxes of 25kg which causes substantial differences in per kg prices. Molasses can be bought in small liter flasks, in containers of one gallon, and also in 200 liter barrels. Part of the variability is probably also caused by imprecise reporting of prices. Not all farmers used the entire list of inputs from Table 2, partly because it contains products that substitute each other. Where they did not and consequently could not report a price, the missing values were complemented with average prices. Therefore n is equal to 178 throughout Table 2.

Table 2 Input Prices in US$ (unit in brackets)

Input	Mean	S.E.	S.D.	Min.	Max
Molasses (barrel)	28.51	0.67	8.97	7.80	120.00
Pollinaza (bag)	1.30	0.02	0.28	0.40	4.00
Salt (bag)	5.67	0.14	1.89	2.00	14.00
Pecutrin (bag)	19.12	0.45	5.95	6.00	60.00
Hay (bale)	1.20	0.02	0.21	0.40	2.00
Concentrate (bag)	8.34	0.05	0.66	6.00	12.00
Semolina (bag)	7.92	0.02	0.30	5.60	10.00
Labor (5hours)	4.85	0.06	0.80	2.00	10.00
24D (gallon)	9.13	0.09	1.22	4.00	17.00
Roundup (gallon)	15.27	0.05	0.66	12.00	20.00
Tordon (gallon)	37.89	0.12	1.65	30.00	48.00
Wire (roll,300m)	16.16	0.27	3.58	6.00	40.00
Fence staples (kg)	0.97	0.02	0.24	0.34	1.80
Fence posts (post)	1.62	0.01	0.20	0.40	3.00
Land Rent (animal/month)	4.13	0.05	0.66	1.25	8.00
Breeding bull (animal)	503.50	2.70	36.01	196.00	850.00
Cow (animal)	305.13	2.46	32.80	120.00	520.00
Heifer (animal)	225.24	0.84	11.17	154.00	290.00
Young bull (animal)	187.32	1.17	15.57	120.00	280.00
Calf (animal)	150.38	0.41	5.46	95.00	180.00
Livestock (500kg)	334.86	4.82	64.33	120.00	607.14

n=178

Output Prices. The main outputs of cattle farms on Nicoya Peninsula are presented in Table 3 together with their sales prices. Like for input prices, minimum and maximum output prices differ quite substantially which can probably be attributed to heterogeneity in quality, size and scale as well as imprecise reporting. Where landholders did not produce an output and could consequently not report a sales price, the same treatment as for input prices was applied and missing values were filled with averages.

Table 3 Output Prices in US$ (unit in brackets)

	Mean	S.E.	S.D.	Min.	Max
Milk (liter)	0.38	0.005	0.070	0.15	1.20
Cheese (kg)	2.06	0.020	0.262	1.00	4.80
Cuajada (kg)	0.35	0.001	0.016	0.20	0.40
Hay (bale)	1.53	0.001	0.012	1.40	1.60
Land rent (animal/month)	3.50	0.011	0.150	2.50	4.00
Breeding Bull (animal)	494.00	3.776	50.380	200.00	842.00
Cow (animal)	275.69	2.898	38.658	140.00	450.00
Heifer (animal)	207.48	1.297	17.300	130.00	300.00
Young bull (animal)	227.73	4.226	56.383	100.00	440.00
Calf (animal)	146.67	1.543	20.592	44.00	260.00
Livestock (500kg)	346.24	8.300	110.740	142.86	866.67

n=178

3.2.2.2 Opportunity Costs

Opportunity costs of forest conservation refer here to the difference in income between the most profitable land use and forest conservation. For the calculation of opportunity costs, ‘pastureland’ is focused as the most likely alternative to natural forest. Natural forest itself is assumed to produce no commercial income. This is because logging and timber sales from natural forests are prohibited by law, unless a management plan has been certified by Costa Rican authorities, which in recent years has almost never occurred. Illegal logging and timber transport are risky, and very few rule violations seem to occur in the study area. Data of this study’s field survey also show that non-timber benefits are close to zero. Though prohibited, gradual land-use change through the elimination of forest undergrowth and smaller trees towards pasture with scattered shading trees is somewhat more frequently observed in the Nicoya Peninsula. Thus, the opportunity cost of maintaining forest is equal to the foregone optional net return from pastures.

Micro level net returns of pastureland were calculated by subtracting from the sum of incoming monetary flows (e.g. from sales of cattle, milk, cheese, hay or renting out farm land) the sum of outgoing monetary flows (e.g. through purchase of farm inputs such as fertilizer, seed, herbicide, machinery, petrol)[9]. This approach is here referred to as the 'Flow' approach. The Flow approach is likely to deliver slight overestimates of opportunity costs for several reasons. First, the cost of land conversion is not considered (which, since timber is not commercialized, is always positive). Second, an average farm-specific opportunity cost based on existing pastures is calculated, ignoring that forests are generally found on economically marginal areas with lower potential pasture productivity. Third, family labor is not deducted from opportunity costs assuming there is no readily available income alternative (see further below in this section 3.2.2.2 for a discussion of this assumption based on descriptive results). These three treatments increase per-hectare-return (and thus opportunity cost) estimates. As the proposed targeting approach uses flexible payments which are equal or marginally above participation costs, the three treatments also imply that the required payments are likely to be higher than they might have to be, therefore giving a disadvantage to the notion of aligning payments with participation costs to increase PES program efficiency. In summary, the three treatments lead to a conservative and careful interpretation of results.

Table 4 presents some aggregate annual cost and revenue figures for the calculation of opportunity costs. The top three lines of the table present mean total farm sales, mean per hectare farm sales, and mean per animal farm sales. On average, the sampled farms sold US$ 5,466 worth of produce. These sales face an average total cost of US$ 3,137 which leaves average total net returns of US$ 2,330 before subtracting the opportunity cost of family labor. The opportunity cost of family labor in Table 4 is assumed to be the average wage of rural peons (day laborers) which is approximately US$1 per hour. Thus, the average number of annual family labor hours (2,265 hours) has an opportunity cost of US$ 2,265. In one of the interviews no information on family labor could be obtained which is why n=177 for this data[10].

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[9] For details see the questionnaire, Appendix II

[10] The mean total return after labor opportunity costs (US$ 79.10) was calculated with n=177 (for the farms where labor opportunity costs were available) which is why this figure is not equal to the difference between the mean total net returns before labor opportunity cost (n=178) and the mean total labor opportunity cost (n=177).

Table 4 Annual revenue and production cost (US$) with and without family labor

Income Variable	**n**	**Mean**	**S.E.**	**S.D.**	**Min.**	**Max**	**P25**	**P75**
Total Sales	178	5,466.49	1131.20	15,092.07	0.00	176,000.00	542.50	5,355.00
Sales/ha	178	195.75	44.52	593.92	0.00	7,680.00	41.19	185.26
Sales/animal	174	130.78	14.47	190.92	0.00	1,645.71	42.50	150.07
Total costs	178	3,136.57	558.66	7,453.50	16.30	69,572.00	337.13	2,889.15
Costs/ha	178	140.52	42.74	570.26	1.88	7,508.53	22.43	117.01
Costs/animal	174	87.90	12.91	170.31	3.98	1,608.97	24.27	81.62
TotalNetReturns before LaborOpportunityCosts	178	2,329.93	665.12	8,873.77	-19,062.00	106,428.00	-33.13	2,361.45
NetReturns/ha before LaborOpportunityCosts	178	55.23	9.01	120.19	-363.31	624.56	-5.01	87.28
NetReturns/animal before LaborOpportunityCosts	174	42.87	5.85	77.15	-247.56	375.07	-3.60	78.16
Total LaborOpportunityCosts	177	2,265.12	132.60	1,764.06	104.00	8,736.00	910.00	3,120.00
LaborOpportunityCosts/ ha	177	166.28	17.16	228.31	1.39	1,497.67	41.31	191.32
LaborOpportunityCosts/animal	174	120.83	12.05	158.93	1.25	1,560.00	37.14	163.20
TotalNetReturns after LaborOpportunityCosts	177	79.10	655.28	8,717.93	-21,246.00	103,932.00	-2,200.90	390.22
NetReturns/ha after LaborOpportunityCosts	177	-110.62	18.88	251.17	-1561.00	450.31	-164.01	20.13
NetReturns/animal after LaborOpportunityCosts	174	-77.96	13.00	171.50	-1423.00	300.21	-131.00	21.74

Mean total net returns after labor opportunity costs are US$ 79.10 (Table 4) which can be allocated to capital income and entrepreneurial profit. In the hypothetical case that capital income is zero (here applied only for illustrative reasons) mean entrepreneurial profit would equal US$ 79.10 over 1,386 hours of labor (these are the landowners' average annual working hours excluding other family members' hours), which makes US$ 0.057/hour. The entrepreneurial benefit in terms of income is thus close to zero, especially when part of this is allocated to capital rents. Table 4 does in fact indicate that the sample also contains negative total net returns after labor opportunity costs, i.e. own labor is remunerated at a rate below that of the market wage for day laborers. Out of 177 farms for which labor data is available, 118 farms (66.7%) have negative and 59 farms (33.3%) positive total annual net returns after labor opportunity costs. This may be due to market imperfections in the sense that labor in a perfect market would be re-allocated to day laborer employment. Reasons why this re-allocation may not occur could be: (i) the day laborer market does not offer sufficient employment, (ii) the distance to off-farm activities is too large to be overcome at a reasonable cost, (iii) access to information about off-farm working opportunities is scarce, (iv) qualification or physical status (e.g. due to age) of land holders do not meet the requirements for day laborer work, (v) the preferences of land holders are such that work on own land with returns below a day laborer's wage is preferred to work on other people's land. Applying a peon's wage as the opportunity cost of labor in the analysis may therefore not be justified as it produces severe overestimates of these costs. For the analyses in chapters 4, 5 and 6 it was therefore decided to use net returns before labor opportunity costs as estimates for forgone revenue from forest conservation.

To shed further light on the plausibility of estimated per-hectare-returns in the Flow approach, interviewees were also asked to give a direct estimate of their perceived per-hectare-returns on pastureland (Perception approach). Only 120 (67.4%) interviewees answered this question and it revealed a mean value of US$84.11/ha/year (Min 0.00; Max 1428.57; S.D. 161.28). An analysis of the available responses in section 5.3.1 shows that per-hectare-returns between the Flow and Perception approaches significantly correlate and their means do not significantly differ, thus confirming the plausibility of estimates.

3.2.2.3 Transaction Costs

The landowners' transaction costs are expenses for contract establishment and maintenance (e.g. travel expenses, information gathering, and external monitoring). On the Nicoya Peninsula, the great majority of PES applications for small and medium sized land plots (<100 ha) is processed by intermediaries (J.A. Jiménez Fajardo, pers. comm., 2007), who handle all associated transactions such as paper work, consultancy, technical study and supervision. For this service, the intermediaries charge a maximum of 18% of the payment, i.e. 7.20US$/ha (FONAFIFO 2005), which is used as an approximation for transaction costs. Applications for large land plots (>100 ha) are normally processed by private forest engineers (regentes) who may offer lower per hectare prices. For these land plots a hypothetical transaction cost of 12% of the PES payment is used, i.e. 4.80US$/ha[11].

3.2.2.4 Protection Costs

Finally, protection costs relate to active forest-protection efforts and mainly consist of establishing firebreaks, fencing off cattle and signposting the areas in PSA. Protection costs are estimated for every plot individually based on the survey data. Firebreak costs were taken directly from survey data. Fencing costs were calculated multiplying per ha fencing costs for pasture with the factor 0.1818. Sign posts were estimated at 5 US$ for every 50 hectares. The mean protection cost is 3.56 US$/ha/yr (Min 0.11, Max

[11] Absolute per-hectare transaction costs are maintained (instead of percentages) giving "cheap" sites a comparable disadvantage in competing for program entry.

3.2.3 Socioeconomic Data

This section presents the descriptive results of socioeconomic characteristics of farm enterprises and associated households. It deals with the following information: age, household members, land ownership, education, household consumption, sources of income, working hours and farm infrastructure.

Age. Land owners are relatively old with a mean age of 58.4 years (S.D.: 14.3) ranging between 25 and 90 years (Table 5).

Household members. The mean number of household members is 4.0 (S.D.: 1.7) ranging from one to a maximum of ten persons (Table 5). Under-age household members (younger than 18 years of age) were found to live in 48% of the households. In most cases (43 or 24%) only one under-age person lived in a household, in 25 cases (14%) two household members were under-age, in 15 cases (8%) three were under-age, and in three cases (2%) four household members were under-age.

Land Ownership. On Nicoya Peninsula, the person who owns the farm and the person who runs the farm are in most cases identical (60.7%). However, in many cases the land is owned by more than one landlord (mostly other family members). On average the land was the shared property of 2.3 landlords (S.D.: 0.6). Yet, the maximum number of landlords was twelve (Table 5). Also, it is common to own more than one farm. In the sample, interviewees owned on average 1.4 farms, with a maximum of four farms (Table 5).

Table 5 Some Metric Land Owner Characteristics

	Mean	S.E.	S.D.	Min.	Max	P 25	P75
Age	58.39	1.07	14.25	25.00	90.00	47.75	70.00
Household members (no.)	3.98	0.13	1.67	1.00	10.00	3.00	5.00
No. of landowners	2.27	0.17	2.28	1.00	12.00	1.00	3.00
No. of farms	1.37	0.05	0.64	1.00	4.00	1.00	2.00
%income from farm	58.09	2.79	37.25	0.00	100.00	20.00	100.00

n=178

Education. The educational level of the land owners was measured in nine categories from no school (0) to completed university education (8) (Table 6). On Nicoya Peninsula, the educational level of cattle farmers is a lot lower than, for example, in Huetar Norte, another region of Costa Rica, where a typical livestock holder would have received secondary education (Wünscher et al. 2004). On the Nicoya Peninsula, in contrast, a typical cattle farmer would only have gone to primary school (Table 6). Of all interviewees 5.6% never had gone to any school, 75.8% had received not more than primary education, and 11% had received some degree of secondary education. Only 8% of the interviewees had studied a minimum of one year at a higher educational institution such as a technical college or university (Table 6).

Since only few land owners could be assigned to categories of a higher educational level (categories four to eight), the nine original categories were regrouped to five categories only: Categories three and four were merged to form a category called ‘secondary school’ and categories five to eight were merged to form the category ‘Higher education’ (Table 6). In the econometric analyses that are presented further ahead, this new grouping is used.

Table 6 Educational level

Education level, original (category)	**#**	**%**	**Educational level, adjusted**	**#**	**%**
No school (0)	10	5.6	No school (0)	10	5.6
Primary school incomplete (1)	72	40.4	Primary school incomplete (1)	72	40.4
Primary school complete (2)	63	35.4	Primary school complete (2)	63	35.4
Secondary school incomplete (3)	14	7.9	Secondary school (3)	20	11.2
Secondary school complete (4)	6	3.4	Higher education (4)	13	7.3
Technical college incomplete (5)	1	0.6			
Technical college complete (6)	2	1.1			
University incomplete (7)	3	1.7			
University complete (8)	7	3.9			
Total	178	100.0		178	100.0

Household Consumption. The interviewees were presented a list of household consumption levels from 1 to 10 (Table 7) and asked to select the level that best reflected their own consumption. Household consumption was used as a proxy for income because it was believed that interviewees would be less hesitant and more honest in revealing consumption levels rather than income levels. As can be seen in Table 7, some of the original categories are poorly represented. Therefore, household consumption categories were regrouped. As there turned out to be none or very few cases in categories one, six, seven, eight, nine and ten the number of categories was reduced to four by merging categories one and two as well as categories five to ten (Table 7). The great majority of interviewees (80.4%) had a monthly household consumption of 100-400$.

Table 7 Household Consumption in US Dollars

Consumption original (category)	#	%	Consumption adjusted (category)	#	%
<50.00 (1)	1	0.6	<100.00 (1)	12	6.7
50.01 – 100.00 (2)	11	6.2	100.01 – 200.00 (2)	69	38.8
100.01 – 200.00 (3)	69	38.8	200.01 – 400.00 (3)	74	41.6
200.01 – 400.00 (4)	74	41.6	>400.00 (4)	23	12.9
400.01 – 600.00 (5)	19	10.7			
600.01 – 800.00 (6)	3	1.7			
800.01 – 1000.00 (7)	0	0.0			
1000.00 – 1500.00 (8)	1	0.6			
1500.01 – 2000.00 (9)	0	0.0			
> 2000.00 (10)	0	0.0			
Total	178	100.0			100.0

Sources of Income. Interviewees stated to earn an average of 58.1% (S.D. 37.3) of their income with on-farm activities (Table 5). On-farm activities yield between zero and 100 percent of the total income (Table 5). 35% of the landowners dedicate themselves also to off-farm activities to generate additional income (Table 8). Of these, most run businesses such as small shops or transport services (51%), work as day laborers on other farms (21%), have regular employment with private companies (14%) or the government (10%), or have other casual work (5%) (Table 8).

Table 8 Off-Farm Activities

Off-Farm Activity	#	% of Total	% of those with off-farm activities (63)
None	115	64.6	
Own business	32	18.0	50.8
Day Laborer	13	7.3	20.6
Employee in private company	9	5.1	14.3
Employee in public service	6	3.4	9.5
Other casual work	3	1.7	4.8
TOTAL	178	100.0	100.0

Additional income sources not only come from off-farm activities as described above, but also from pensions or other family members' financial support. 19% said they would receive a personal pension or a pension of a close relative; 7% stated to receive financial help from other family members and another 3% stated that another family member in the house earns an additional regular salary.

Working Hours and Family Work. Land owners stated to personally work an average of 28.5 hours per week and a maximum of 84 hours per week in on-farm activities (Table 9). Most working hours (an average of 92.6%) are dedicated to cattle production (including pasture management). Annual crops, for example, are only dedicated a mean of 3.7% of the land owner's working hours. The average proportion of working hours that is dedicated to perennial crops, forest plantations or natural forest are even lower than that. Nevertheless, there are also land owners who dedicate a maximum of 80% of their on-farm working time to perennial crops, 30% to forest plantations, 33% to natural forest and 70% to other on-farm activities (Table 9).

Table 9 Land Owner's Weekly Working Hours

	Mean	S.D.	Minimum	Maximum
Total hours	28.5	18.7	0.0	84.0
% Cattle	92.6	17.3	0.0	100.0
% Annual crops	3.7	11.5	0.0	70.0
% Perennial crops	1.2	7.8	0.0	80.0
% Forest Plantations	0.6	3.6	0.0	30.0
% Natural Forest	0.2	2.6	0.0	33.0
% Other	1.2	8.0	0.0	70.0

n=178

In exactly half of the cases the interviewed farm owner received also help from other family members (Table 10). On average, other family members worked 18.7 hours per week in on-farm activities. Again, most of this labor is dedicated to cattle production including pasture management (92.3%). Other on-farm activities only play a minor role in terms of labor distribution.

Table 10 Weekly working hours of land owner's family members

	n	Mean	S.D.	Minimum	Maximum
Total hours	178	18.7	26.9	0.0	120.0
% Cattle	89	92.3	19.0	0.0	100.0
% Annual crops	89	4.9	13.6	0.0	60.0
% Perennial crops	89	1.4	9.1	0.0	80.0
% Forest Plantations	89	0.1	1.1	0.0	10.0
% Natural Forest	89	0.0	0.0	0.0	0.0
% Other	89	0.2	2.1	0.0	20.0

Farm Infrastructure. Infrastructure of the sampled farms is generally poor. The interviewees stated, for example, that 21% of the farms have no access to electricity. 24% of the farms have no water pipe system. A telephone is missing on 59% of the farms and street lighting cannot be found on 46% of the farms (Table 11).

Table 11 Farm access to electricity, water, telephone and street lighting

	Electricity		Water pipes		Telephone		Street light	
	#	%	#	%	#	%	#	%
Existent	141	79	136	76	73	41	97	54
Not existent	37	21	42	24	105	59	81	46
TOTAL	178	100	178	100	178	100	178	100

Due to the partially mountainous landscape some of the farm properties lie in very secluded areas with only limited road access (Table 12). In some cases they cannot be reached with an ordinary 4x2 automobile at all times during the year (12.9%), and in the worst cases all year access is not possible with a 4x4 vehicle (4.5%). However, the majority of properties are connected to roads that allow year round access with any type of vehicle (82.6%), (Table 12).

Table 12 Type of Road that gives access to property

Type of Road that gives access to property	#	%
(1) Tarmac road – all year circulation of all types of vehicles	18	10.1
(2) Primary gravel road – all year circulation of all types of vehicles	87	48.9
(3) Secondary gravel or dirt road – all year circulation of all types of vehicles	42	23.6
(4) Tertiary gravel or dirt road – does not permit all year circulation of 4x2 automobile	23	12.9
(5) Small dirt trail – does not permit all year circulation of 4x4 automobile	8	4.5
TOTAL	178	100.0

3.2.4 Land Use and Production

Farm Area and land use. The 178 interviewed landowners had a total land area of 12,078 hectares (Table 13). Property size ranged from three to 3,000 hectares with a mean of 67.4 hectares (S.D.: 232). Most of the land, a total of 7,814 ha or 65% of the sampled farm area, was used for pasture (and the average percentage of pasture cover on the farms was even higher with 75%). Second most common land use was secondary and primary natural forest (3,172 ha or 26%) and pasture fallow (563 ha or 5%). Annual crops were found to be on 240 ha (2%), perennial crops on 34 ha (<1%) and timber plantations on 238 ha (2%), (Table 13).

Table 13 Farm area, land use and number of cattle

Variable	Mean	S.D.	Var.	Min	Max	Total	%
Annual crops	1.3	8.4	70.4	0	100	240.0	2.0
Perennial crops	0.2	0.9	0.8	0	8	34.0	0.3
Pasture	43.9	139.8	19544.6	2	1800	7814.2	64.7
Pasture Fallow	3.2	9.2	85.1	0	50	563.1	4.7
Forest Plantation	1.3	7.9	61.8	0	100	237.6	2.0
Primary Forest	7.2	33.9	1150.2	0	400	1287.0	10.7
Secondary Forest	10.6	59.3	3511.9	0	700	1885.1	15.6
Other	0.1	0.6	0.4	0	7	16.6	0.1
TOTAL	67.4	231.8	53715.7	3	3000	12077.5	100.0
% Pasture	74.8	26.2	688.7	13.3	100.0	n.a.	n.a.
Cattle head	46.8	154.1	23,757.4	0.0	2000.0	8330	n.a.

n=178

Cattle Production. Synonymously to the dominance of pasture, the main agricultural activity within the sample is cattle production. The farmers held a total number of 8,330 heads of cattle at the time of the interview (Table 13). With total pasture land being 7,814 hectares (Table 13) this makes an average of 0.81 animals per hectare (this number includes animals of all ages and weights). On average farmers owned 46.8 heads of cattle (S.D.: 154.1) ranging between zero for some who had just sold their complete stock at the time of interview and a maximum of 2,000 animals (Table 13). 77% of the interviewed farmers stated to produce predominantly meat, while 21% stated to produce both meat and dairy products. None of the interviewees focused predominantly on dairy production. In three cases the type of production was not determined (Table 14).

Table 14 Production Focus of Livestock Holders

Production Focus	Meat	Meat&Milk	Milk	Not determined	Total
Number	137	38	0	3	178
Percentage	77.0	21.3	0.0	1.7	100.0

Pasture Management. Interviewees were questioned about their pasture management practices in 2004. To give a rough idea of pasture management practices that are common for the region Table 15 presents the results for six pasture management interventions. It is interesting to see that only a minority of livestock holders apply fertilizer to their pastures (12.9%). On the other hand, the use of herbicides is very common (79.2%), yet, does not seem to have suppressed manual weed control which is normally carried out with a machete (87.6%). The practice to apply both manual and chemical weed control is due to the fact that each method targets specific weed species and also intensities of occurrence. Almost all land owners (94.4%) conducted some type of fence repairs and also the great majority maintains fire breaks around their pasture land (80.9%). In the dry season livestock holders often temporarily rent some additional land to feed their livestock, mostly only for two to three months. 40.4% of the interviewees reported to have done that in 2004. This type of land rental is paid per animal and month (not in hectares per year).

Table 15 Number (no.) of land owners applying selected pasture management practices

Activity	no.	%
Use of Fertilizer	23	12.9
Manual Weed Control	156	87.6
Herbicide Use	141	79.2
Fence Repairs	168	94.4
Firebreak maintenance	144	80.9
Temporal Renting of Pasture	72	40.4

n=178

3.2.5 Land Owners and PES

Interviewees were asked whether they had heard about the PES program in Costa Rica. Of all interviewed land holders only 42 (24%) replied positively while the great majority (136 or 76%) had not heard about it. The program's rules (as of 2005), obligations, land use restrictions and payment levels for 'forest protection' and 'natural forest regrowth' were then briefly explained to all interviewees (see questionnaire in Appendix II for details). Natural forest regrowth was only introduced in the official program in 2006 but was presented to the interviewees as an equally eligible modality. The land holders' replies concerning PES related questions therefore refer to the two land use modalities. After describing the PES program, some of those who before stated to not have heard about it then said to do in fact know it. On Nicoya Peninsula, the PES program is often simply referred to as the "Protection Program". It was also observed that the program is frequently not associated with FONAFIFO (National Forest Financing Fund) but with the local agency which helps to organize the paper work and also makes the payments on behalf of FONAFIFO. The PES program might therefore be better known than the figures suggest. Nine interviewees (5%) had part of their farm in the PES program, all of them in the modality of forest protection. The 33 interviewees who had heard about PES but had no part of their land in the program were asked why they did not participate. This question was open ended and multiple answers were possible. In total, only 26 responses were given to that question. Out of the 26 responses, the most common reasons were "I wouldn't know how to do it" (23%) and "The farm is too small to include part of it" (19%), (Table 16). There were also land holders who were either in the process of applying or have already applied and were not accepted (23%). One interviewee said that once pasture is submitted to the program for natural forest regrowth it would be lost as a source of income in the case that the PES contract was not renewed (Table 16). Enrolling pastureland could imply a non-reversible land use change. Once forest is grown it is expensive to turn back into pasture, but most of all, it would be illegal to do so (forest is prohibited to be converted to other land uses). Participation, in the case that contract renovation fails to materialize, could therefore prove to be fatal for a landowner who depends on the income from the farm.

Table 16 Reasons given by land owners who knew the PES program for not participating

Reason	**#**	**%**
I would not know how to do it.	6	23.1
The farm is too small to include part of it.	5	19.2
The program is too restrictive.	4	15.4
I applied but was not accepted.	3	11.5
I am applying.	3	11.5
I never thought about it.	3	11.5
The farm is not registered in the national registry.	1	3.8
Once included, trees will grow. If contract does not get renewed I will lose pasture without having alternative income.	1	3.8
TOTAL	26	100.0

All interviewees, including those who already had land in the program, were then asked whether they would hypothetically submit land to PES under the previously described conditions (for either modality). 45 farmers (25%) said they would submit land under the described conditions (Table 17). These replies are used in section 6 to develop a logistic adoption model.

Table 17 Real and hypothetical adoption of PES

	Real Adoption		Hypothetical Adoption	
	#	%	#	%
Adopters	9	5.1	45	25.3
Non-Adopters	169	94.9	133	74.7
TOTAL	178	100.0	178	100.0

To shed some more light on the reasons for rejection in this descriptive section, the 133 non-adopters were asked to explain their decision. The question was open ended and multiple answers were possible. In total 176 replies were given (Table 18). A vast majority of the non-adopters (61.7%) found the payment was too low. Unfortunately, this answer does not reveal much about what precisely the payment does not sufficiently compensate for. With respect to a concept that is presented in section 6 and hypothesizes that personal preferences influence adoption beside monetary costs and risk considerations, further differentiation could have provided some clues for the type of preferences that could play a role. Unfortunately, such differentiation was not made available.

“I do not have enough land” (Table 18) was the second most frequent answer (27.1%). Those who said “I do not have enough land” had an average farm size of 15.43 ha, which is significantly smaller than the remaining non-adopters’ farm size (60.44 ha) [12]. However, every interviewee fulfilled the minimum area requirement of three hectares and thus had sufficient land to be eligible for program participation. The answer therefore indicates that PES, at least in an initial phase of adoption, is not seen as a full land use alternative or ‘substitute’ but as an ‘additional’ option only in the case that regular farming is not severely compromised. This hypothesis is also confirmed by the type of land that adopters stated to be willing to enroll (in total 3,823 ha), of which 629 ha (16.5%) were already under PES contract, 2,353 ha (61.5%) were forest areas, 511 ha (13.4%) were pasture fallow (Tacotales or Charrales), only 324 ha (8.5%) were pastures and 6 ha (0.2%) were plantations. The figures show that only a small minority of this land was under economically productive use at the time of the interviews.

”I don’t want to compromise the farm” (15.8%) is an answer that would have required further differentiation, too. Probably some of the true reasons behind this answer can be found in other more specific answers. “I want to sell the farm”, for example, would be a good reason why a land owner does not want to compromise the property. Land under PES might be more difficult to sell and maybe obtains a lower price.

Some of the answers show that non-monetary values can play a role in adoption such as “Cattle farming is a tradition”. Risk considerations can also influence adoption decisions as is expressed by answers such as: “I don’t trust the program” and “I fear that I could lose rights over my land to the state”. These answers reflect very clearly that uncertainty and lack of trust can contribute to the decision making process. Like in Table 16, hypothetical non-adopters also pointed out problems of pasture enrolment such as “I would lose within 5 years pasture to forest” and “There is no guarantee for contract renovation”.

The answer “Cattle serve as a short term income” also shows that cattle fulfill an insurance function as in times of crisis or necessity it can quickly be turned into urgently needed financial resources. PES, although it offers a small and steady annual income, cannot fulfill such a function.

[12] According to ANOVA excluding the extreme value of case 228 with 3000 ha.

Table 18 Reasons given by interviewees for not adopting PES

Reason	# hypothetical non-adopters	% hypothetical non-adopters
The payment is not high enough	82	61.7
I do not have enough land	36	27.1
I don't want to compromise the farm	21	15.8
I want to sell the farm	8	6.0
The program is very restrictive	7	5.3
Cattle farming is a tradition	5	3.8
The farm is heritage for my children	5	3.8
This would be a family decision	2	1.5
I would loose within 5 years pasture to forest	2	1.5
The obligations are very expensive	2	1.5
I fear I could lose rights over my land to the state	2	1.5
I would no longer be able to make fence posts and wood	1	0.8
I don't trust the program	1	0.8
Cattle serves as short term income (insurance)	1	0.8
There is not guarantee of contract renovation	1	0.8

One of the reasons why land holders did not want to participate in the PES program (Table 19) was the restriction that forest wood could no longer be utilized. To find out which benefits forest owners perceive to obtain from the forest, they were asked to report these benefits in open ended questions that allowed multiple responses. There were 107 forest owners (60%) in the sample. Of these, 72 (67%) stated to benefit from their forest. The remaining 35 forest owners (33%) reported they would not benefit from their forest in any way. The 72 benefiting forest owners gave a total of 116 responses (Table 19). Of all responses, the most frequently mentioned benefit was making fence posts from forest wood (45%). It was later learned that the very common "life fences" were also sometimes referred to as 'forest'. Life fences consist of closely spaced actual trees which are grown vegetatively from sticks which are, in turn, cut directly from the trees that form the fence. It is likely, therefore, that what was described as a forest benefit in some cases might be a 'life fence' benefit. The second most reported benefit is grazing (28%). Farmers explained that cattle often feed on forest fruit, seeds and leaves during the dry season. Firewood (10%) is the third most frequently reported benefit. 11 ranchers (9%) said to benefit from the forest's shade for cattle. Hunting and tourism were not mentioned in any of the responses (Table 19).

Table 19 Forest Benefits reported by forest owners

Benefits	#	%
Making fence posts	52	44.8
Grazing (Browsing) seeds, fruit, leaves	33	28.4
Firewood	12	10.3
Shade for cattle	11	9.5
Water regulation	4	3.4
Other uses of forest wood	3	2.6
Recreation	1	0.9
TOTAL	116	100.0

3.2.6 Personal attitudes and beliefs

Beside the monetary participation costs as they were calculated in section 3.2.2, the land owners' decision to participate in a PES program might also be influenced by personal attitudes and beliefs. For example, one would expect those who do not trust state-run programs to require higher payments, i.e. a kind of risk premium to make up for the perceived risk (expressed as low levels of trust) of participation. Such hypotheses are tested in section 6. To get a grip of some of these personal characteristics the interviewees were questioned about (i) their degree of trust in state-run programs, (ii) the impact illegal cutting of trees would have on their conscience, (iii) their expectations of their land's future profitability and (iv) their individual risk behavior.

Trust in state-run programs. The interviewees were asked: "What is your degree of trust towards state-run programs such as the FONAFIFO PES program." 176 interviewees replied. Of these, the majority of land holders (80 or 45.5%) expressed little trust in state-run programs, 61 (34.7%) said to have a moderate degree of trust and 35 (19.9%) stated to trust such programs a lot (Table 20).

Table 20 Degree of trust in state run programs

Degree of Trust	#	%
Low degree of trust	80	45.5
Moderate degree of trust	61	34.7
High degree of trust	35	19.9
TOTAL	176	100.0

Attitude towards illegal tree cutting. The interviewees were asked: "Knowing that cutting trees is an illegal activity, let's assume you did cut trees for whatever reason, which of the following consequences would apply to you?" The question was closed with four possible answers (answers 1 to 4 in Table 21). It is interesting to see that 76 (43%) said their conscience would depend on the situation and objective of the logging (answer 4, Table 21). When this answer was chosen interviewees were asked to specify (4a to 4d, Table 21). In most of these cases interviewees found it rightful to cut a tree if it was for domestic use and not for commercialization. The second largest proportion of interviewees (74, or 42%) stated they would have a bad conscience about cutting trees. Only five land owners (3%) said they would have an unconditionally good conscience about cutting trees. In 3 cases (2%) the farmers did not want to choose any of the four offered answers and insisted to not cut a tree under any circumstances unless they had an official permit to do so.

Table 21 Conscience after hypothetically cutting a tree

Conscience	**#**	**%**
1. I would have a clear conscience	5	2.8
2. I would have a bad conscience	74	41.6
3. My conscience would be neither good nor bad	3	1.7
4. My conscience would depend on the situation and the objective of the logging:	76	42.7
4a. I would have a clear conscience if I use the wood for my farm or house.	*(73)*	*(41.0)*
4b. I would have a clear conscience if I use the wood for my farm or house and as long as the tree does not belong to any protected tree species and is not close to a river.	*(1)*	*(0.6)*
4c. I would have a clear conscience if I use the wood for fence posts. However, I would not cut a tree to sell its timber or use it for my house.	*(1)*	*(0.6)*
4d. I would have a clear conscience if I need the wood and plant a new tree after cutting.	*(1)*	*(0.6)*
5. I would never cut a tree without a permit	3	1.7
6. Not further specified	17	9.6
TOTAL	178	100.0

The interviewees were further asked whether under the hypothetical logging of trees they would fear to be reported to the police and/or fear that their reputation could suffer in the community. 106 land owners (59.6%) said they would fear to be reported and 32 land owners (18%) said they would fear their reputation to suffer in the community (Table 22).

Table 22 Impacts of illegal logging

Impact	#	%
Fear to be reported	106	59.6
Reputation would suffer	32	18.0

n=178

Expectations on future profitability. Expectations regarding future land profitability could also affect the adoption of PES. Decreasing profitability could trigger interest in land use alternatives. The interviewees were therefore asked: “Do you believe that the profitability of your land will increase, decrease or remain unchanged in the next 10 years?" The land owner's replies are presented in Table 23. Approximately 30% of the interviewees expected their profitability to decrease while 37% expected it to increase. 33% did not expect the profitability to change.

Table 23 Future land profitability expectations

Profitability Expectations	#	%
Increase	66	37.1
No change	59	33.1
Decrease	53	29.8
TOTAL	178	100.0

Risk behavior. Risk behavior might have two contrary effects on whether land owners show an interest in PES or not: (i) Risk-averse land holders may prefer a small but steady annual PES to the sometimes very volatile income from agricultural activities, even if the latter was on average higher. (ii) Adoption theory says that risk-averse landowners are less likely to adopt a new technology, here PES. In order to examine the farmer's risk behavior the interviewees were presented three possible business opportunities A, B and C, and were asked to identify the business opportunity they prefer. The business opportunity A allowed two different outcomes: a profit of US$ 20 or a profit of US$ 200, each occurring with a probability of 50%. The expected value of this option is therefore US$ 110. The second business opportunity B allowed three different outcomes: a profit of US$ 20, US$ 100 or US$ 200, each occurring with a probability of 33.3%. This option's expected value is therefore US$ 106.67. The third business opportunity C allowed only one outcome: a guaranteed profit of US$ 100. Interviewees with a relatively strong risk-aversity would be expected to tend towards option C because they would prefer a guaranteed profit of US$ 100 even though this is the lowest expected value of all options. Risk neutral interviewees would be expected to choose A with the highest expected value. Risk loving interviewees and those who are only slightly risk averse (where the risk-aversity is smaller than the difference of expected value) would be expected to go either with A or B. The risk-averse interviewees can thus be distinguished from all other interviewees. Table 24 presents the results of this question. An absolute majority (137 or 77%) opted for the risk-averse business opportunity (C).

Table 24 Business options and risk behavior

Options	Outcomes ($) and Probabilities (in brackets)	Expected Value	#	%
Option A	20 (1/2) or 200 (1/2)	110.00	23	12.9
Option B	20 (1/3) or 100 (1/3) or 200 (1/3)	106.67	18	10.1
Option C	100 (1/1)	100.00	137	77.0
TOTAL	n.a.	n.a.	178	100.0

3.3 Secondary Data

The secondary data that were used for the analysis consist of digital maps with various information layers. The section is divided into three parts. The first and largest part describes the data that was used to measure the environmental services and how these were integrated. The second part presents the deforestation data. And the third part shows spatial information that was used for analyses in chapters 5 and 6.

3.3.1 Measuring Service Provision

This section describes the data that was used to quantify the four environmental services (biodiversity, carbon, water and scenic beauty) and also poverty alleviation services. Main data source was the Atlas digital of Costa Rica ITCR (2004). In addition, Imbach (2005) kindly provided data on groundwater consumption and aquifer extension. All data is spatially explicit and service potentials were determined for the forest area of the sample sites. Total forest area is 3,736 hectares. Ideal estimation of environmental services requires complex and detailed data. Yet, to be operationally applicable, a targeting tool has to be based on simplifying assumptions to adapt service estimations to individual demands and available data. Below, the service estimations are presented as conducted in this study; at the same time the viability of alternative approaches in Costa Rica (e.g. Imbach 2005, Barton et al. 2003, Tattenbach et al. 2006) is acknowledged.

Each of the four services is measured in service-specific units (e.g. slope in percentage, distance in meters) and so cannot be compared directly. Therefore, a z-normalization was applied, yielding comparable scores with a mean equal to zero and standard deviation and variance equal to one (Hogg and Craig 1978)[13]. The z-value normalization for data sets where higher values are given priority over lower values (e.g. slope) has the following formula:

$$z = \frac{x_i - \text{mean}}{\text{S.D.}} \qquad (1)$$

[13] See Ferraro (2004) for alternative standardization techniques.

with x_i being the observed value of the i^{th} site. For data sets where lower values are given priority over higher values (e.g. distance of plots to existing or proposed protected areas) the z-normalization has the following formula:

$$z = \frac{\text{mean} - x_i}{\text{S.D.}} \qquad (2)$$

3.3.1.1 Biodiversity Services

Biodiversity services are defined here as contributions towards the conservation of species communities in their natural forest habitat. Forest conversion to other land uses destroys natural habitat causing the decline and, ultimately, extinction of forest dwelling species. The estimation of forest biodiversity services would ideally require a long list of information components, among them a population's distribution, its contribution to represent a species, the minimum sustainable population size and requirements concerning area extension and habitat quality, an estimate of its irreplaceability with respect to endemism, information about its expected persistence concerning current protection status, connectivity of habitats as well as present and future threats including environmental, demographic and genetic stochasticity (e.g. Rodrigues et al. 2003, Sanderson et al. 2003, Faith et al. 2001, Powell et al. 2000). Available data, however, do not allow such complexity to be taken into account. Although biodiversity data has improved significantly in recent years (Rodrigues et al. 2003), adequate data is still unavailable for many parts of the world.

In the simplified estimation approach used here, habitat types (life zones) by Holdridge (1967) are used as a surrogate for biodiversity. Holdridge (1967) defined life zones (regions on earth with relatively homogenous climatic conditions and thus also relatively homogenous macro vegetation types) according to the three indicators (i) biotemperature[14], (ii) precipitation and (iii) ratio of evapotranspiration to precipitation (Woodward 1996). The logic is that sufficiently large ecologically intact areas of each of these life zones will ensure the conservation of all biodiversity within them. It was assumed that the conservation of the macro vegetation on 20% of the (original) extension of each life zone would be sufficient to conserve all biodiversity that is typical for a particular life zone. It was then measured to what

[14] Biotemperature refers to all temperatures above freezing, with all temperatures below freezing adjusted to 0° C. The assumption was that, from the perspective of plant physiology, there is no real difference between 0° C and temperatures less than zero: plants are dormant (Woodward 1996).

extent the current system of protected areas on Nicoya Peninsula already represents the individual life zones. Those life zones that are least represented in the current protected areas (Map 3, Appendix I) receive the highest priority to be complemented with PES contracted land plots. The mean representation deficit of the life zones that were found to be within the sample sites is 12.8% (Table 25). Furthermore, connectivity was considered by measuring the distance (in m) from the sample sites to already existing protected areas and proposed conservation corridors on private land (the latter were proposed in the so-called GRUAS study by García (1996). Plots close to these areas are given priority to increase the connectivity between conserved areas (Map 4, Appendix I). The mean distance from the sample sites to these areas is 3005m (Table 25). The z-values for representation and connectivity are combined to compute an aggregate mean z-value for total biodiversity service provision (Map 5, Appendix I), giving equal weight to the two sub-criteria[15].

Table 25 Descriptive Statistics of Service Proxies in Forest Parcels

Variable	Mean	Min.	Max.	S.D.
Lifezone Representation deficit (%)	12.8	0.0	19.3	4.9
Distance to existing/proposed PA (m)	3005	0	9191	2154
Carbon storage potentials (t)	126.2	94.0	135.8	9.4
Slope (%)	3.8	0	68.5	8.7
Water consumption (liters/hour/ha)	16.2	0.0	208.4	45.0
Visibility (number viewpoints)	9.0	0.0	30.0	7.4
5-year deforestation probability (%)	3.86	2.09	6.81	1.24

3.3.1.2 Carbon Services

Carbon services are defined here as the mitigation of carbon releases (carbon storage) through avoided deforestation, which is not recognized by the Kyoto framework but currently traded on voluntary carbon markets. Ideal estimation of mitigation services would require information on the amount of stored carbon before and after land use change, and on the risk of land use change to occur for which deforestation rate estimates by Pfaff and Sanchez-Azofeifa (2004) are used here[16]. Lacking data on site specific forest maturity, each Holdridge lifezone is assigned a per-hectare amount of stored carbon that is typical for primary forests, thus overestimating carbon storage in secondary forests. Life zone specific carbon-storage

[15] Weights could also be distributed differently, but for lack of a clear weight preference are set equal here.

[16] See section 3.3.2 for more details on deforestation rates by Pfaff and Sanchez-Azofeifa (2004).

quantities are derived from data on biomass per hectare (Imbach et al. 2005) assuming a carbon content of 50% (IPCC 1996). It is assumed that, if deforested, land use converts to pasture with a biomass carbon storage of 5 tC/ha[17] (Rojas 2005). The spatial distribution of carbon storage potentials is depicted in Map 6 (Appendix I). The crudely estimated mean carbon-storage potential of the sample sites is 126.2tC/ha (Table 25).

3.3.1.3 Hydrological services

Hydrological services are defined here as the forest's contribution to the natural supply of freshwater. Vegetation cover and soil management influences the interception, infiltration, storage, runoff and evapotranspiration of water. These are properties which, in turn, have different effects on the three hydrological services (i) total surface and groundwater yields, (ii) seasonal distribution and (iii) water quality (e.g. sedimentation). The exact relation between forest cover and these services is highly site specific, and sometimes contested. Bruijnzeel (2004) concludes from a wide range of available scientific evidence that (a) total annual yield increases with the percentage of biomass removed, (b) infiltration is reduced by deforestation and subsequent soil degradation, thus often reducing dry season flows; and (c) tree cover may prevent surface erosion and, in the case of a well-developed tree cover, shallow land sliding as well. Since total annual yield is of less concern in Costa Rica, this study focuses on (b) and (c) as prospective hydrological benefits from forest conservation. This approach represents the interests of groundwater users who hold 36% of water concessions and account for approximately 10% of total utilized water volume; and it represents the interests of those who seek low silt concentrations including hydroelectric power stations, which account for 70% of total utilized water volume.

Ideally, hydrological service estimation would require information on site specific soil characteristics, vegetation cover, slope, distribution and intensity of precipitation as well as spatially differentiated information on user demands in terms of attributes (i) to (iii). In this simplified estimation approach slope is used as a proxy for erosion and thus sedimentation potential (Map 7, Appendix I). Slope (%) was derived from an elevation model, drawing on contour lines from the Digital Atlas 2004 (ITCR 2004). Mean slope within the sample sites is 3.8% (Table 25). Sites with steep slopes are given higher forest-conservation priority. Secondly, groundwater demand is determined using data by Imbach (2005) which sums up water consumption (private, agricultural and industrial) from all registered wells. Using an

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[17] Carbon quantities vary depending on type and management of pastures, including the number of trees. However, to ease the analysis we work with a single average only.

aquifer map from the same study, per-hectare water consumption for each aquifer can be calculated (Map 8, Appendix I). Water consumption from the sample sites has a mean of 16.2 liters/hour/ha (Table 25). Sites with high water consumption are given higher forest-conservation priority. The z-values for slope and water consumption are combined to compute an aggregate mean z-value for hydrological services (Map 9, Appendix I) giving equal weight to the two sub-criteria.

3.3.1.4 Scenic beauty

Scenic beauty services are defined as the forest's contribution to an aesthetically appreciated landscape. Deforestation often deteriorates the landscape vista, and thus its scenic beauty. Ideally, scenic beauty services would be measured as a function of the composition of various landscape elements. Thus, a specific plot's marginal contribution would depend on its spatial relation to other landscape elements. Moreover, service values would depend on the number of people who view the landscape, and their individual level of appreciation. In the simplified approach here it is assumed that any loss of forest cover reduces the aesthetic value of a landscape and associated scenic beauty services and that a plot's degree of scenic contribution depends on its visibility. Therefore, the visibility of forest is calculated from hypothetical lookout points spaced in equal distances along the national road network (Map 10, Appendix I). The calculation was based on a triangulated irregular network (TIN) elevation file derived from ITCR (2004). Pixels within the sample sites can be seen from a mean of 9.0 viewpoints (Table 25).

3.3.1.5 The Social Development Index (IDS)

The IDS is a summary indicator which measures the social standard of regions in Costa Rica (MIDEPLAN 2001). It is composed of the following variables: educational infrastructure, access to special educational programs, infant mortality, child mortality (under-5-year-olds), stunted growth of first graders, monthly consumption of residential electricity and births of children to single mothers. Its value ranges between zero and 100, corresponding to the socially least developed region and the region with the best socio-demographic situation, respectively. In Nicoya Peninsula the IDS is relatively evenly distributed. It ranges from 46.1 to 56.9 (MIDEPLAN 2001) (

Map 11, Appendix I). In the present Costa Rican PES priority area system, the welfare status of recipients is considered crudely through the targeting of the poorest regions with an IDS lower than 40. This means, for instance, that poverty is not considered in contract allocation in Nicoya, which is not sufficiently poor on aggregate. However, in the approach offered in section 4.5, the IDS is considered by comparing the relative social development level of one site to competing sites. Consequently, land parcels in a low IDS region are given a higher score. Payments for environmental services are believed to help overcome social inequalities.

3.3.2 Deforestation Risk

An index for deforestation pressures estimated by Pfaff and Sanchez-Azofeifa (2004) is used. They econometrically estimate a model determining the annual deforestation rate (r) for Holdridge life zones within administrative districts, based on forest clearing data over time (1963, 1979, 1986, 1997 and 2000)[18]. Intersecting Holdridge life zones with districts produces a total of 142 land plots. Both socio-economic and biophysical explanatory variables are used in the model. Then, estimating the future values of all the explanatory variables, they project forward the dependent variable (annual deforestation rate) for the year 2002. In the simplified approach presented here these estimated deforestation rates are assumed to be constant over a period of five years, the usual duration of PES contracts in Costa Rica, for example for the period 2005-2010. Ideally, projected deforestation rates should have been estimated anew for future points in time other than 2002. Although this was not done here due to time constraints the author believes that 2002 deforestation estimates are sufficient for the illustration of how deforestation probabilities can be integrated into targeting. The average annual deforestation rate (r) is used to calculate deforestation probabilities for a period of 5 years (r_5) (Map 12, of Appendix I)[19].

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[18] Note that Pfaff and Sanchez-Azofeifa (2004) do not differentiate between non-PES and PES sites. In theory this may lead to an underestimation of deforestation. It is believed that this effect will be small because (i) forest cover data goes back to well before the implementation of PES in 1997 (thus PES may only have had a risk-decreasing effect on the forest-cover data from 2000); (ii) the ratio of PES forest (256,521 ha in 2000 (Ortiz 2002)) to total forest cover (2,557,370 ha in 1996/97 (Calvo et al. 1999)) is relatively small and high risk areas were not systematically targeted.

[19] Correlation of deforestation rates by Pfaff and Sanchez-Azofeifa (2004) and field data opportunity costs were tested. Correlation coefficients are not significant (Pearson 0.90, Spearman 0.76).

$$r_5 = 1 - (1-r)^5 \quad (3)$$

The mean of r_5 within the forest sites is 3.86 % (Table 25).

3.3.3 *Other Spatial Characteristics*

The use of a geographic positioning system (GPS) also allowed linking the sampled land plots with other secondary spatial information from digital maps. Table 26 presents some of the spatial characteristics of the sampled properties (land parcels). Most of this data was determined by overlaying the geographical co-ordinates that were obtained in the field survey with secondary digital map data.

Altitude and Precipitation. Nicoya Peninsula includes hilly areas and interviewed properties were found on elevations of up to 900 meters (mean: 193, S.D.: 174), (Table 26). Annual precipitation ranges between 2,000 and 3,500 mm with an average of 2,458 mm (S.D.: 427). Precipitation falls during the rainy season which is contrasted by four to six, or a mean of 4.6 dry months.

Distance to auction and market. The sampled land properties have a mean distance of 23 km (as the crow flies) to the next cattle auction place (S.D.: 16). The largest distance that would have to be covered to buy or sell cattle at an auction place is 72 km, and the closest livestock holder has to travel some 3 km. Market places for general supplies and spares are somewhat closer with a mean of 13 km (S.D.: 9) (Table 26).

Table 26 Characteristics of Land Parcels in the Sample

	Mean	S.E.	S.D.	Min.	Max	P 25	P75
Annual precipitation (mm)	2,457.8	32.0	427.0	2000.0	3500.0	2000.0	2500.0
Dry months per year	4.6	0.0	0.5	4.0	6.0	4.0	5.0
Elevation (m)	193.3	13.1	174.2	0.0	900.0	100.0	200.0
Distance to nearest auction (km)	23.3	1.2	15.6	2.9	71.5	12.1	28.7
Distance to nearest Commercial Center (km)	13.4	0.7	9.3	0.3	46.8	6.4	18.4

n=178

Soil use capacity. The soil use capacity classifies the land by its agricultural production potential (Table 27). In Costa Rica one distinguishes eight categories of soil use capacities with (1) being the category with the highest agricultural potential and fewest production limitations and (8) being the category with the least potential and most limitations. Of the interviewed properties most (44.9%) have soil use capacities of class (2), followed by 19.7% of the properties with class (3). These soils are suitable for agricultural production. Categories (6) to (8) are not suitable for agricultural production and 30.9% of the properties were found to be situated in areas with these categories (Table 27).

Table 27 Soil use Capacity

Soil Use Capacity	no.	%
(1) Agriculture with no limitations	0	0.0
(2) Agriculture with light limitations	80	44.9
(3) Agriculture with moderate limitations	35	19.7
(4) Agriculture with strong limitations	8	4.5
(5) Livestock farming or forest management	0	0.0
(6) Permanent plant cover	28	15.7
(7) Forest management	18	10.1
(8) Forest Protection	9	5.1
TOTAL	178	100.0

Soil Types. Alfisols are the most common soil types on the sampled properties on Nicoya Peninsula (Table 28). A total of 102 (57.3%) properties were associated with Alfisols. Second most common soil types are Inceptisols with 20.2% of the properties, and Vertisols with 16.3% of the properties. Mollisols and Entisols were found on few properties only, 3.9% and 2.2%, respectively.

Table 28 Soil Types

	Alfisols	Entisols	Inceptisols	Mollisols	Vertisols	TOTAL
# Properties	102	4	36	7	29	178
% Properties	57.3	2.2	20.2	3.9	16.3	100.0

Lifezones. Eight Holdridge life zones can be found on Nicoya Peninsula (Holdridge 1967). Holdridge life zones are regions with relatively homogenous climatic conditions and thus also relatively homogenous macro vegetation types. They are defined, as has already mentioned above, using the three indicators (i) biotemperature, (ii) precipitation and (iii) ratio of evapotranspiration to precipitation (Woodward 1996). The sampled properties fell into seven of these life zones. Only the ‘Tropical Dry Forest’ is not represented by the sample. Most farms are situated in the life zone ‘Tropical moist forest’ (35.4%) and in the life zone ‘Premontane moist forest, basal belt transition’ (30.3%), (Table 29).

Table 29 Holdridge Life Zones

Life Zone (Holdridge)	#	%
Premontane wet forest (Bmh-P)	13	7.3
Premontane wet forest, basal belt transition (Bmh-P6)	2	1.1
Premontane moist forest, basal belt transition (Bh-P6)	54	30.3
Tropical moist forest, perhumid transition (Bh-T2)	3	1.7
Tropical moist forest (Bh-T)	63	35.4
Tropical moist forest, transition to dry (Bh-T10)	33	18.5
Tropical dry forest, moist province transition (bs-T2)	10	5.6
TOTAL	178	100.0

4 The Targeting Tool

This chapter starts in section 4.1 with a description of relevant concepts and definitions for the targeting tool. It continues to introduce eight different targeting approaches in section 4.2 which were implemented in order to compare alternative applications of the stipulated targeting criteria. The corresponding empirical results are presented in section 4.3. The stability of the results with respect to the assumptions that were made in the analysis is challenged in a sensitivity analysis in section 4.4. The focus of sections 4.1 to 4.4 is forest protection, the most dominant service provision activity acknowledged in the PSA program. Of 178 land properties in the sample, forest was encountered on 107 (Map 13 of Appendix I). Section 4.5 expands the applicability of the tool to natural forest regeneration on pasture land and also introduces a way to integrate social objectives. Since implementation costs have been stated to pose a potential impediment to the use of improved targeting these costs are estimated in section 4.6. The chapter closes with a summary in section 4.7.

4.1 Concept and Definitions

The three principal targeting variables (services, costs and deforestation risk) are represented by six main spatial data sets. Four of these hold estimates for the levels of environmental services (hydrological services, biodiversity conservation, carbon mitigation and landscape beauty services). The two others concern deforestation probabilities and participation costs.

Additionality (e) is defined to be the product of environmental service score (u) and deforestation probability (r):

$$e = u * r \qquad (4)$$

It is assumed that property holders are always willing to participate if the per hectare PES payment ($C_{payment}$) exceeds the sum of per hectare opportunity (C_{opp}), protection (C_c) and transaction costs (C_t)[20]:

$$\gamma_j = 1 \quad \text{if} \quad C_{opp} + C_c + C_t < C_{payment}\ ; \ \gamma_j = 0 \text{ otherwise} \qquad (5)$$

[20] See Antle and Valdivia (2006) for a similar approach

where $\gamma_j \in \{0,1\}$ is an indicator variable reflecting participation. Opportunity costs refer to the difference in income between the most profitable land use (before PES) and forest conservation. Protection costs relate to active forest-protection efforts (e.g. firebreaks, fencing off cattle). The landowners' transaction costs are all residual PES-related landowner expenses for contract establishment and maintenance (e.g. travel expenses, information gathering, and external monitoring). The sum of these three cost elements is defined here as the participation cost. If payment levels are flexible and aligned to participation costs, individual site-specific benefit-cost ratios can be established.

Combining the five-year deforestation risk (r_5) of pixel i with its service score for biodiversity (b_i), hydrology (w_i), carbon (c_i) and scenic beauty (s_i), the pixel's additionality e_i can be estimated using equation 6, giving:

$$e_i = r_{5i} (b_i + w_i + c_i + l_i) \quad (6)$$

As a neutral point of departure, equation (6) gives equal weight to all four services, which nevertheless could be changed. For instance, in the wake of coming water-user fees for watershed conservation (Pagiola 2008), increased weight might be given to water services in relevant watersheds. An alternative approach could be to adjust weights to the relative importance of different funding sources and the services that buyers are most interested in. Map 14 of Appendix I shows the bundled service score distribution and Map 15 of Appendix I the bundled additionality on Nicoya Peninsula. The conservation of lighter shaded areas provides less additionality than the conservation of darker areas. The 107 forest parcels deliver an overall environmental service score of 230,563 (mean 61.8/ha) and, if put under PES protection, would provide an additionality score of 9,212 (4.0%) with a mean additionality of 2.47 score units per hectare. Their total water score is 26,432 (mean 7.1/ha). If the 107 sites were to be compensated with their individual cost of PES participation, total expenditure would amount to 264,263US$, implying an additionality efficiency of 34.9/1,000US$. The sample contains 57 sites (1,309 ha) with per hectare participation costs smaller than the fixed payment of US$40.

4.2 Targeting approaches

Eight different targeting approaches for choosing among the group of 107 forest plots are compared. Given an equal budget, the results will show which of the approaches delivers most additionality. An overview of the eight targeting approaches and their main differences is given in the upper part of Table 30.

The ‘Baseline’ approach follows the selection procedure currently employed by FONAFIFO. This means all forest sites are selected that (i) have a cost of participation smaller than the fixed payment of 40US$/ha and (ii) lie within priority areas[21]. For comparability, the total computed expenditure in the Baseline approach will also serve as the budget limit (C_{budget}) in all other approaches.

The ‘FlexAdd’ approach is the main and most complete targeting approach. It integrates the full range of targeting criteria: (i) Scoring information for the four environmental services, (ii) flexible payments that are aligned to participation costs and (iii) deforestation probabilities or the risk of service loss to compute additionality. Forest sites (j) with the highest ratio of total additionality (e_j) to cost (C_j) are selected and total additionality is maximized using:

$$\underset{б_j}{\mathrm{Max}} \sum_{j=1}^{n} б_j \, (e_j) \qquad (7)$$

where $б_j \in \{0;1\}$ is an indicator variable which takes the value of one if the site is selected and zero otherwise[22]. The maximization is subject to the budget constraint:

$$\sum_{j=1}^{n} б_j \, (C_j) \leq C_{budget} \qquad (8)$$

Given the assumption that land owners participate as long as they receive at least their participation cost, with flexible payments it would be optimal for the implementing agency to choose a level of payment just equal to (or marginally above) participation costs. Thus, flexible payment levels are set equal to participation costs here.

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[21] As farm location is determined with a point, it may occur that parts of it lie outside priority areas.

[22] In all approaches (except Baseline) it is maximized manually listing plots from highest to lowest service potential (e.g. additionality/cost in FlexAdd approach) and selecting plots until budget is depleted.

The ‘FlexScore’ approach is similar to the ‘FlexAdd’ approach in that it employs flexible payments equal to participation costs. But it only utilizes information on service score (ignoring deforestation threat) and selects sites with the highest ratio of total score (u_j) to C_j subject to budget constraint (8):

$$\underset{б_j}{\text{Max}} \sum_{j=1}^{n} б_j \, (u_j) \tag{9}$$

The ‘FlexWater’ approach is similar to the ‘FlexScore’ approach in that it employs flexible payments and utilizes service scores which, however, are scores for water services only. It selects the sites with the highest ratio of water score (u_{wj}) to C_j and budget constraint (8) applies. The ‘FlexWater’ approach simulates a funding situation for water services only. Other services are delivered as by-products.

$$\underset{б_j}{\text{Max}} \sum_{j=1}^{n} б_j \, (u_{wj}) \tag{10}$$

The ‘Flex’ approach employs flexible payments and simply targets the “cheapest” sites (regardless of environmental services provided) until the budget is depleted (constraint (8) applies).

In the ‘FixAdd’ approach, a fixed payment of 40US$/ha ($C_{fix}$) is used. It utilizes information on service score and deforestation risk to compute additionality. Among the land plots with $C_j/a_j<C_{fix}$ (where a_j is the size of plot j in hectares) those with the highest mean additionality values ($\bar{e}_j$) are selected and total additionality is maximized using:

$$\underset{б_j}{\text{Max}} \sum_{j=1}^{n} б_j \, (\bar{e}_j) \tag{11}$$

subject to budget constraint:

$$\sum_{j=1}^{n} б_j \, (a_j C_{fix}) \leq C_{budget} \tag{12}$$

In the ‘FixScore’ approach it is proceeded as in the ‘FixAdd’ approach, but deforestation threat is ignored. Payments are fixed and the highest mean scores ($\bar{u}_j$) are targeted (subject to budget constraint (12)):

$$\underset{б_j}{\text{Max}} \sum_{j=1}^{n} б_i \, (\bar{u}_j) \qquad (13)$$

The ‘FixWater’ approach is similar to the ‘FixScore’ approach. Payments are fixed but the sites with the highest mean water scores ($\bar{u}_{wj}$) are selected. Like the ‘FlexWater’ approach, the ‘FixWater’ approach simulates a funding situation for water services only with other services delivered as ‘by-products’.

4.3 Results

Table 30 presents the principal results from the eight targeting approaches. Map 15 to Map 22 of Appendix I depict the site selections made in each of the approaches. In the Baseline approach, 20 sites with a total area of 750.7 ha are selected. Total payments equal 30,028US$, which also determines the budget for all other approaches. The Baseline approach yields a total overall score of 52,148 and a total additionality of 1,969 which translates into an additionality efficiency of 65.6 per 1,000US$. Total water score is 6,900.

In each of the other approaches, total payments are almost identical, but always slightly below those of the Baseline. This is because only entire sites can be selected, and hence small parts of the budget remain unspent. Similarly, the contracted area in the fixed payment approaches is almost identical. Contracted area in the flexible payment approaches, however, rises sharply by up to 92%. This is because average per hectare payments are lower, although individual payments go up to US$61.95 in the FlexScore, US$68.32 in the FlexAdd and US$183.30 in the FlexWater approach.

All approaches achieve higher efficiencies (i.e., additionality per 1,000$ spent) than the Baseline approach, independent of whether additionality, overall score or water score was targeted. Yet, the degree to which efficiencies increase differs. In general, increases in the fixed payment approaches (by 6 to 17%) are not as high as in the flexible payment approaches (increases of 63-105%) reflecting the dominance of cost-aligned payment differentiation. The main reason for this is the considerable increase of contracted area in the flexible payment approaches. However, in some cases benefits increase more than area. For example, in the FlexAdd approach area increases by 79% while efficiency more than doubles, increasing by 105%. Therefore, the efficiency increase must have two causes: (i) targeting low-cost sites and thus increasing area and (ii) targeting high additionality sites. To see how big the latter effect is, the results of the FlexAdd and Flex approach are compared. It can be found that efficiency in the Flex approach, which simply maximizes total area by allowing for flexible payments, increased by 93%, compared to an increase of 105% in the FlexAdd approach. The remaining 12% may thus be attributed to targeting high additionality sites. Whether this relatively small incremental efficiency gain justifies the more complex targeting procedure of the FlexAdd approach is a subject that requires debate. In general, whether a policy of simply targeting the cheapest sites as in the Flex scenario leads to desired outcomes depends on the variability and correlation of demanded services and costs. For example, if only water services are of interest, the Flex approach increases water score efficiency by 59% compared to the Baseline approach, while targeting water services explicitly (in the FlexWater approach) yields an increase of 131%,.

Even though efficiency is highest in the postulated FlexAdd approach, it can also be seen that efficiencies in the FixAdd (76.4) and FlexAdd (134.3) approaches are only slightly superior to those in the FixScore (75.1) and FlexScore (130.3) approaches, by 1.7% and 3.1%, respectively. The reason for this is the low variability of deforestation rates (r_5) within the sample sites, causing almost identical selection results between the score and additionality approaches. Additionality in the targeting approaches ranges from 3.8% of total service score in the Baseline to 4.3% in the FlexAdd. For example, the FixAdd selection has a total score of 57,156 and an additionality of only 2,294 or 4.0%.

Compared to the Baseline approach, the FixWater and FlexWater approaches are particularly successful in increasing the water score, by 39% and 131%, respectively. While water service acts here as an “umbrella service” which provides other services as mere by-products[23], the overall score and additionality for all four services also increase, though to a lesser degree than in their counterpart multiple-service targeting approaches. This makes the water-based approaches interesting alternatives particularly when funding is obtained predominately for one service. In 2005, for example, as already mentioned above, Costa Rica added an earmarked watershed conservation fee to the existing water tariff. Once fully implemented this fee will generate an estimated US$19 million annually, of which 25% would be channeled through the PSA program (Pagiola 2008).

[23] See Turpie and Blignaut (2008) for an example of how water as an “umbrella service” can help to achieve conservation goals in South Africa.

It is also observed that the Baseline approach contracts sites with a mean size (37.5 ha) higher than any other approach (20.3– 30.0 ha)[24,25]. The selection tool's bias towards smaller parcels thus triggered the question whether this could imply increased participation of poorer households with less land available for program enrolment. Using monthly household consumption data from the survey as a proxy for wealth, it was found that mean household consumption in the Baseline is higher (index 2.7), though not significantly, than in the other selections (index 2.4–2.5). This rough indicator may suggest that the targeting tool tends to select more lands belonging to poorer households. Higher opportunity costs, tenure insecurity, lack of land titles, technical constraints and transaction costs have been named as prime obstacles obstructing poorer landowners' access to PES programs (Pagiola et al. 2005). The results here suggest that poorer landowners can actually be more competitive service providers, providing higher environmental benefits per monetary unit spent. Policy measures to reduce obstacles like the ones mentioned above are therefore justified not only on grounds of equity but also of program efficiency. However, note that in the case of flexible payments as presented here in the “Flex” approaches, payments only just compensate participation costs, implying that increased participation would not lead to increased welfare and poverty alleviation.

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[24] The selection procedure of only allowing entire sites into the program results in somewhat smaller means, compared to a procedure allowing for the splitting of sites. However, the splitting procedure was checked and it was found that average site sizes (22.7, 23.5, 31.3, 24.5, 25.2, 26.8 ha) also stay well below the Baseline (37.5 ha).

[25] Note that per-contract transaction costs to service buyers were not considered in the selection procedure. As these are likely to be independent of land size, their consideration in the selection procedure might discourage the inclusion of smaller sites.

Table 30 Results of Targeting Approaches (percentages in brackets)

	Baseline	**FlexAdd**	**FlexScore**	**FlexWater**	**Flex**	**FixAdd**	**FixScore**	**FixWater**
Payment	Fixed	Flexible	Flexible	Flexible	Flexible	Fixed	Fixed	Fixed
Budget Limit	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Selection Criteria	Priority Area	Addition-ality/Cost	Score/Cost	Water Score/Cost	Mean Cost	Mean Additio-nality	Mean Score	Mean WaterScor e
Total Cost (US$)	30,028 (100.00)	30,014 (99.95)	29,997 (99.90)	30,016 (99.96)	30,000 (99.91)	30,016 (99.96)	30,012 (99.95)	30,024 (99.99)
No. of Sites	20 (100)	56 (280)	62 (310)	44 (220)	68 (340)	37 (185)	36 (180)	25 (125)
Area (ha)	750.7 (100.0)	1350.2 (179.0)	1423.3 (189.6)	1178.7 (157.0)	1441.7 (192.0)	750.4 (100.0)	750.3 (99.0)	750.6 (100.0)
Mean Site Size (ha)	37.5 (100.0)	24.1 (64.3)	23.0 (61.3)	26.8 (71.5)	21.2 (56.5)	20.3 (54.1)	20.8 (55.5)	30.0 (80.0)
Total WaterScore	6,900 (100.0)	10,301 (149.3)	11,194 (162.2)	15,931 (230.9)	10,952 (158.7)	8,591 (124.5)	8,267 (119.8)	9,618 (139.4)
Total Env. Service Score	52,148 (100.0)	94,829 (181.8)	98,259 (188.4)	82,289 (157.8)	96,421 (184.9)	57,156 (109.6)	57,770 (110.8)	52,444 (100.6)
Total Additionality	1,969 (100.0)	4,033 (204.8)	3,909 (198.5)	3,211 (163.1)	3,798 (192.9)	2,294 (116.5)	2,253 (114.4)	2,088 (106.0)
Additionality / 1000$	65.6 (100.0)	134.3 (204.7)	130.3 (198.6)	107.0 (163.1)	126.6 (193.0)	76.4 (116.5)	75.1 (114.5)	69.5 (105.9)

Source: Own computations

4.4 Sensitivity Analysis

This analysis has necessarily had to rely on relatively crude data and sometimes arbitrary assumptions. To what extent do the results remain stable if these assumptions were changed? To answer this question, a sensitivity analysis is conducted in which it is tested how the selected sets of sites from the various targeting approaches perform if spatial service distribution differed due to alternative assumptions and scoring techniques. Imagine, for example, a situation where new data change the previous assumptions about service distribution. The presented sensitivity analysis examines to what extent the originally selected sites' service potential changes in terms of total and additional score (additionality). The originally assumed multiple service distribution is changed to four alternative distribution scenarios (i-iv), in which (i) a zero value for scenic beauty services is assumed for all sites, (ii) biodiversity scores depend exclusively on the representativity criterion and not on connectivity, (iii) the distribution of water services depends only on water consumption and not on slope, and (iv) all three of these variations are combined. Moreover, for the single-service case, it is examined how the parcel selections of the water approaches perform in terms of water score if assumptions about water distribution change: in addition to the original water service distribution, distribution scenarios where only water use intensity or slope are considered are now introduced. In addition to the alternative assumptions, also a different scoring technique is used. Instead of the z-normalization, an interval normalization (Ferraro 2004) returning values from zero to one is applied to each service. For large values preferred to low values, the interval score (k) is computed as

$$k = \frac{x_i - \min(x)}{\max(x) - \min(x)} \quad (14)$$

where x_i is the observed value of a specific variable of pixel i, min(x) is the minimum and max(x) the maximum value observed within the sample. For small values preferred to large values the normalization takes the form

$$k = \frac{x_i - \max(x)}{\min(x) - \max(x)} \quad (15)$$

The results of the sensitivity analysis are presented in Table 31. The results are not directly comparable between the scenarios, because in each the entire scoring dimension changes. Therefore the results of the Baseline site selection in one service distribution scenario are compared with the results of other targeting approaches in the same scenario.

For ease of comparison, Table 31 repeats in the first column results from Table 30 (only those for interval normalization are new). Looking at the z-scores (z-normalized scores), a general pattern can be observed throughout the alternative service distribution scenarios: there is a low to moderate increase of total score from the Baseline to the FixScore approach; total score almost doubles in the FlexScore and stays slightly below FlexScore levels in the Flex approach. When additionality is derived by multiplying z-scores by deforestation risk, the same pattern (as in the score approaches) between the Baseline, FixAdd, FlexAdd and Flex approach can be observed throughout the alternative service distribution scenarios. When interval normalized scores are used the results also broadly follow this pattern, except that some of the relative increases of total scores in the Flex selections are slightly higher than those in the FlexScore selection. It can be concluded from these observations that any of the proposed targeting mechanisms increases bundled services also under changing assumptions and scoring techniques. However, for the fixed payment approaches the increases under some alternative assumptions may be too low to justify the use of a complex targeting system. Flexible payment approaches, on the other hand, are found to be clearly dominant even under alternative service distributions.

The water scores do not quite follow the above pattern. Drastic water score differences between the Baseline and FixWater approaches as well as between the Flex and FlexWater approaches show the importance of well defined targets in the presence of high service variability as is the case for water services. The bundling of service scores, on the other hand, leads to spatially more evenly distributed services with less variability and therefore have more robust results.

Table 31 Scoring results in the Sensitivity analysis

(Percentages of values compared to Baseline selection in brackets)

	Alternative Service Distribution Scenarios				
Targeting approaches	**Initial assumption**	**Omitting scenic beauty**	**Basing bio-diversity only on representativity**	**Basing water only on groundwater**	**Combing all three changes**
z-normalized scores					
Baseline	52,148 (100.0)	48,477 (100.0)	38,147 (100.0)	45,553 (100.0)	27,823 (100.0)
FixScore	57,770 (110.8)	49,414 (101.9)	43,602 (114.3)	51,734 (113.6)	29,151 (104.8)
FlexScore	98,259 (188.4)	86,490 (178.4)	74,460 (195.2)	90,416 (198.5)	54,736 (197.7)
Flex	96,421 (184.9)	84,508 (174.3)	72,600 (190.3)	88,851 (195.0)	53,003 (190.5)
z-normalized additional scores (additionality)					
Baseline	1,969 (100.0)	1,827 (100.0)	1,440 (100.0)	1,718 (100.0)	1,044 (100.0)
FixAdd	2,294 (116.5)	1,928 (105.5)	1,762 (122.4)	2,074 (120.7)	1,173 (112.4)
FlexAdd	4,033 (204.8)	3,511 (192.2)	3,050 (211.8)	3,748 (218.2)	2,237 (214.3)
Flex	3,798 (192.9)	3,317 (181.6)	2,873 (199.5)	3,514 (204.5)	2,104 (201.5)
Interval normalized-scores					
Baseline	15,182 (100.0)	14,412 (100.0)	13,197 (100.0)	14,859 (100.0)	12,104 (100.0)
FixScore	16,185 (106.6)	14,470 (100.4)	14,280 (108.2)	16,039 (107.9)	12,421 (102.6)
FlexScore	28,866 (190.1)	26,448 (183.5)	25,927 (196.5)	28,715 (193.2)	23,358 (193.0)
Flex	28,700 (189.0)	26,251 (182.1)	26,002 (197.0)	28,566 (192.2)	23,419 (193.5)
Water-only scenarios	**Initial assumption**	**Basing water only on groundwater**	**Basing water only on slope**		
z-normalized scores for water services only					
Baseline	6,900 (100.0)	331 (100.0)	9,648 (100.0)		
FixWater	9,618 (139.4)	2,312 (698.5)	12,223 (126.7)		
FlexWater	15,931 (230.9)	9,190 (2776.4)	13,909 (144.2)		
Flex	10,952 (158.7)	3,430 (1036.3)	13,020 (135.0)		

Source: Own computations

4.5 Allowing for Natural Forest Regeneration on Pastures

Since 2006, the PSA program also includes payments for the retirement of agriculturally used land for natural forest regrowth. The tool could also help to target these forest regeneration contracts. In this section, forest conservation and natural forest regeneration on pasture land are both eligible activities for PSA program entry. Payment levels are, like in the real PSA program, identical for both activities with US$40/hectare/year of enrolled land. With the possibility to enroll pasture land the number of land properties eligible for program entry increases by 71 (properties with pasture only) from 107 (properties with forest land most of which can now also enroll pasture land) to 178. Like in previous sections the targeted environmental services are (i) hydrological services, (ii) biodiversity services, (iii) carbon services and (iv) scenic beauty services. Environmental service provision of a naturally re-growing forest is likely to be different from an established forest and change over time. Ideally, service provision levels at different stages of forest development should be distinguished. Lacking appropriate data, this simplified approach sets service provision levels in forest conservation and natural forest regeneration as equal. In addition to the environmental services, the social development index (IDS, see section 3.3.1.5 for details) is introduced as an indicator for welfare impacts of payments. In regions with a low social development index the payments would be expected to contribute relatively more to social development than in regions with a high index.

Ideally, a targeting mechanism for a program that explicitly includes land retirement and natural forest re-growth should employ probability estimates for the likelihood of land retirement in the absence of PES, complementary to the deforestation probabilities for forested land. Land retirement is a process that can be observed on areas with decreasing productivity, increasing input prices and/or decreasing product prices. In the presence of land abandonment, the additionality of a PES program then depends on the degrees to which PES avoids deforestation and induces land retirement. Yet, as no estimates for abandonment probabilities were available, the concept of additionality is not considered in this section, neither for forested nor pasture land.

The four environmental services biodiversity (b_i), water (w_i), carbon (c_i) and scenic beauty (l_i) plus the social service (s_i) are combined to a single mean score for pixel i ($\bar{u}_i$):

$$\bar{u}_i = (b_i + w_i + c_i + l_i + s_i)/5 \qquad (16)$$

Weights are equally distributed among services which could be changed if service preferences were available. Like above, scores are numbers without unit.

Opportunity costs are identical for (i) land use change from “pasture” to “natural forest” and (ii) non-realized land use change from ‘natural forest’ to ‘pasture’. In both cases the opportunity cost of forest conservation/regeneration is equal to the foregone income from pasture. Like above, it is assumed that “natural forest” has a commercialization value of zero.

Three different targeting approaches are compared: i. Baseline Scenario (‘Baseline’), ii. Fixed Payment Score (‘FixScore’) and iii. Flexible Payment Score (‘FlexScore’). The approaches are identical with the approaches presented in section 4.2. The budget limit, however, is determined by the site selection of the Baseline approach in this section.

Table 32 presents the most important findings from the three different targeting approaches. In the Baseline approach, 24 sites with an area of 1,737 ha are selected. This is an area twice as large as the forest area which was selected in the Baseline approach in section 4.3. The budget required to pay for these sites is 69,476 US$. This is also the budget limit for the other two targeting approaches. The residual budgets that remain in the FixScore and FlexScore approaches due to the selection procedure of entire sites are relatively small with up to 178.67 US$ (0.26%). Due to the fixed per hectare payment, the total area that could be contracted in the FixScore scenario is almost identical to the area contracted under the Baseline scenario, differing only by the same percentage as total expenditure. Contracted area nearly doubles from the fixed to the flexible payment approaches as average payments decrease to nearly half. Yet, even though the average flexible payment is lower than the fixed payment, the application of score/cost ratios also permits program entry of sites with opportunity costs that go well beyond the fixed payment, and in the presented case, reaches up to 69.49 US$ per hectare and year.

Table 32 Principal Results of the three Targeting Approaches

	Baseline	FixScore	FlexScore
Payment	Fixed	Fixed	Flexible
Budget Limit	No	Yes	Yes
Selection Criteria	Priority Area	Mean Score	Score/Cost Ratio
Total Cost (US$)	69,476.40 (100.0%)	69,429.60 (99.9%)	69,471.26 (99.9%)
No. of Sites	24 (100.0%)	40 (166.7%)	82 (341.7%)
Area (ha)	1,736.9 (100.0%)	1,735.7 (99.9%)	3,417.8 (196.8%)
Mean Site Size (ha)	72.4 (100.0%)	43.4 (60.0%)	41.7 (57.6%)
Score (total)	27,421 (100%)	31,325 (114%)	55,724 (203%)
Score/1000$	395 (100%)	451 (114%)	802 (203%)

The Baseline approach contracts a total score of 27,421. Relative to the Baseline, the FixScore approach increased the total contracted score by 14% and the FlexScore increased it by 103%. Similarly, the efficiencies in score units per 1000 dollar increase from 395 in the Baseline approach to 451 (by 14%) in the FixScore and 802 (by 103%) in the FlexScore approach. Like in the forest site only treatment, the increase in the FlexScore scenario can be attributed to two effects: (i) the effect of more land being contracted due to decreased average payments and (ii) the effect of improved targeting towards land with a high score/cost ratio. The results are very similar to the results presented in section 4.3 showing the tool's stability with increases in scale.

4.6 Transaction Costs of Tool Implementation

Any change of a currently employed targeting approach causes transaction costs – a factor not considered in the above. In the Costa Rican setting, FONAFIFO's transaction costs are limited by law, implying that increasing transaction costs would require savings elsewhere. There are two main sources for incremental transaction costs associated with the suggested targeting approach: (i) Changes in administrative processes; and (ii) the cost of creating and maintaining the targeting tool itself. For (i) two significant changes are identified: First, site coordinates of all applying sites have to be fed into the selection tool. As digitization is already undertaken for all approved sites (755 in 2005) (FONAFIFO 2006), additional costs therefore only occur for rejected sites, an estimated 1510, as there are about three times more applications than actually signed contracts (E. Ortiz, personal communication, 2004). At a labor cost of 50US$/day, the additional costs would be an estimated US$2,400/year. Second, the new targeting approach would change the seasonal workload distribution, because applications can only be fully processed after the site selection was made. Theoretically, this should not impose additional costs, and is thus not specifically considered here[26]. Regarding (ii), tool creation, maintenance, data update and continued data improvement could be realized by a full-time GIS expert with an annual gross salary of approximately US$30,000 and overhead and equipment costs of around US$10,000.[27]

Total additional transaction costs should therefore be less than US$ 42,500/year. For 2006, the program's total budget was US$ 15.22 million including a politically determined administrative budget of US$1.12 million (MINAE 2006). Thus the estimated cost for the presented targeting mechanism would present 0.28% of the total budget and 3.8% of the administrative budget. If it is assumed that actual environmental service payments budgeted for 2006 (US$ 14.1m) reflect a minimum valuation of the services delivered, an efficiency increase of e.g. 14.4% in the FixScore approach would correspond to an increase of services by US$ 2.0m (relative to Baseline efficiency). The cost-effectiveness of using the new tool therefore seems to stand beyond any doubt.

4.7 Summary

It could be shown for the case of Costa Rica's PSA program, exemplified by the Nicoya Peninsula, that a targeting process which integrates spatial data potentially achieves much higher financial efficiency in environmental service provision than a targeting system that is based solely on priority areas. All considered targeting approaches led to higher environmental service efficiency compared to the Baseline approach. Yet, the spatial attributes (benefits, risks and costs) contribute very differently to the efficiency increase: While the integration of environmental service scores led to moderate efficiency increases, the integration of participation costs boosted efficiency, largely due to decreasing average payments and, consequently, increasing total contracted area. The use of deforestation probabilities, on the other hand, barely improved efficiency, as this attribute shows little variation between sites in the study region. The results are stable as assumptions about service distributions change and as the scale in terms of budget and

[26] FONAFIFO used to process all applications at once, but switched to a rolling process which more evenly distributes workloads. It is acknowledged that FONAFIFO might not agree with this view on cost neutrality.

[27] Initial costs of tool creation might be much higher, but this cost could probably be supported by a donor, and so is possibly less of a constraint than the increase in annual operating costs.

land area increases. The tool's estimated running costs were shown to be much below the potential benefits for Costa Rica's PSA program.

5 Practical Alternatives to Estimate Opportunity Costs

The previous chapter showed that flexible payments that are aligned to micro level participation costs (sum of opportunity, protection and transaction costs) contributed most to the efficiency increases of the targeting mechanism. However, cost-effective and precise estimation of individual participation costs is a major challenge. The opportunity cost estimates used in the previous chapter 4 are assumed to be relatively accurate but the information that was necessary to compute them was raised in personal face to face interviews. For real world PES programs this method (Flow approach) is therefore likely to be too costly and it also bears the risk of strategic bias by the interviewee. Ferraro (2008) describes three policies that are used to determine payment levels near the opportunity cost of environmental service provision: (i) gather information on observable landowner attributes that are correlated with opportunity costs, (ii) screening contracts (self-selection mechanisms) and (iii) procurement auctions. In this chapter, two approaches are further examined that fall into group (i): First, opportunity costs (per-hectare-returns) are estimated in section 5.1 with the use of annual land rents (‘Rent’ approach). Second, the estimates from the Flow approach are modeled in section 5.2 using easily observable and difficult to manipulate spatial and socio-economic independent variables (‘Model’ approach). Both the Rent and the Model approach could be less costly alternatives to the Flow approach. The extent to which they are also cost-effective depends largely on how precisely they can estimate opportunity costs. Section 5.3 tests the plausibility of the Flow approach estimates.

5.1 The ‘Rent’ Approach

In the Rent approach, returns were approximated using annual land rents. Since land is not normally rented but owned by the farmers, hypothetical land rents had to be estimated. Land is only occasionally rented in order to balance seasonal shortages of feed supply. Rent is then paid per animal and month and was treated in this study merely as feed supplement.

5.1.1 Methodology

Annual rents were therefore derived from land sale market values which were in turn estimated applying a valuation tool (“Valoración Comparativa”) developed and provided by the Costa Rican Ministry of Finance (Ministerio de Hacienda). The Ministry of Finance applies this valuation technique to determine land taxes, the level of which is based on land value. The technique is based on a comparison of ‘to be estimated land parcels' with 'reference land parcels' within 'homogenous zones'. Homogenous zones are areas within which land parcels with identical characteristics have identical market prices, while between homogenous zones land parcels with identical characteristics normally have differing market prices. The valuation tool is, after all, a linear land value regression model. The ministry obtains market prices for the reference land parcels from field observations. The most reliable type of observation is actual market transactions. The data base is complemented with observations of land sale offers and land value estimates by the National Insurance Institute (Instituto Nacional de Seguros), the Central Bank (Banco Nacional) and other governmental institutions. Depending on the type of observation, adjustments are made to the observed land value. Sale offers, for example, are multiplied with a factor smaller than one to adjust to the expected difference between offered price and actual selling price.

For this study, the ministry kindly provided the required prices for the 'reference land parcels' and the geographically referenced extension of associated 'homogenous zones'. The 178 land properties of the survey sample fell into a total of 24 homogenous zones. Differences in land characteristics increase or decrease the land value. The following land characteristics were solicited during the survey and then fed into the model:

a) Size of the property in hectares.
b) Length of the part of the property that runs along a public road in meters.
c) Slope in percentages.
d) Availability of public services (electricity, telephone, canalization and street lighting) applying dummies.
e) Type and quality of road which gives access to property in 11 categories.
f) A measure of soil use capacity as a classification of land by its agricultural and forestry potential from one (worst) to eight (best).
g) Categories (one to five) representing access and availability of water on property.

The obtained land market values needed to be adjusted for bias and inflation. According to employees of the Finance Ministry and other land value experts of the Center of Tropical Agricultural Research and Higher Education (CATIE) the "Valoración Comparativa" consistently underestimates land values. With the help of these experts it was determined that the estimated land values had to be increased by 20% to compensate for the underestimation. Further, adjustments were necessary as the latest determination of reference properties was made in 1997. This was acknowledged by multiplying each estimated land value with the inflation rates of the years 1998-2004. These were determined to be 11.7% (1998), 10.0% (1999), 11.0% (2000), 11.3% (2001), 9.2% (2002), 9.4% (2003) and 11.5% (2004) (IMF 2006). Eventually, the annual rental value was estimated using the capitalization formula:

[Land Rental Value] = [Land Market Value] x [Capitalization Rate] (17)

The terms are defined as follows: (i) Land Rental Value is the annual fee individuals pay for the exclusive right to use a land site. (ii) Capitalization Rate is a market determined rate of return that attracts individuals to invest in the use of land, considering all the risks and benefits which could be realized. (iii) Land Market Value is the price paid for the land when sold on the market (Gwartney 1999). While the land market value is estimated using the 'Valoración Comparativa', the capitalization rate has to be taken from literature. As no appropriate data could be found for the Peninsula Nicoya, figures for Minnesota, USA, are used instead. Capitalization rates in Minnesota reached a historic maximum of 8.3% in 1975 and a minimum of 5.0% in 1981 (Lazarus 2000). For the Peninsula Nicoya a conservative estimate of 5.0% is used. As we use an identical capitalization rate for all sites, its level will affect absolute but not relative land rental values between sites. The estimated land rental values could later be calibrated using field observations of rental rates. In case any of the assumptions were wrong, the calibration corrects (i) the adjustments that were made to compensate for consistent underestimation of the "Valoración Comparativa", (ii) the adjustments that were made to account for inflation, (iii) the estimated capitalization rate and (iv) the adjustments to obtain breakeven rents as explained below.

Land rental values show a long term correlation to more volatile breakeven rents which are defined as the amount of money that remains from the sale of products minus the cash operating costs, depreciation and the opportunity cost of operator labor and management, i.e. the amount which remains to pay the rent in a particular year (Lazarus 2000). For the land parcels in our sample the breakeven rent is equal to the estimated net returns (and thus the opportunity cost of forest conservation). The breakeven rent's long term average normally lies above the land rental value which means that our estimates for land rental values will have to be corrected upwards. Without calibration the adjustments (i) to (iv) only affect absolute but not relative land rental values between sites.

5.1.2 Comparison of results from Rent and Flow approach

The Rent approach revealed mean values (US$109.26) that are substantially higher than those of the Flow approach (US$55.23) (Table 33). After identification and exclusion of extreme outliers within each approach[28] (indicated with ‘adjusted’ in Table 32), the mean opportunity costs of the Flow (50.49$) and Rent (96.60$) approaches came slightly closer. An analysis of variance (ANOVA[29]) shows the means of the Flow and Rent approaches to be significantly different with and without extreme values. While the Rent approach revealed strictly positive values, several negative values were obtained in the Flow approach.

Table 33 Per hectare returns (in US$) according to Flow and Rent approaches

Estimation Approach	N	Mean	S.D.	Var. (-1)	Min.	Max.	Range
Flow	178	55.23	123.47	15,243.81	-363.31	624.56	987.87
Flow (adjusted)	176	50.49	109.88	12,074.09	-363.31	532.72	896.03
Rent	178	109.26	146.16	21,362.82	13.35	980.26	966.91
Rent (adjusted)	175	96.60	109.60	12,011.98	13.35	562.92	549.57

Adjusted: outliers excluded from the statistic.

Even though the absolute mean per hectare returns differ between approaches, it is possible that the approaches deliver estimates that are correlated, i.e. land plots with relatively high value estimates in one approach also tend to have relatively high estimates in the other approach and vice versa. In case such correlation exists, a bias that causes consistently different estimates could be corrected. However, Table 34 presents the results of a correlation analysis and shows that the Flow and Rent approaches are not significantly correlated. By omitting outliers from the analysis (indicated with ‘adjusted’) the Pearson correlation coefficient only slightly improved while the Spearman correlation coefficient even worsened. Given these results, the Rent approach does not appear to be a potential estimation alternative (based on the assumption that the Flow approach delivers relatively precise estimates). Yet, since the correctness of Flow approach estimates is not ensured, the estimates of the Flow, Rent or both approaches could potentially be incorrect.

[28] Outliers were identified as such if their z-standardized value was larger than 4 or smaller than -4 (Hair et al. 1995).

[29] According to the three tests Tukey, Duncan and LSD Fisher.

Table 34 **Correlation analyses of opportunity cost estimates between approaches**

Variables	**n**	**Pearson**	**Signif.**	**Spearman**	**Signif.**
Flow/Rent	178	-0.04	0.56	-0.05	0.53
Flow/Rent (adjusted)	173	-0.06	0.46	-0.03	0.68

Adjusted: outliers excluded from the statistic.

5.2 The 'Model' Approach

In this approach per-hectare returns from the Flow approach are regressed on independent variables that are easy to elicit and difficult to manipulate (Ferraro 2008, Tattenbach et al. 2006). A similar approach has been used by Moore et al. (2004) to estimate conservation costs in Africa. The variables were either taken directly from the field survey, were determined by overlaying the position of sampled land properties with secondary digital maps e.g. for soil quality, soil type or slope (see descriptive results in chapter 3), or were calculated from these variables if so indicated in Table 35 and Table 36.

5.2.1 Variables and Tests on Normality, Homoscedasticity and Linearity

Table 35 and Table 36 show a list of the explanatory spatial and socio-economic variables available for the model. They were selected on the criteria of being easy to elicit and difficult to manipulate in a real PES program setting. The spatial variables are clearly difficult to manipulate and easy to elicit with the use of digital maps provided that correct geographical coordinates of the land parcel in question are available. Most of the socio-economic variables would also be relatively easy to obtain in a real PES program by making the PES applicant reveal specific personal details in the program application form such as age and number of property owners. Some of the socio-economic variables are, however, easier to manipulate, the risk of which could be reduced by cross checking information, e.g. with personal identification documents.

Endogenous variables were excluded from the list of regressors by testing logical endogeneity for correlations. If these were not significant, the variables were maintained. For example, 'Off-FarmWork' could, theoretically, be explained in part with 'Area' because smaller farms require less labor and earn less income and therefore make 'Off-FarmWork' more likely and necessary. But since the two variables were not significantly correlated they were both maintained. The same is true for 'ProductionFocus' which could depend on 'Capacity' because the soil use capacity theoretically explains a focus on beef or dairy production. As no significant correlation could be detected also these two variables were maintained. If the correlation was significant, as for example between ‘Family Labor’ and ‘Household Size’, the variable which was thought to be endogenous, in this case ‘Family Labor’, was deleted from the list of regressors.

Table 35 List of easily obtainable spatial variables

Variable	**Meaning**	**Type**	**Sign**
DistAuction	Distance in meters to nearest cattle auction center. Distance measured “as the crow flies”. Longer distance is expected to decrease per-hectare-returns because of higher transport costs or increased use of intermediaries.	Metric	(-)
DistCommerce	Distance in meters to nearest commercial center. Distance measured “as the crow flies”. Longer distance is expected to decrease per-hectare-returns because of higher transport costs and less access to spare parts and repairs.	Metric	(-)
Slope	Average slope of land in %. Steeper slopes are expected to decrease per-hectare-returns.	Metric	(-)
Precipitation	Precipitation in mm per year. Higher rainfall is expected to increase per-hectare-returns.	Metric	(+)
SocialIndex	Average index for level of social development of a region ranging from 0 to 100. Advanced social development (higher index) is expected to increase per-hectare-returns.	Metric	(+)
DryMonths	Average number of annual dry months. Higher number of dry months is expected to decrease per-hectare-returns.	metric	(-)
Altitude	Altitude in meters above sea level. Higher elevation is expected to increase per-hectare-returns because of more moderate temperatures.	metric	(+)
Area	Size of property in hectares. Large properties are expected to have higher per-hectare-returns because of economies of scale.	metric	(+)
Life zone	Holdridge life zone on property. Seven categories. Bh-P6 (humid premontane forest in transition to basal) is used as reference category and assumed to be the most favorable life zone for agricultural production. All other life zones are expected to decrease per-hectare-returns as they offer either too humid, too dry or too hot conditions: Bh-T (Humid Tropical Forest), Bh-T10 (Humid Tropical Forest in transition to dry), Bh-T2 (Humid Tropical Forest in transition to perhumid), Bmh-P (Very humid premontane tropical forest), Bmh-P6 (Very humid premontane forest in transition to basal), Bs-T (Tropical Dry Forest), Bs-T2 (Tropical Dry Forest in transition to humid).	categorical	(-)
Soil	Soil type. 13 categories. Ah-e (Alfisols, very steep slope) is reference category. All other categories expected to increase per-hectare-returns because soil type and/or slope are more	categorical	(+)

	favorable for production. Other soil types are Ah-fo (Alfisols, steep slope), Ah-mo (Alfisols, moderate slope), Ah-so (Alfisols, light slope), Ah-p (Alfisols, flat), Eu-e (Entisols, very steep slope), Id-so (Inceptisols, Dystropept, light slope), It-p (Inceptisols, Tropaquept, flat), Iw-p (Inceptisols, Ustropept, flat), Iw-so (Inceptisols, Ustropept, light slope), Mt-p (Mollisols, flat), Vi-p (Vertisols, Pelludert, flat), Vm-p (Vertisols, Pellustert, flat)		
Road	Type and quality of road leading to property. Categories from 1 to 5 with decreasing quality. Reference category is Type 1. Types 2-5 are expected to decrease per hectare returns because of increased transport costs.	categorical	(-)
Canton	Canton to which land parcel belongs to (canton is an administrative unit in the order, from small to large: (i) municipality, (ii) district, (iii) canton, (iv) province. Six categories. Canton Carrillo is reference category. All other cantons of the study area (Hojancha, Nandayure, Nicoya, Puntarenas, Santa Cruz) are expected to decrease per-hectare-returns. This is because all observations in Carillo lie on good and even soils with favorable production conditions and high per-hectare-returns.	categorical	(-)
Well	Existence of wells on property. 1=yes, 0=no.	binomial	(+)

Table 36 Socio-Economic Variables

Variable	**Meaning**	**Type**	**Sign**
PriceIndex	Index for product prices in %. Built from various individual prices collected in the field survey. The population's average is 100%. Higher prices (i.e. higher index values) are expected to increase per-hectare-returns.	Metric	(+)
FactorIndex	Index for factor costs in %. Built from various individual factor costs collected in the field survey. The population's average is 100%. Higher factor prices (i.e. higher index values) are expected to decrease per-hectare-returns.	Metric	(-)
NumberLandlords	Number of property owners. It is expected that a higher number of owners decreases per-hectare-returns because management decisions are more difficult to take.	count	(-)
HouseholdSize	Number of household members. A high number of household members is expected to increase per-hectare-returns because of availability of labor.	count	(+)
Off-FarmWork	Dedication to farm activities only (1) or also to off-farm activities (0). It is expected that off-farm activities	binomial	(+)

	contribute to income and thus increase per-hectare-returns as farm investments may be made possible.		
Accessibility	All year accessibility of property with 4x2 automobile. 1=yes, 0=no. All year accessibility is expected to increase per-hectare-returns because it reflects good road conditions and lower transport costs.	binomial	(+)
ProductionFocus	Main production focus: 1=principally milk, 2=principally meat, 3=milk and meat. Category 2 is used as a reference dummy. Both categories 1 and 3 are expected to be associated with higher per-hectare returns.	binomial	(+)
EducationalLevel	Educational level of farm owner. Eight categories from 'never went to school (0)' to 'University degree (8). Reference Dummy is category 1. Higher educational levels are expected to improve farm management capabilities and therefore per-hectare-returns. Signs for categories 2-8 are therefore expected to bear a positive, category 0 is expected to bear a negative sign.	categorical	(-) (+)
Age	Age of landowner in years. Per-hectare returns are expected to decrease with age.	metric	(-)
Capital	The amount of capital ($/ha/year) that was put into production on pasture land. Higher capital amounts are expected to increase per-hectare-returns.	metric	(+)

To see whether the variables fulfilled the assumptions of normal distribution, homoscedasticity and linearity each variable underwent appropriate tests. Normality was tested applying a QQ-plot to the metric variables, where the R as a measure of normal distribution has to be larger than 0.94 to be considered normally distributed. Variables with R smaller than 0.94 and/or with a distribution that appeared to be skewed or irregular were transformed taking a log, square root or inverse, in Table 37 indicated by column 'Action taken'. If the transformation did not raise the R above 0.94 the variables were omitted, although two exceptions were made for variables that turned out to be rather categorical than metric, namely 'Precipitation' and 'DryMonths' (Table 37). As the assumption of normality applies less strictly to categorical variables they were not omitted. The variables 'Altitude' and 'NumberLandlords', however, were excluded from further analysis.

Table 37 Testing Variables for Normal Distribution

Variable (category)	Observation	R_a	Action taken	R_p	Maintained
Per-hectareReturns	Appears normal	0.917	Omit 2 outliers	0.941	Yes
PriceIndex	Slight left skew	0.939	Log-Transformation	0.987	Yes
FactorIndex	Irregular	0.956	Root-Transformation	0.965	Yes
DistAuction	Left Skew	0.939	Log-Transformation	0.995	Yes
DistCommerce	Left Skew	0.963	Root-Transformation	0.997	Yes
Slope	Irregular	0.954	None	n.a.	Yes
Precipitation	Categorical	0.913	None[1]	n.a.	Yes
SocialIndex	Normal	0.942	None	n.a.	Yes
DryMonths	Categorical	0.828	None[1]	n.a.	Yes
Altitude	Left Skew	0.793	Log-Transformation	0.798	No
NumberLandlords	Left Skew	0.805	Log-Transformation	0.855	No
Area	Left Skew	0.425	Log-Transformation	0.986	Yes
HouseholdSize	Irregular	0.972	None	n.a.	Yes
Capital	Left Skew	0.364	Log-Transformation	0.993	Yes

[1]No transformation was applied as variable appeared to be categorical and variable was accepted for analysis without satisfying normality assumption. R_a=R before transformation. R_p=R after transformation.

Homoscedasticity was tested using an F-test for equal variance. Variables or categories which showed to be heteroscedastic were excluded from further analysis (Table 38). Finally, all metric variables or their transformations were tested for linearity. This was done using simple regressions with “Per-hectareReturns” as the dependent variable. The standardized residuals were plotted against the predicted values and where no pattern could be identified the variable was classified to be linear. This was the case for all tested variables.

Table 38 Testing variables for homoscedasticity

Variable	Observation	Action taken	Maintained
Lifezone	Partially Heteroscedastic	Exclusion of category Bmh-P6	Yes
Soil	Partially Heteroscedastic	Exclusion of categories Eu-e and Id-so	Yes
Road	Partially Heteroscedastic	Exclusion of category 5	Yes
Off-FarmWork	Heteroscedastic	Exclusion	No
Canton	Partially Heteroscedastic	Exclusion of category Nicoya	Yes
Well	Homoscedastic	None	Yes
Accessibility	Heteroscedastic	Exclusion	No
ProductionFocus	Homoscedastic	None	Yes
EducationalLevel	Partially Heteroscedastic	Exclusion of category 3	Yes

5.2.2 The Models

This section analyses the potential of linear regression models to estimate per hectare returns with the variables presented in the previous section. Three different models are constructed:

(i) The 'AllVariable' model with all the variables which were presented in Table 35 and Table 36 as long as they fulfill the assumptions of normality, homoscedasticity and linearity.

(ii) The 'ManualSelection' model with a manual selection of the variables used in the AllVariable model.

(iii) The 'AutoSelection' model with an automatic selection of the variables used in the AllVariable model applying a backward elimination technique.

Table 39 presents the AllVariable model. Because of the high number of variables the difference between the R^2 (0.34) and the adjusted R^2 (0.15) is large. This model has only six significant variables: 'DryMonths',_'LifeZone(bh-T2)', 'Soil(Ah-fo)', 'Soil(Ah-so)', 'ProductionFocus' and 'EducationalLevel(0)'. The estimators of four of these carry signs as expected in Table 35 and Table 36. The coefficient for 'DryMonths' and 'EducationalLevel(0)' do not carry the expected signs. 'DryMonths' has a positive sign and increasing number of dry months therefore is associated with increasing per-hectare returns. Even though this relation would make sense for other parts of Costa Rica where an excess of rain may cause production problems, it is surprising to find this result on the Nicoya Peninsula where the number of dry months is relatively high (mean: 4.6). Therefore no immediate logical explanation for this finding can be offered. For 'EducationalLevel(0)' a negative sign was expected since no formal education at all is generally associated with an lower economic performance. In the field survey, however, there happened to be ‘EducationalLevel(0)’ landowners (n=10) with per-hectare returns (mean 78.58$) higher than those of the ‘EducationalLevel(1)’ landowners (n=72) who had a mean of 36.63$.

Table 39 **Model 1 (AllVariable)**

Dependent Variable	**N**	**R^2**	**R^2 Adj.**	
Per-hectare-returns	176	0.34	0.15	
Independent Variables	**Estimator**	**S.E.**	**T**	**p**
Constant	-1262.96	632.34	-2.00	*0.048
LOG_PriceIndex	22.02	77.33	0.29	0.776
ROOT_FactorIndex	-10.67	7.66	-1.39	0.166
LOG_DistAuction	67.55	71.01	0.95	0.343
ROOT_DistCommerce	-0.11	0.36	-0.30	0.766
Slope	11.27	10.05	1.12	0.264
Precipitation	0.03	0.04	0.86	0.393
SocialIndex	9.34	8.96	1.04	0.299
DryMonths	96.77	44.33	2.18	*0.031
LOG_Area	24.27	18.88	1.29	0.201
HouseholdSize	-6.12	5.78	-1.06	0.291
LOG_Capital	33.19	16.93	1.96	0.052
LifeZone (bh-T)	44.58	43.69	1.02	0.309
LifeZone (bh-T10)	14.43	30.13	0.48	0.633
LifeZone (bh-T2)	-200.00	79.24	-2.52	*0.013
LifeZone (bmh-P)	80.62	54.95	1.47	0.145
LifeZone (bs-T2)	-3.44	45.57	-0.08	0.940
Soil (Ah-fo)	69.09	33.36	2.07	*0.040
Soil (Ah-mo)	45.52	35.39	1.29	0.201
Soil (Ah-p)	-32.78	113.36	-0.29	0.773
Soil (Ah-so)	109.65	43.31	2.53	*0.012
Soil (It-p)	170.65	115.08	1.48	0.140
Soil (Iw-p)	26.67	32.43	0.82	0.412

Soil (Iw-so)	74.89	50.29	1.49	0.139
Soil (Mt-p)	56.68	49.23	1.15	0.252
Soil (Vi-p)	-12.53	112.32	-0.11	0.911
Soil (Vm-p)	21.50	32.10	0.67	0.504
Road (2)	-33.56	27.45	-1.22	0.224
Road (3)	6.72	30.45	0.22	0.826
Road (4)	0.54	35.76	0.02	0.988
Canton (Hojancha)	-148.14	85.02	-1.74	0.084
Canton (Nandayure)	-101.13	63.48	-1.59	0.113
Canton (Puntarenas)	-114.32	79.15	-1.44	0.151
Canton (Santa Cruz)	-46.99	45.58	-1.03	0.304
Wells	-13.93	19.95	-0.70	0.486
ProductionFocus	59.89	21.51	2.78	*0.006
EducationalLevel (0)	85.96	39.21	2.19	*0.030
EducationalLevel (2)	27.81	19.19	1.45	0.150
EducationalLevel (8)	1.96	34.80	0.06	0.955

Finding so few variables to be significant in the AllVariable model raises the question whether simple significant relations between the dependent and explanatory variables become suppressed due to correlations between the explanatory variables. To shed some light on this it was analyzed whether significant simple relations do exist between the dependent and independent variables. Table 40 presents the results of simple correlations between the independent variables and ‘Per-hectare-returns’. There are only five significant simple correlations, one less than significant variables in the AllVariable model. Consequently, the low number of significant variables in the AllVariable model is not caused by intercorrelation, but rather there do not exist significant relations between the explanatory variables and per-hectare-returns in the first place. Three variables are significant in both the AllVariable model and simple correlation, namely ‘DryMonths’, ‘LifeZone(bh-T2)’ and ‘ProductionFocus’, each in both cases with the same sign. The two variables ‘PriceIndex’ and ‘CantonHojancha’ are significant in the simple correlations (and carry expected signs) but not in the AllVariable model, possibly because intercorrelations suppress their significance in the model. The three variables Soil(Ah-fo), Soil(Ah-so) and Education(0) which are not significant in simple correlations attain significant roles in the AllVariable model, possibly because of mediator effects.

Table 40 Individual correlations of independent variables with per-hectare-returns

Variable	Spearman	p	Pearson	p
Per-hectare-returns	1.00	n.a.	1.00	n.a.
LOG_PriceIndex	0.15	*0.05	0.03	0.74
ROOT_FaktorIndex	-0.06	0.43	-0.11	0.14
LOG_DistAuction	0.34	0.07	-0.02	0.82
ROOT_DistCommerce	-0.00	0.77	-0.05	0.49
Slope	-0.00	0.98	0.02	0.78
Precipitation	-0.10	0.20	-0.13	0.08
SocialIndex	-0.15	0.05	-0.14	0.07
DryMonths	0.10	0.17	0.16	*0.04
LOG_Area	0.08	0.29	0.04	0.62
HouseholdSize	0.01	0.95	-0.01	0.85
LOG_Capital	-0.01	0.90	0.05	0.50
LifeZone (bh-T)	-0.09	0.26	-0.08	0.31
LifeZone (bh-T10)	0.06	0.43	0.06	0.43
LifeZone (bh-T2)	-0.20	*0.01	-0.30	*0.00
LifeZone (bmh-P)	0.06	0.40	0.05	0.49
LifeZone (bs-T2)	-0.01	0.85	0.03	0.72
Soil (Ah-fo)	0.12	0.12	0.08	0.28
Soil (Ah-mo)	-0.14	0.06	-0.13	0.08
Soil (Ah-p)	-0.08	0.30	-0.05	0.55
Soil (Ah-so)	0.05	0.49	0.07	0.37
Soil (It-p)	0.12	0.12	0.14	0.07
Soil (Iw-p)	-0.03	0.71	-0.00	0.98
Soil (Iw-so)	0.10	0.20	0.06	0.47
Soil (Mt-p)	0.04	0.56	0.05	0.50
Soil (Vi-p)	-0.04	0.56	-0.03	0.72
Soil (Vm-p)	-0.01	0.95	0.01	0.92
Road (2)	-0.10	0.18	-0.10	0.19

Road (3)	0.04	0.60	0.05	0.53
Road (4)	0.10	0.18	0.07	0.37
Canton (Hojancha)	-0.15	*0.05	-0.12	0.11
Canton (Nandanyure)	0.06	0.47	0.04	0.63
Canton (Puntarenas)	-0.06	0.40	-0.11	0.15
Canton (Santa Cruz)	-0.02	0.83	0.02	0.79
Wells	0.09	0.25	0.09	0.22
ProductionFocus	0.24	*0.00	0.23	*0.00
EducationalLevel (0)	0.03	0.67	0.06	0.41
EducationalLevel (2)	0.13	0.09	0.11	0.15
EducationalLevel (8)	0.05	0.54	0.08	0.32

In an attempt to simplify the model, all variables that test significant in the simple correlations are used in the ‘ManualSelection’ model (Table 41). Also, instead of manually selecting and omitting variables from the model, an automated backward elimination process is applied in the ‘AutoSelection’ model (Table 42). In the ManualSelection model (Table 41) only two of the five variables that were used for the model are significant, namely ‘LifeZone(bh-T2)’ and ‘ProductionFocus’. They carry the same signs as in the simple correlations and the AllVariable model. Maintaining their significance in both the AllVariable and ManualSelection model these two variables appear to be relatively stable. The adjusted R-square of the ManualSelection model is 13% and thus only 2% lower than the R-square of the AllVariable model.

Table 41 Model 2 (ManualSelection)

Dependent Variable	**N**	**R^2**	**R^2 Adj.**	
RentabilS	176	0.15	0.13	
Independent Variable	**Estimator**	**S.E.**	**T**	**p**
Constant	-247.795	177.389	-1.397	0.164
LOG_PriceIndex	61.468	70.093	0.877	0.382
LifeZone (bh-T2)	-234.004	60.914	-3.842	*<0.001
Canton (Hojancha)	-36.194	28.363	-1.276	0.204
ProductionFocus	53.754	18.878	2.847	*0.005
DryMonths	13.920	16.847	0.826	0.410

The AutoSelection model (Table 42) contains seven variables (categories) of which four significantly contribute to explaining the dependent's variable variance. The four significant variables are LifeZone(bh-T2), Canton(Hojancha), ProductionFocus and EducationalLevel(0). The two variables LifeZone(bh-T2) and ProductionFocus stick out because they showed to be significant in the simple correlations and all three presented models. The only additional variable that was tested significant in the simple correlation and is also significant in the AutoSelection model is Canton(Hojancha). It bears, as expected, a negative sign. EducationalLevel(0) reappears in the AutoSelection model as a significant variable after having been significant already in the AllVariable model. If the p-values were rounded to the second digit EducationalLevel(2) would also count as a significant variable bearing, as expected, a positive sign. With the exception of EducationalLevel(0) all remaining significant variables also bear signs as expected. The adjusted R-square of the AutoSelection model is 14% and thus only 1% above the ManualSelection model and only 1% below the AllVariable model.

Table 42 Model 3 (AutoSelection)

Dependent Variable	**N**	**R^2**	**R^2 Adj.**	
Per-HectareReturns	176	0.18	0.14	
Independent Variable	**Estimator**	**S.E.**	**T**	**p**
Constant	-8.36	25.84	-0.32	0.747
LOG_Capital	25.29	14.68	1.72	0.087
LifeZone (bh-T2)	-272.48	59.97	-4.54	*<0.001
Soil (It-p)	180.58	101.82	1.77	0.078
Canton (Hojancha)	-74.30	27.82	-2.67	*0.008
ProductionFocus	49.81	18.31	2.72	*0.007
EducationalLevel (0)	82.90	34.06	2.43	*0.016
EducationalLevel (2)	33.19	16.92	1.96	0.051

Yet, although the number of variables could be reduced substantially in the latter two models (ManualSelection and AutoSelection), the R-square in all models was too low (13% to 15%) to sufficiently estimate per hectare returns for the implementation of cost-aligned (flexible) payments in a real world PES program.

5.3 Testing Plausibility of Data

The poor results of the Rent and Model approaches to determine opportunity costs give reason to question the quality of the opportunity cost estimates from the Flow approach. In this section various plausibility tests are conducted. The Perception approach was already briefly mentioned in section 3.2.2.2. As a control for the plausibility of the results from the Flow approach interviewees were asked to give a direct estimate of their perceived per-hectare-returns on pastureland. Here, in section 5.3.1, the results of the two approaches are compared in detail. The plausibility of data will also be tested by submitting input and output quantities that were used to calculate the Flow approach estimates to production functions (5.3.2).

5.3.1 Comparing Estimates from the Flow and Perception Approaches

The principal results of the Flow and Perception approaches were already presented in section 3.2.2.2 and for ease of comparison are again presented in Table 43. In terms of mean opportunity costs, the Flow approach reveals a smaller value (55.23$) than the Perception approach (84.11$). The results of an analysis of variance (ANOVA[30]) show the means of the Flow and Perception approach to be not significantly different. After the identification and exclusion of extreme outliers within each approach[31] (indicated with ‘adjusted’ in Table 43) the mean opportunity costs of the Flow (50.49$) and Perception (66.65$) approaches come closer together and the analysis of variance (ANOVA) confirms the means to remain not significantly different.

Table 43 Opportunity Costs (in US$) according to different approaches

Approach	N	Mean	S.D.	Var. (-1)	Min.	Max.	Range
Flow	178	55.23	123.47	15,243.81	-363.31	624.56	987.87
Flow (adjusted)	176	50.49	109.88	12,074.09	-363.31	532.72	896.03
Perception	120	84.11	161.28	26,011.00	0.00	1,428.57	1,428.57
Perception (adjusted)	118	66.65	79.49	6,318.45	0.00	400.00	400.00

Adjusted: outliers excluded from the statistic.

Not significantly different absolute mean opportunity costs do not necessarily mean that the approaches are also consistent in their relative estimates, i.e. land plots with relatively high opportunity cost estimates

[30] According to the three tests Tukey, Duncan and LSD Fisher.

[31] Estimates were identified as outliers if their z-standardized value was larger than 4 or smaller than -4.

in one approach also tend to have relatively high estimates in the other approach and vice versa. Table 44 shows the results of a correlation analysis and suggests that the opportunity cost estimates of the Flow and Perception approaches are significantly correlated. By omitting outliers from the analysis (indicated in Table 44 with ‘adjusted’) the Pearson correlation coefficient could be increased from 0.27 to 0.44 (which corresponds to an R^2 of 0.07 and 0.19, respectively) and the Spearman correlation coefficient could also be slightly increased from 0.50 to 0.53 (corresponding to an R^2 of 0.25 and 0.28, respectively). The results suggest that the estimates from the Flow approach are plausible, i.e. the land holders perceive their per hectare returns to be similar to the estimated per hectare returns.

Table 44 Correlation analyses of opportunity cost estimates between approaches

Variables	n	Pearson	Signif.	Spearman	Signif.
Flow/Perception	120	0.27	*0.003	0.50	*<0.001
Flow/Perception (adj.)	116	0.44	*<0.001	0.53	*<0.001

Adj.: outliers excluded from the statistic.

5.3.2 Production Functions

Instead of looking directly at the plausibility of per hectare return estimates, production functions are used here to examine the relation between the input (x_i) and output (y) data (Fuss et al. 1978) of the production process. A significant positive relation would mean the input and output quantities that were determined as part of the field survey, are plausible. Table 45 presents the output variable (y) and the input variables (x_i) that were used in the production functions.

Table 45 List of variables and the expected relation (sign) of input to output variable

Output variable	Description	type	sign
TotalSales	Total annual sales in $.	metric	
Input variables			
Labor	Total labor in hours per year	metric	(+)
CircCapital	Total annual value of circulating capital in $	metric	(+)
Area	Land area in hectares	metric	(+)
Herd	Herd size in head of cattle	count	(+)

In a first step, a simple correlation matrix helps to give an overview of how the variables are related to each other. In Table 46 it can clearly be seen that all four input variables are significantly correlated to the output variable ‘TotalSales’. However, it can also be seen that nearly all input variables are significantly correlated with each other, with ‘Area’ and ‘Labor’ being the only exception. Therefore it is likely that some of these variables become suppressed in a multiple regression.

Table 46 Correlation Matrix of Input and Output Variables

		TotalSales	**Labor**	**CircCapital**	**Area**	**Herd**
TotalSales	Pearson Coeff.	1	0.179	0.845	0.880	0.908
	Signif. (both sides)		*0.017	*<0.001	*<0.001	*<0.001
	N	178	178	178	178	178
Labor	Pearson Coeff.	0.179	1	0.183	0.134	0.165
	Signif. (both sides)	*0.017		*0.015	0.074	*0.028
	N	178	178	178	178	178
CircCapital	Pearson Coeff.	0.845	0.183	1	0.931	0.908
	Signif. (both sides)	*<0.001	*0.015		*<0.001	*<0.001
	N	178	178	178	178	178
Area	Pearson Coeff.	0.880	0.134	0.931	1	0.968
	Signif. (both sides)	*<0.001	0.074	*<0.001		*<0.001
	N	178	178	178	178	178
Herd	Pearson Coeff.	0.908	0.165	0.908	*0.968	1
	Signif. (both sides)	*<0.001	*0.028	*<0.001	<0.001	
	n	178	178	178	178	178

In the next step the data are used in a Cobb-Douglas production function. The Cobb-Douglas production function has the following functional form (Fuss et al. 1978):

$$\text{Log } y = a_0 + \sum_{i=1}^{n} a_i \log x_i \tag{18}$$

where y is the output, x_i is the i^{th} input and a_0 and a_i are the coefficients that are to be estimated. Due to highly significant correlations between the logs of ‘Labor’ and ‘Area’ (Pearson Coeff.=32,9; p=<0.001) as well as the logs of ‘Labor’ and ‘Herd’ (Pearson Coeff.=45.7; p=<0.001), ‘Labor’ turns out to be an insignificant variable in the multiple Cobb-Douglas production model (Table 47).The Cobb-Douglas production function as presented in Table 47 shows that total sales significantly increase, as expected (Table 45), with the amount of inputs, land area and number of animals. The model has a high adjusted R-square of 59.3%.

Table 47 Cobb-Douglas Production Function

Dependent Variable	**N**	**R^2**	**R^2 (adj.)**	
TotalSales	155	60.3	59.3	
Coeff.	**Est.**	**S.E.**	**T**	**p**
Constant	4.824	0.646	7.463	*<0.000
Labor	-0.105	0.094	-1.121	0.264
Circulating Capital	0.145	0.071	2.034	*0.044
Area	0.208	0.088	2.377	*0.019
Herd	0.685	0.107	6.377	*<0.000

To confirm these results the data are also applied to a quadratic production function by Lau (1974, in: Fuss et al. 1978) which is a more flexible form than the Cobb-Douglas production function. As such it is expected that it enables an even better fit to the data providing a higher R^2 than the Cobb-Douglas production function. The quadratic production function has the following functional form (Fuss et al. 1978):

$$y = a_0 + \sum_{i=1}^{n} a_i x_i + \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} x_i x_j \qquad (19)$$

All variables and cross products are expected to have positive signs. The quadratic production function as presented in Table 48 shows total sales to significantly increase, as expected, with ‘circulating capital’ and the cross products ‘CirculatingCapital*Labor’ as well as ‘Area*Herd’. The cross product ’CirculatingCapital*Area’ has, unexpectedly, a negative estimator. The R-square is exceptionally high and shows the model to explain 96.6% of the variance of total sales. As expected, the flexible form of the quadratic production function provided a better fit than that of the Cobb-Douglas production function. It can be concluded that the elicited data on input and output quantities is plausible and gives no reason of concern.

Table 48 Quadratic Production Function

Dependent Variable	**N**	**R^2**	**R^2 (adj.)**	
Total Sales	176	96.8	96.6	
Coeff.	**Est.**	**S.E.**	**T**	**p**
Constant	184.229	450.984	0.409	0.683
Labor	-0.148	0.170	-0.869	0.386
CirculatingCapital	0.980	0.083	11.746	*<0.001
Area	6.827	7.612	0.897	0.371
Herd	23.481	14.402	1.630	0.105
CirculatingCapital*Labor	0.000	0.000	3.619	*<0.001
CirculatingCapital*Area	-0.004	0.001	-3.462	*0.001
CirculatingCapital*Herd	0.001	0.002	0.731	0.466
Labor*Area	0.000	0.002	0.160	0.873
Labor*Herd	0.000	0.003	0.160	0.873
Ha*Herd	0.123	0.045	2.741	*0.007

5.4 Summary

Payment differentiation might encounter several obstacles such as the identification of a reliable, sufficiently precise and cost-effective method to determine micro level participation costs. Two approaches to estimate opportunity costs of conservation were tested in this chapter: The ‘Rent’ approach which derives opportunity costs from annual land rents, and the ‘Model’ approach which regresses opportunity costs on easily obtainable and difficult to manipulate spatial and socio-economic independent variables such as soil quality. None of these approaches appeared to estimate opportunity costs sufficiently well. But since this judgment is based on how well the estimates compare to the Flow approach estimates (in the case of the Rent approach), or how well the independent variables model the Flow approach estimates (in the case of the Model approach), it is possible that the Rent and Model approaches did not perform well because of flaws in the Flow approach estimates. Therefore, the plausibility of the Flow approach estimates was tested by (i) comparing them to the per hectare returns as they were perceived by the land holders and (ii) using input and output quantities from the survey (on which the Flow approach estimates are based) in production functions. The tests confirmed the plausibility of data.

6 Determinants of PES Adoption

This chapter examines the influence of participation costs and other variables on the adoption of PES. The chapter is divided into five sections and sets out with a conceptual framework in section 6.1 which is followed by an overview on adoption theory in section 6.2. It then describes the methodology and the explanatory variables that are examined in section 6.3 and presents the results in section 6.4. The chapter concludes with a summary in section 6.5.

6.1 Conceptual Framework

For the targeting approach in chapter 4 it was assumed that landowners are always willing to enroll land in PES if the per hectare payment ($C_{payment}$) exceeds their participation cost (C_i), i.e. the sum of their per hectare opportunity (C_{opp}), conservation (C_c) and transaction costs (C_t). The costs were computed from monetary flows in the past. In this chapter I relax the assumption that participation costs as they were calculated in previous chapters fully represent all relevant costs. Rather, a land holder's decision is likely to be based on expected future net returns B_{exp} (i.e. opportunity costs of forest conservation) which depend on returns in the past (C_{opp}), perceived risk and risk behaviour (R) and the ability to access and process information (I). Also, it is possible that non-monetary costs and benefits (N) influence the land holder's decision. For example, professional pride or tradition may increase the perceived personal cost of land retirement. The sum of monetary and non-monetary values can be expressed in utilities. The utility of the agricultural land use option (U_a) could then be expressed in:

$$U_a = U_a (B_{exp}, N_a) \qquad (20)$$

where B_{exp} is a function of past returns (C_{opp}), risk perceptions and behavior (R) and information (I):

$$B_{exp} = B_{exp}(C_{opp}, R, I) \qquad (21)$$

and N_a are the non-monetary costs and benefits of the agricultural land use option. Synonymously, forest conservation through PES enrollment has a utility (U_c) which depends on the expected net payment (P_{exp}) and non-monetary values of forest conservation (N_c):

$$U_c = U_c (P_{exp},N_c) \qquad (22)$$

where P_{exp} is a function of the offered payment ($C_{payment}$), expected transaction and protection costs (C_{t+p}), perceived risk and risk behavior (R) as well as the ability to access and process information (I):

$$P_{exp} = P_{exp}(C_{payment}, C_{t+p}, R, I) \quad (23)$$

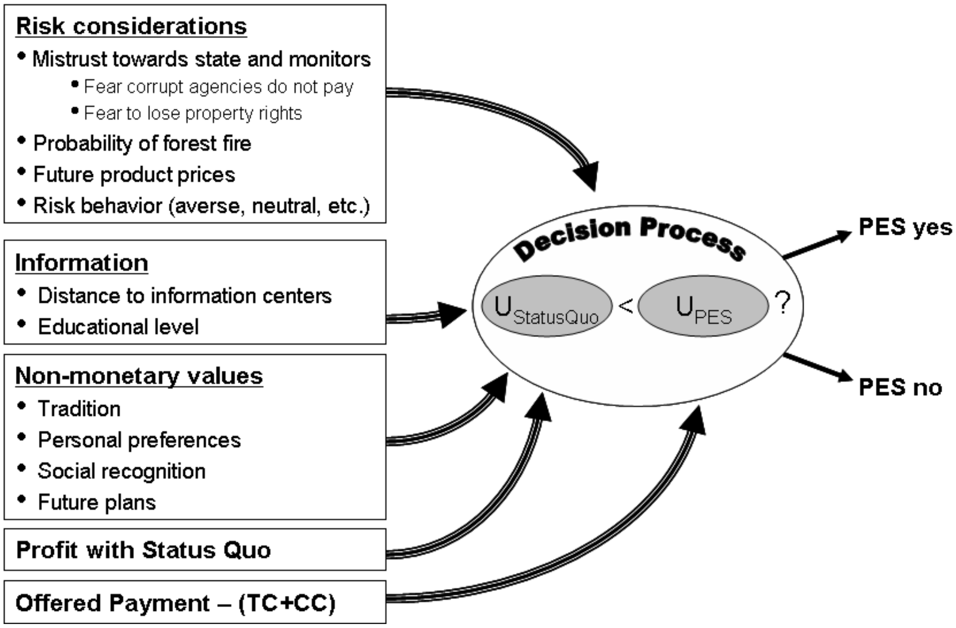
Mistrust towards state-run programs may, for example, increase the perceived risk that the payment ($C_{payment}$) will not be made. The non-monetary benefit from PES participation (N_c) can, for example, be higher if a land holder has a general sympathy towards nature conservation. The decision to enroll land in the PES program would then not depend on a comparison of $C_{payment}$ and C_i as in equation 5 but rather on the utilities U_a and U_c:

$$\gamma_i = 1 \quad \text{if} \quad U_a < U_c\,; \qquad \gamma_i = 0 \text{ otherwise} \quad (24)$$

where $\gamma_i \in \{0,1\}$ is an indicator variable reflecting participation.

While it is difficult to monetarily value risk considerations, information and personal preferences, it is attempted here to study variables that are known or expected to have an influence on these criteria and thus on the landholder's enrolment decision. For example, the perceived risk from implementing a new technology or land use, here the production of environmental services through PES, has been shown to increase with age. The access to information may depend on the distance to commercial centers and on-farm infrastructure; and the ability to interpret and utilize such information can depend on the educational level. The objective is to analyze whether factors other than monetary flows in the past influence enrolment decisions given a flat per hectare payment (Figure 1). These factors have been known and analyzed for many years in so called "adoption" studies for newly developed agricultural technologies (e.g. Albrecht 1969, Mössner 1958, Wilkening 1953, Rogers 1958, Byerlee and Hesse de Polanco 1986, von Platen 1985, Gabersek 1990, Van den Ban 1970, Brandner and Kearl 1964, Hoffer and Stangland 1958, Lionberger 1962). Instead of calculating U_a and U_c to determine γ_i, adoption studies seek to explain the adoption (γ_i = 1) of a new technology (here production of ES) with explanatory variables that also influence the values of U_a and U_c. In the adoption analysis presented here, participation cost is one of the variables that are examined in a descriptive and econometric analysis, together with a number of other variables which are believed to proxy participation costs, risk considerations, information and individual preferences. The chapter continues with an overview on adoption theory (6.2), then lays out the methodology used for the analysis (6.3), subsequently presents and discusses the results (6.4) and concludes with final comments in section (6.5).

Figure 1 Conceptual Framework of Adoption Analysis



Source: Own

6.2 Adoption Theory

In agri-sociological literature adoption is described as the taking-over of an innovation by an individual or another “taking-over unit”. Adoption is characterized as a mental process through which an individual has to go from first realization of an innovation to its eventual take-over (Albrecht 1969). Adoption research has its origin in the North American extension service, which wanted to evaluate the success of its work by the rate of adoption of recommended innovations (Mössner 1958).

There are a number of different concepts and models describing the adoption process. Wilkening (1953) developed an adoption model for agro-sociological studies based on the information behavior of the individual. According to this concept the individual goes through five phases before the final decision of adoption is taken:

- “Awareness Stage”: The individual becomes aware of the existence of an innovation but has no details about it and no interest to gather information about it.

- “Interest Stage”: The individual develops an interest and gathers more information.

- “Evaluation Stage”: Advantages and disadvantages are considered.

- “Trial Stage”: The innovation is tested in small trials.

- “Adoption Stage”: The innovation comes to permanent effect with all consequences.

Wilkening’s model was criticized, among other criticism, because the model considers the farmer to act purely rational whereas irrational behavior can also be observed. Because of this criticism Campbell (1966) developed a model which considers rational as well as irrational behavior. He distinguishes four types of decision processes (Table 49). In type 3 and 4 the interest stage follows adoption. In these cases the irrational adopter seeks to justify already taken decisions.

Table 49 Typical adoption processes by Campbell (1966)

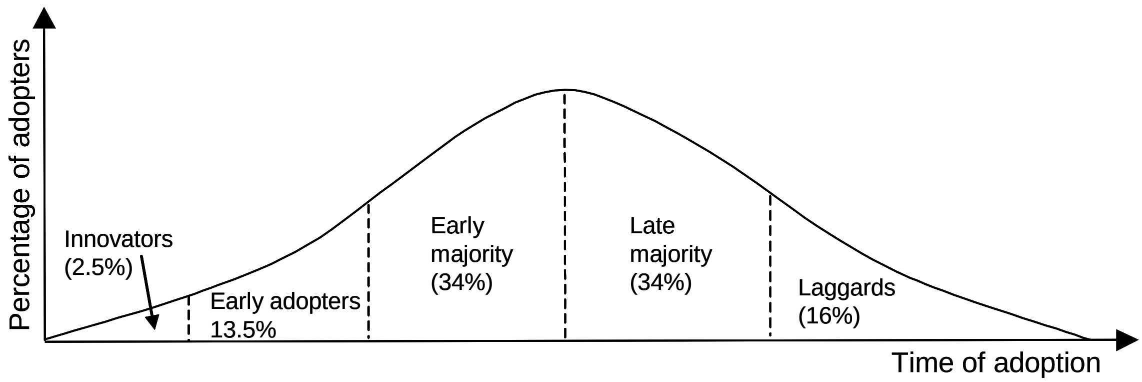
	Rational Types		**Irrational Types**	
Event	Type 1	Type 2	Type 3	Type 4
Becoming aware of a problem	+	-	+	-
Interest	+	+	-	-
Becoming aware of an innovation	+	+	+	+
Evaluation of innovation	+	+	-	-
Rejection or Trial	+	+	-	-
Rejection or Adoption	+	+	+	+
Interest	-	-	+	+

+ Event takes place; - event does not take place

Source: Campbell (1966)

Rogers (1958) developed a method of “adopter categorization”. This method is based on the standard distribution of the time of adoption by the individuals within a population. This distribution was confirmed in many studies. From this Rogers derived five categories of adopters: Innovators, early adopters, early majority, late majority and laggards (Figure 2).

Figure 2 “Adopter categories” by Rogers (1958)



Whether or not adoption takes place is influenced by characteristics of the innovation, by characteristics of the farmer himself and of the society which (s)he lives in. Looking at the characteristics of an innovation Rogers (1962) and von Blankenburg (1982) indicate that farmers are more likely to adopt innovations:

a. the higher the economic attractiveness (input / output relation) of the innovation (relative economic advantage). Depending on the regional conditions and the involvement of the farmers in the cash-economy, the threshold value (to induce farmers to adopt the innovation) may be from ten to over 100 per cent increase of returns to the additional inputs. Given flat per hectare payments, the PES output ($C_{payment}$) is fixed and the direct input in terms of protection costs (C_c) is not high returning favorable output-input ratios. If indirect inputs are also considered, especially monetary and non-monetary opportunity costs as well as transaction costs (C_t), then the input level is very variable and the output-input ratio for many landholders does not turn out to be favorable.

b. the lower the required capital in absolute terms. The attempt to introduce a new variety of coffee, for example, will probably be more successful than the attempt to introduce costly machinery. The required capital for PES enrolment is relatively low (protection plus transaction costs). In general, it is not expected that the required capital poses a major hurdle to participation although in individual cases, the PES requirements may impose high protection costs, e.g. when large areas have to be fenced off to keep cattle out of the conserved forest.

c. the more the innovation raises total farm income. Doubling the gross margin of maize may be of low importance for a farmer, when maize contributes only two or three per cent to the total farm income. The impact of PES on total income is, according to own data, very variable. Its impact increases with property size and decreases with per hectare returns (in case of flat payments). Similarly, it is therefore expected that adoption probability increases with property size and decreases with per hectare returns.

d. the sooner the innovation shows returns. PES payments in Costa Rica are made annually and therefore show returns sooner than the main land use alternatives forestry and cattle production (the latter depending on the specific production system).

e. the more easily the innovation can be adopted in parts. Farmers tend to select parts of an innovation (e.g. only the herbicide but not the fertilizer of a technical package). PES cannot be adopted in parts, yet it can be adopted in small quantities (see next point).

f. the better the innovation can be divided. Improved seed, for example, can be tested by farmers on a small plot. The same is not possible with an irrigation pump, which can only be bought as a whole. PES can be adopted for small areas. In Costa Rica, the smallest eligible land area is three hectares. For a small scale land holder, however, this could mean putting all land into PES while for a large scale land holder three hectares might be negligible. It is therefore expected that adoption probability increases with property size.

g. the better the innovation fits into the current system of production. An innovation requiring labor in a slack period is more likely to be adopted than one requiring labor in a peak season. In PES, the enrolment of natural forest would fit very well into the current system of production since it is normally not actively utilized. Enrolling pasture land, on the other hand, normally means to give up the current production system entirely. It is therefore expected that availability of forest area increases the probability of PES adoption.

h. the more the innovation removes a severe bottleneck. A labor saving innovation will be more rapidly adopted when it cuts down the labor requirements in a peak-demand season rather than in a slack period. The retirement of labor intensive marginal pastures (e.g. with respect to weed control) through PES enrolment may contribute to remove bottlenecks for the better management of more productive pastures or other agricultural activities.

i. the lower the farmers estimate the risk of failure. Important in this context is the farmers' estimation of the risk, not the knowledge of the creator of the innovation about the risk. In general PES, can be said to have a low risk of failure. Yet, landowners may perceive risks such as corrupt agencies that do not pay, hidden fees, the risk of losing long term land rights or the risk of fire and foregone payments. Perceived risk is measured here in mistrust towards state-run programs and the probability of adoption is expected to decrease with mistrust.

j. the more the innovation is “additive” in contrast to “substitutive”. When traditional ways do not have to be given up, at least immediately, it is easier for a farmer to experiment with the innovation. Similar to ‘g.’, PES would be additive if forest land was enrolled and substitutive if pasture land was enrolled. This implies that probability of adoption increases with forest area.

k. the more farmers can rely on the availability of inputs. Farmers may see that improved seeds are important for improved production, but this understanding is of little consequence if the seed is not available sufficiently close to the farm and at the right time. The inputs that are required for PES are readily available in the study area. This point is therefore thought to have little relevance on the adoption of PES.

l. the more reliable markets are in prices and capacity of absorption. This could be an important point for the adoption of PES. Although the payment levels have been steady, priority areas have shifted over the years and FONAFIFO’s available budget also fluctuates. In the long term, therefore, payments for environmental services could be subject to a lot of uncertainty, i.e. the capacity of market paid absorption of environmental services is uncertain. This uncertainty would be reflected in the landowner’s risk considerations.

m. the more the innovation fits into the social and cultural environment. Irrigation, for example, makes little sense in a nomadic society without land titles but does make sense in a smallholder area with private property of land. PES can be said to fit well into the Costa Rican social and cultural environment.

n. the less complex and difficult to understand an innovation is. PES can be seen as a simple and complex innovation at the same time. From the landowner’s viewpoint PES can be seen to be quite straight forward: “I am paid money for protecting my forest. People pay me because they value the forest”. The underlying concept and implementation of PES, however, is more complex and might in some cases not be very clear. This may cause a certain degree of suspicion and reluctance to adopt.

This catalogue does not claim completeness, nor do all of the factors come into effect in any particular case. Moreover, one favorable attribute of an innovation may counteract other, unfavorable ones (von Platen 1985). Several studies show the importance of economic attractiveness and low risk of failure to trigger adoption of an innovation. An example is that of Byerlee and Hesse de Polanco (1986). They estimated the risk and economic potential of three innovations (variety, fertilizer and herbicide) in two different agro-climatic regions in Mexico. They compared their data with actual adoption behavior in the regions. The farmers were not able to adopt the innovation package as a whole but within 5 years first adopted the innovation with the highest profitability and lowest risk involved. Because of higher profit potentials in the temperate zone the adoption process took place more swiftly there than in the arid zone. The landholder had, in fact, proved rational adoption behavior following their individual economic situation.

Looking at the characteristics of the landholder's situation and the society (s)he lives in, von Platen (1985) points out the crucial influence the following factors have on adoption:

1. The economic situation: Poorer landholders are less likely to take a risk by trying "new things", which could bring them into economic dependency (from creditors, middlemen, etc.) or could even, in the worst case, endanger their existence. Farm size has often been used as an indicator of the economic situation because it is easily quantifiable. Large farms tend to have higher absolute profits and can therefore more easily introduce capital intensive innovations. However, 33% of all studies of this kind (of 228 in total) came to the conclusion that farm size had no influence on the adoption of innovations.

2. The level of education: The higher the educational standard, the higher is a landholders ability to identify problems and the more likely (s)he is to search for information and solutions beyond the traditional means. Rogers (1962) could prove a positive correlation between education and innovative readiness.

3. The attitude of the society towards innovations: The more reserved a society is towards changes, the less a member of this society will dare to try innovations, because he will run the risk of being excluded from social life.

4. The support (in the form of credit, technical assistance, etc.): The more support the government or other institutions dedicate to the introduction of an innovation and the more assistance the farmer receives in his decision making processes, the more likely the farmer is to adopt the innovation.

5. Social participation and cosmopoliteness: These terms refer to the open-mindedness of a landholder. Both are reflected by indicators such as membership in farming organizations and a generally positive attitude towards extension. The effect is better access to information exchange. A large number of studies found a positive correlation between social participation and the adoption of innovations. Rogers (1983) analyzed 174 publications with regard to cosmopoliteness and found that 74% of these confirmed this correlation.

6. Presence of key persons: If key persons (persons with a strong influence on the opinions of other farmers) adopt an innovation, the confidence of other farmers in the new technology rises and they are more likely to adopt it themselves. The key persons are not necessarily the innovators who – sometimes – are not fully integrated into the society of the majority.

7. Access to information: Adoption theory distinguishes the classes "interpersonal communication" and "mass media communication". The presence of these communication forms can increase the flow of information. More information helps reduce the perception of risk and thus the adoption process is accelerated. Which of the two classes of communication has the stronger influence on adoption differs and may depend on the type of innovation and/or the individual situation and characteristics of a farmer. Mass media are often seen as an instrument to spread first general information among the potential adopter group. In contrast, interpersonal communication can respond to individual problems and questions. However, interpersonal communication holds the risk that that "second hand" and thus less precise information is passed on.

8. Risk aversion: The less risk averse a farmer is the more likely he is to adopt a new technology. Individually perceived risk can be reduced by information supply.

Gabersek (1990) makes clear that it is very difficult to generalize what determines adoption. The factors influencing adoption differ very much from case to case. In this sense, Albrecht (1969) admitted that the insight gained in one case can not be transferred to another. The motives, objectives and opinions of farmers may vary widely from situation to situation. Moreover, there are large discrepancies between verbally expressed opinions and actually realized behavior (Six 1975).

6.3 Methodology and Variables

In the field survey, the Costa Rican PES program in its valid form of 2005 (requirements, obligations, payment levels, etc.) were described in detail to the 178 land holders. In addition to the 2005 program conditions, the option to retire agricultural land and allow natural forest regrowth was also described[32]. In the survey, the hypothetical payment level for land retirement and subsequent natural forest regrowth was identical to that of forest protection. Following the program description, the interviewees were asked whether under these conditions they would place part of their land in the PES program. Those with an affirmative answer were classified as hypothetical adopters. Two Logit models were constructed to examine the explanatory effect of the variables in Table 50 on the hypothetical adoption decision. The

[32] This option was officially included in the PES program in 2006 with a payment of US$41/ha/year.

variables for the model are selected with the use of a backward elimination procedure. Since logistic models do not necessarily require normal distribution of determinants, transformations are refrained from.

Table 50 Variables with an expected explanatory effect on adoption

Dependent Variable	**Meaning (expected effect in brackets)**	**Type**	**Exp. sign**
PES Adoption	Hypothetical acceptance of a PES contract under the conditions of the Costa Rican PES program as of 2005. 1 = Yes, I would include part of my land in the program. 0 = No, I would not include part of my land in the program.	binomial	
Independent Variables	**Meaning (Hypothesized effect)**	**type**	
Variables which proxy costs of participation			
ParticipationCosts	Sum of opportunity, transaction and conservation costs. Opportunity costs according to Flow approach. (Higher costs are expected to decrease adoption probability).	metric	(-)
PriceIndex	Index for product prices in %. Constructed from own survey data on product prices. Sample average is 100%. (Higher prices, i.e. higher index values, are expected to increase opportunity costs and hence decrease adoption probability.)	metric	(-)
FactorIndex	Index for factor costs in %. Constructed from own survey data on factor costs. Sample average is 100%. (Higher factor prices, i.e. higher index values are expected to decrease opportunity costs and hence increase adoption probability.)	metric	(+)
DistAuction	Distance in kilometers to nearest cattle auction center. Distance measured “as the crow flies”. (Longer distance is expected to increase product transport costs, thus decrease opportunity costs and hence increase adoption probability.)	metric	(+)
DistCommerce	Distance in kilometers to nearest commercial center. Distance measured “as the crow flies”. (Longer distance is expected to increase transport costs, thus decrease opportunity costs and hence increase adoption probability.)	metric	(+)
Slope	Average slope of land in %. (Steeper slopes reduce production capacity and are thus expected to decrease opportunity costs and increase adoption probability.)	metric	(+)
Altitude	Altitude in meters above sea level. (Higher elevations with moderate temperatures favor agricultural production and thus increase opportunity costs decreasing adoption probability.)	metric	(-)
Capacity	Soil use capacity for agricultural production. Six categories with decreasing quality from II (best) to VIII (worst) transformed to five	binomial	(+)

	dummies with category II used as reference category. Categories from II upwards are expected to decrease opportunity costs and thus increase adoption probability.)		
FamilyWork	Family members work in farming activities (1) or they do not (0). (Availability of family labor is expected to increase opportunity costs and thus decrease PES adoption probabilities.)	binomial	(-)
ProductionFocus	Main production focus: 0=principally meat, 1=milk and meat, (zero farms produced principally milk). Milk production is generally a more profitable agricultural activity. Therefore the joint production of ‘milk and meat’ is expected to increase opportunity costs and thus decrease adoption probabilities.)	binomial	(-)
FireBreaks	Fire breaks were given maintenance in 2004 (1) or they were not (0). (Costa Rica’s PSA program requires fire breaks. If fire breaks are already maintained they are not perceived to be an additional cost. Adoption probability is therefore expected to increase with 1)	binomial	(+)
Canton	Canton in which land parcel is located (canton is an administrative unit that is smaller than the province but larger than municipality and district). Five dummies for six cantons. Canton Carrillo is reference canton. (The other cantons of the study area, namely Hojancha, Nandayure, Nicoya, Puntarenas, Santa Cruz, are expected to have lower per hectare returns than Carrillo and therefore higher adoption probabilities.	binomial	(+)
Variables which primarily measure or proxy risk considerations			
Area	Size of land property in hectares. Property size is expected to have contrary effects: (1a) A large property allows the land owner to ‘experiment’ with the new land-use on small parcels without significant risk to the overall enterprise, thus increasing adoption probability. (1b) Area proxies the overall economic situation. The risk of adoption decreases with the economic situation (failure can more easily be buffered) and increases the probability of adoption. (1c) A large property also decreases transaction costs and thus increases adoption probability. (2) Economies of scale (and thus opportunity costs) increase with property size, hence decreasing adoption probability.	metric	(+/-)
Consumption	Household consumption. Four categories for low (1) to high consumption (4) represented by three dummies. Category 1 is used as reference category. (Household consumption is assumed to proxy the economic situation of the landowner. It is expected that the risk of adoption decreases with the economic situation (failure can more easily be buffered) and increases the probability of adoption.	binomial	(+)
Off-farmIncome	Existence of off-farm income: 1=yes, 0=no. (Off-farm income decreases dependence on farm production and thus willingness to	binomial	(+)

	take risks with new land use technologies such as PES. As a result, adoption probability increases with off-farm income.)		
%FarmIncome	Percentage of income that is generated on-farm. (The expectation for this variable follows the argumentation of the variable 'Off-farmIncome'. The risk of adopting new land-use technologies (here PES) increases with on-farm income, hence decreasing adoption probability.)	metric	(-)
Forest	Existence of forest on land property: 1=yes, 0=no. The existence of forest enables the landowner to adopt PES as an 'additive' land use as opposed to a 'substitutive' land use in the presence of pasture only. Introducing the new technology, here PES, as an 'additive' component reduces the risk and thus increases adoption probability.	binomial	(+)
%Forest	Percentage of total property area with forest. (This variable is similar to the previous ('Forest'), yet instead of indicating only the existence of forest it measures its proportion. Higher percentages increase the possibility of 'additive' technology adoption, here PES, which decreases risk and thus increases adoption probability.	metric	(+)
HouseholdSize	Number of household members. (This variable is expected to have two complementary effects on adoption: Household size increases vulnerability and thus the risk aversion of the landowner. Hence, adoption probability decreases. (ii) Household size increases the availability of family labor increasing opportunity costs, and thus decreasing adoption probability.)	count	(-)
Trust	Degree of trust in state-run programs. Three variables low (1), medium (2) and high degree of trust (3) transformed to two dummies variables with category (1) as reference. Higher degrees of trust decrease the perceived risk of adoption and thus increase adoption probability.	binomial	(+)
ProfitExpectations	Land owner's expected profit trends. Returns will go down (1), stay the same or will go up (0). (Expectations for returns to decrease would increase the attractiveness of PES and its adoption probability.)	binomial	(+)
RiskBehavior	Risk behavior. Interviewees were asked to choose between three business opportunities with different levels of risk. Depending on their choice interviewees were classified as risk-averse (1) or other (0). Risk-averse landholders are less likely to adopt a new technology, hence adoption probability is expected to decrease.	binomial	(-)
Age	Age of land owner. (In general older landholders are expected to be more risk averse or conservative decreasing the adoption probability of PES).	metric	(-)

Variables which proxy ability to access and process information			
EducationalLevel	Educational level of farm owner. Five categories from ‘never went to school’ (0) to ‘Higher education’ (4). Reference Dummy is category 1. (Higher educational levels are expected to increase the ability to access and process information which decreases uncertainties and hence the perceived risk of adoption. Adoption probability is expected to increase with education.)	binomial	(+/-)
DistInfoCenters	Distance in kilometers from land property to four ‘PES information centers’ which are: Agricultural Cantonal Centers (i) Hojancha, (ii) Nandayure, (iii) Puntarenas and (iv) non-governmental organization Fundecongo. Increasing distance inhibits access to information on PES which increases the perceived risk of participation and thus decreases adoption probability.		(-)
Road	Type and quality of road leading to property. Categories from 1 to 5 with decreasing quality, transformed to four dummies with reference category 1. (Road type is expected to have two contrary effects: (i) Decreasing road quality reduces the access to information on PES and thus increases the perceived risk, hence decreasing adoption probability. (ii) Decreasing road quality increases transport costs and thus decreases opportunity costs increasing adoption probability.)	binomial	(+/-)
Accessibility	All year accessibility of property with 4x2 automobile. 1=yes, 0=no. (This variable is simplified version of the previous variable ‘Road’ and thus is also expected to have two contrary effects: (i) All year accessibility improves the access to information about PES and thus decreases the perceived risk, hence increasing adoption probability. (ii) All year accessibility decreases transport costs and thus increases opportunity costs, decreasing adoption probability.)	binomial	(+/-)
Variables which proxy perceived non-monetary costs/benefits			
Conscience	State of conscience in the hypothetical situation of having cut down a tree: 1=bad conscience, 0=other. (Adoption probability is expected to be higher among those with a ‘bad conscience’ because their perceived personal benefit from cutting a tree is lower than for those who do not have a bad conscience).	binomial	(+)
FearDenounce	Fear to be reported to the police in the hypothetical situation of having cut down a tree: 1=fear, 0=other. (Adoption probability is expected to be higher among those who fear to be reported to the police because their perceived personal benefit from cutting a tree is lower than for those who do not fear to be reported).	binomial	(+)
FearReputation	Fear that one’s social reputation could suffer in the hypothetical situation of having cut down a tree: 1=fear, 0=other. (Adoption probability is expected to be higher among those who fear to lose social reputation because their perceived personal benefit from	binomial	(+)

	cutting a tree is lower than for those who do not fear to lose reputation).		
Other variables			
NumberLandlords	Number of property owners. (It is expected that a higher number of owners decreases PES adoption probabilities because among a larger group of decision makers it is more difficult to come to an agreement for land-use change.)	count	(-)

6.4 Results

Among the 178 interviewees 45 (25.3%) were classified as hypothetical adopters and 133 (74.7%) as hypothetical non-adopters. In section 6.4.1, a binary logistic regression model (Adoption Model) is constructed to measure the explanatory effect of proxies for participation costs, risk, information and non-monetary considerations on adoption. With the intention to simplify the model, a second model (Reduced Adoption Model) is developed in section 6.4.2 by manually selecting the most significant variables that explain the largest part of adoption variance. Since participation costs did not turn out to be a significant determinant of adoption in neither of the two models, a descriptive analysis of adoption decision and participation costs follows in section 6.4.3.

6.4.1 Adoption Model

The ‘Adoption Model’ is presented in Table 51. Beside the constant, the model is comprised of a total of 21 variables, of which eight are metric, one is a count and twelve are binomial variables. Of the twelve binomial variables, six are dummy transformed categories of multinomial variables. Thirteen variables plus the constant are significant and the model explains 50% (Cox&Snell pseudo R^2) to 74% (Nagelkerkes pseudo R^2) of the variance of the dependent variable.

Table 51 The Adoption Model

Dependent Var.	N	Log-Likelihood	Cox&Snell R^2	Nagelkerkes R^2
Adoption (1;0)	178	70.364	0.496	0.735

Independent Var.	Coeff.B	S.E.	Wald	df	Sig.	Exp(B)	Simple[a]
ParticipationCosts	0.006	0.003	3.500	1	0.061	1.006	*.04(+); .03/.04
PriceIndex	-0.030	0.014	4.322	1	*0.038	0.970	.71(+); .00/.00
DistCommerce	-0.083	0.042	3.895	1	*0.048	0.921	.59(+); .00/.00
Slope	1.149	0.452	6.465	1	*0.011	3.156	*.00(+); .06/.09
ProductionFocus	-1.983	1.111	3.187	1	0.074	0.138	.50(+); .00/.00
Canton(Hojancha)	-7.651	2.748	7.754	1	*0.005	0.000	.09(-); .03/.04
Canton(Nicoya)	2.310	0.938	6.066	1	*0.014	10.078	.17(+); .01/.02
Area	0.022	0.007	10.491	1	*0.001	1.022	*.00(+); .12/.18
Consumption(2)	-1.659	0.872	3.617	1	0.057	0.190	.06(-); .02/.03
Consumption(4)	-2.622	1.435	3.339	1	0.068	0.073	.92(+); .00/.00
Road(4)	-3.049	1.310	5.420	1	*0.020	0.047	.54(+); .00/.00
Off-FarmIncome	-3.247	1.867	3.022	1	0.082	0.039	*.02(-); .03/.05
%FarmIncome	-0.045	0.026	2.985	1	0.084	0.956	.08(+); .02/.03
Forest	2.943	1.496	3.869	1	*0.049	18.974	*.00(+); .12/.18
%Forest	0.038	0.020	3.724	1	*0.054	1.039	*.00(+); .16/.23
Trust(3)	3.509	1.107	10.043	1	*0.002	33.415	*.00(+); .06/.09
RiskBehavior	-2.761	1.057	6.821	1	*0.009	0.063	.14(-); .01/.02
Age	-0.066	0.032	4.196	1	*0.041	0.936	*.04(-); .03/.04
Conscience	1.382	0.792	3.043	1	0.081	3.983	.08(+); .02/.03
FearDenounce	-1.791	0.966	3.434	1	0.064	0.167	.78(-); .00/.00
NumberLandlords	-1.028	0.356	8.367	1	*0.004	0.358	.12(-); .02/.02
Constant	8.129	4.225	3.703	1	*0.054	3391.241	n.a.

[a] This column depicts the significance of the variable in a simple logistic model containing the variable as the only determinant. If the variable is significant this is depicted with an asterisk before the p-value which is followed in brackets by the sign of the coefficient in the simple regression. After the apostrophe follow the two pseudo R-square values Cox&Snell and Nagelkerkes, respectively.

Of the thirteen significant variables five are proxies for participation costs (PriceIndex, DistCommerce, Slope, CantonHojancha, CantonNicoya). Six belong to the group of risk proxies (Area, Forest, %Forest, Trust3, RiskBehavior, Age), one belongs to the group of information proxies (Road4), and one belongs to the group of other proxies (NumberLandlords). The results clearly show that adoption is not determined by participation costs (as measured here) alone. Non-monetary personal values could not be shown to play a significant role in adoption (the model does not contain a significant variable from that group). Below follows a brief discussion of the thirteen significant variables as well as the insignificant variable 'ParticipationCosts':

The variable 'PriceIndex' has, as expected, a negative coefficient and shows that adoption probability decreases as product prices increase.

'DistCommerce' was expected to have a positive sign because of its negative impact on opportunity costs. Yet, in the model the sign is negative. It is possible that DistCommerce has also other effects. For example, distance to commercial centers might proxy access to PES information (like DistInfoCenters). It is possible that information exchange with colleagues at commercial centers (interpersonal communication) have more significant impacts on the adoption decision than information from the so called 'Information Centers'. The likeliness to obtain such information decreases with the distance to commercial centers, negatively impacting adoption.

The variable 'Slope' shows that adoption probability significantly increases with slope. Steep areas are less favorable for conventional agricultural production and therefore more apt to produce ES. Note, the measure is an average for the entire property while the adoption decision is likely only based on the most marginal and least productive areas within a farm, here those with the steepest gradients. In the case of slope the farm average turns out to be sufficient in explaining part of the adoption variation.

The two dummy variables Canton(Hojancha) and Canton(Nicoya) are both significant, the first with a negative coefficient, the second with a positive coefficient. Both were expected to bear positive signs due to lower average per hectare returns in Hojancha and Nicoya compared to those in Carrillo. But the cantons bundle several characteristics (not only per hectare returns) that can potentially influence adoption and as a whole produce an observed aggregate effect. Canton(Hojancha), for example, is significantly correlated to thirteen variables in the model, and Canton(Nicoya) is correlated to seven variables.

The variable 'Area' explains a large percentage of variance in the simple logit model (Pseudo R^2s: Cox&Snell 12%; Nagelkerkes 18%). With every additional hectare of land the marginal odds of adoption increase by 2.2% (Exp(B)=1.022) in the Adoption Model. The variable clearly shows that PES participation depends on the availability of land. As was already stated in Table 50, large land properties allow the landowners to experiment with new land-uses such as PES on smaller parcels without significantly impacting the current production system and without taking major risks in case of failure. Large properties also enable the landowner to enroll larger areas reducing transaction costs and thus increasing the attractiveness of adoption. Farm size also proxies the overall economic situation of a farmer which decreases the risks of adoption in case of failure. It is also likely that the owner of much land is underutilizing marginal and less favorable parts of the terrain. Their inclusion in a PES program therefore hurts less than the inclusion of highly utilized parts. PES might tip the scales in determining the land use on such marginal areas switching from underutilized agricultural use to forest conservation under PES. Given the results these effects clearly overrule the hypothesized effect that economies of scale may increase per hectare returns and thus make adoption less likely.

The existence of forest ('Forest') drastically increases adoption probability as the odds of adoption are almost nineteen times higher (Exp(B)=18.97) for someone with forest than for someone without. Among all variables though, '%Forest' (proportion of forest on total land area) explains the largest part of adoption variance in a simple logistic regression (Pseudo R^2s: Cox&Snell 16%; Nagelkerkes 23%). Its significance makes a strong statement about what type of land use is particularly interesting for landowners to enroll in PES. With every additional percent of forest on the total land area, the odds of adoption increase by 3.9% (Exp(B)=1.039) in the Adoption Model. This indicates that landowners predominantly include forest in the program. Descriptive data confirm this observation: the majority of the 3,823 ha which landowners said to be willing to enroll in PES consisted of forest (2,353 ha or 61.5%), land already under a PES contract at the time of the interview 629 ha (16.5%) and pasture fallow, so called 'Tacotales' or 'Charrales' (511 ha or 13.4%). Only 324 ha (8.5%) were pastures and 6 ha (0.2%) plantations.

If 'Trust(3)' takes the value of one an interviewee highly trusts state-run programs. In a simple logistic model this variable explains 6% (Cox&Snell R^2) to 9% (Nagelkerkes R^2) of adoption variance. A high level of trust boosts the odds of adoption by about 33 times (Exp(B)= 33.415) in the Adoption Model. The descriptive results confirm this finding and show that the hypothetical adoption rate among landowners with a high degree of trust (48.6%) is considerably higher than the adoption rate among land owners with lower degrees of trust (18.8%).

As expected, the variable 'RiskBehavior' shows that risk-averse land holders are less likely to adopt PES than others. According to the Adoption Model, the odds of adoption for risk-averse land holders are 93.7% lower (Exp(B)=0.067).

‘Age’ is negatively correlated with adoption. In the Adoption Model the odds of adoption decrease by 6.4% with every year of age (Exp(B)=0.936) and thus confirm the expectation that, with age, landholders become more conservative and risk-averse, both impediments to the adoption of new technologies.

The variable ‘Road(4)’ bears, as expected, a negative sign indicating that access to information is more difficult along bad roads. Less information increases the perceived risk of adoption and thus decreases adoption probability. Also, a poor road imposes higher transaction costs on the landowner as (s)he seeks to obtain information on PES.

The negative coefficient for ‘NumberLandlords’ shows that adoption probability decreases significantly (p=0.004) with the number of landlords of a property. Decision making processes may become more complex and difficult with a growing number of landowners. Although daily management is mostly in the hand of only one of the owners, fundamental decisions have to be made among all. Descriptive data supports this interpretation: Some hypothetical non-adopters stated that participation in the PES program had to be decided by the family.

‘ParticipationCosts’ turned out to be in the model but not among the significant variables. This could be due to suppressor effects by other proxies for participation costs (e.g. PriceIndex, Slope). But although ‘ParticipationCosts’ is significant in a simple regression (see column ‘Simple’), it bears an unexpected positive sign which suggests problems with the computed estimates for ‘ParticipationCosts’. The quality of the cost estimates was already questioned in section 5.3 but plausibility tests could not confirm these doubts. Standard measures to prevent survey errors had also been taken. For example, the plausibility of individual interviewee responses was controlled by cross-checking answers throughout the related questionnaires. Transfer errors from paper into digital format were minimized by comparing the final digital data sheet with the original questionnaires.

It is possible that participation costs are significant for specific groups in the sample: For example, land holders who do not trust state-run programs do not adopt independent of their participation costs while those with trust base their adoption decision on costs. The validity of this and similar assumptions was tested by using interaction terms multiplying ‘ParticipationCosts’ with variables like ‘Trust’, ‘ProductionFocus’, ‘Accessibility’, ‘Off-FarmIncome’, ‘Forest’, ‘RiskBehavior’, ‘Conscience’, ‘FearDenounce’ and ‘FearReputation’. Each variable was multiplied with three different estimates of participation costs derived from the Flow, Rent and Perception approaches giving a total of 27 interaction terms. Regressing adoption on the interaction terms, however, returned not a single significant relation.

‘ParticiaptionCosts’ is, like other variables (e.g. ‘Slope’), an average measure across all parcels of a farm. It is possible that this average is not sufficient to explain adoption. A land holder is likely to first enroll the most marginal and least productive land parcels of his property into the program. Average participation costs do not reflect the participation costs of the least productive areas and therefore may turn out to be insignificant in explaining adoption.

Comparing the performance of a variable in the simple regression (see column ‘Simple’) with its performance in the multiple regression can reveal information about a variable’s explanatory strength and relation to other independent variables. For example, the variables ‘Slope’, ‘Area’, ‘Forest’, ‘%Forest’, ‘Trust’ and ‘Age’ belong to the variables which are significant in both the simple and multiple regressions. ‘ParticipationCosts’ and ‘Off-FarmIncome’, on the other hand, are significant in simple regressions, yet lose their significance in the multiple model due to influences by other variables: ‘ParticipationCosts’ is positively correlated with ‘ProductionFocus’ ($p<0.001$) and ‘%FarmIncome’ ($p=0.029$); ‘Off-FarmIncome’ is negatively correlated with ‘ProductionFocus’ ($p=0.007$), ‘Area’ (0.009), ‘%FarmIncome’ ($p<0.001$) and ‘Forest’. A third group of variables benefit from mediator or moderator effects in the multiple regression where they are significant while they are not in the simple regression. These are ‘PriceIndex’, ‘DistCommerce’, ‘Canton(Hojancha)’, ‘Canton(Nicoya)’, ‘Road(4)’, ‘RiskBehavior’ and ‘NumberLandlords’.

6.4.2 Reduced Adoption Model

The variables that seem to contribute most to explaining variance are among the group of variables that are significant both in the simple and multiple regression. These are (i) ‘%Forest’ which in the simple regression has pseudo R-squares of 16% (Cox&Snell) and 23% (Nagelkerkes), (ii) ‘Area’ and (iii) ‘Forest’ which both have pseudo R-squares of 12% (Cox&Snell) and 18% (Nagelkerkes), (iv) ‘Trust(3)’ and (v) ‘Slope’ both with 6% (Cox&Snell) and 9% (Nagelkerkes), and finally, (vi) ‘Age’ (3% and 4%). If these six variables are used for a logistic regression applying a backward elimination process with likelihood ratio, ‘Slope’ and ‘Forest’ are excluded and a model results (Reduced Adoption Model) with four highly significant variables and pseudo R-squares of 30.6% (Cox&Snell) and 45.2% (Nagelkerkes) (Table 52). Forest is probably excluded from this model because of its correlation with %Forest ($p<0.001$) and Area ($p=0.032$). Slope is probably excluded because of its correlation with %Forest ($p<0.001$). The other variables in the model are not significantly correlated with each other.

Table 52 Reduced Adoption Model

Dependent Var.	N	Log-Likelihood	Cox&Snell R^2	Nagelkerkes R^2
Adoption (1;0)	178	138.383	0.306	0.452

Independent Var.	Coeff.B	S.E.	Wald	df	Sig.	Exp(B)	Simple[a]
Area	0.010	0.003	9.152	1	0.002	1.011	*.00(+); .12/.18
Age	-0.034	0.016	4.770	1	0.029	0.967	*.00(+); .03/.04
%Forest	0.044	0.009	23.093	1	<0.001	1.045	*.00(+); .16/.23
Trust(3)	2.122	0.527	16.220	1	<0.001	8.350	*.00(+); .06/.09
Constant	-1.346	0.902	2.226	1	0.136	0.260	n.a.

[a] This column depicts the significance of the variable in a simple logistic model containing the variable as the only determinant. If the variable is significant this is depicted with an asterisk before the p-value which is followed in brackets by the sign of the coefficient in the simple regression. After the apostrophe follow the two pseudo R-square values Cox&Snell and Nagelkerkes, respectively.

6.4.3 Comparison of Participation Costs with Adoption Decisions

The insignificance of 'ParticipationCosts' in the Adoption Model can possibly be explained with suppressor effects by other proxies for participation costs (e.g. PriceIndex, Slope). But 'ParticipationCosts' is significant in the simple regression bearing the 'wrong' sign (Table 51). Some possible explanations (non-consideration of on-farm variability, interaction with other variables) have already been suggested above. This section offers a closer descriptive look at how participation costs compare with adoption decisions.

Adoption decisions are compared to six different estimates of participation costs: (i) Opportunity costs from Flow approach, (ii) Opportunity costs from Rent approach, (iii) Opportunity costs from Perception approach, (iv) Opportunity costs from the Flow approach + transaction costs + protection costs, (v) Opportunity costs from the Rent approach + transaction costs + protection costs, (vi) Opportunity costs from Perception approach + transaction costs + protection costs.

Among the 178 interviewees there are 45 (25.3%) hypothetical adopters and 133 (74.7%) hypothetical non-adopters (Table 53). Among the 120 interviewees who gave an estimate of their perceived returns (perception approach) there are 30 (25.0%) hypothetical adopters and 90 (75.0%) hypothetical non-adopters. Although risk, information and non-monetary costs or benefits were not considered for the calculation of participation costs, it was, nevertheless, expected to find a trend that land holders with participation costs clearly above the payment level of 42$ will tend to reject participation, and land holders with participation costs clearly below the payment level will tend to participate in PES. In other words, the adopters are expected to have costs below 42$ and non-adopters are expected to have costs above 42$.

However, looking at the opportunity cost estimates from the Flow approach (first block in Table 53), there are approximately the same number of adopters with opportunity costs below and above the payment line, 22 and 23, respectively. Also, among the non-adopters those with opportunity costs larger than 42US$ are a slight minority (44.4%). Surprisingly, the mean opportunity cost of adopters (92.92$) is significantly higher than the mean opportunity cost of the non-adopters (44.64$)[33] which is in line with the positive sign of 'ParticipationCosts' in the simple adoption model (Table 51). When protection costs (PC) and transaction costs (TC) are added to the Flow estimates for opportunity costs, the overall trend does not change: (i) The number of adopters with participation costs larger than 42$ even increases from 23 (51.1%) to 26 (57.8%); (ii) The number of non-adopters with opportunity costs larger than 42$ slightly increases to from 44.4% to 48.9% but remain the minority among non-adopters; (iii) The mean opportunity cost of the adopters (101.80$) maintains to be significantly higher than that of the non-adopters (55.67$). As was already explained in section 3.2.2 the estimates from the Flow approach are believed to be slight overestimates. This could explain why for many adopters participation cost estimates result to be too high, yet that does not explain why for many non-adopters participation cost estimates are too low.

[33] according to ANOVA analysis.

Table 53 Comparing hypothetical adoption decisions with participation cost

OC(Flow) (n=178)	45 Hypothetical Adopters (25.3%)			133 Hypothetical Non-Adopters (74.7%)		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	45 (100%)	22 (48.9%)	23 (51.1%)	133 (100%)	74 (55.6%)	59 (44.4%)
Mean ($)	91.92*	9.14	171.10	44.64*	-23.93	130.65
OC(Rent) (n=178)	**45 Hypothetical Adopters (25.3%)**			**133 Hypothetical Non-Adopters (74.7%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	45 (100%)	21 (46.7%)	24 (53.3%)	133 (100%)	38 (28.6%)	95 (71.4%)
Mean ($)	108.65	29.26	178.12	109.46	31.58	140.61
OC(Perc.) (n=120)	**30 Hypothetical Adopters (25.0%)**			**90 Hypothetical Non-Adopters (75.0%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	30 (100%)	14 (46.7%)	16 (53.3%)	90 (100%)	44 (48.9%)	46 (51.1%)
Mean ($)	63.10	17.12	103.34	91.11	16.30	162.67
OC(Flow)+PC+TC	**45 Hypothetical Adopters (25.3%)**			**133 Hypothetical Non-Adopters (74.7%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	45 (100%)	19 (42.2%)	26 (57.8%)	133 (100%)	68 (51.1%)	65 (48.9%)
Mean ($)	101.80*	14.47	165.62	55.67*	-17.62	132.34
OC(Rent)+PC+TC	**45 Hypothetical Adopters (25.3%)**			**133 Hypothetical Non-Adopters (74.7%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	45 (100%)	13 (28.9%)	32 (71.1%)	133 (100%)	20 (15.0%)	113 (85.0%)
Mean ($)	118.53	32.21	153.60	120.49	35.39	135.55
OC(Perc.)+PC+TC	**30 Adopters (25.0%)**			**90 Non-Adopters (75.0%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	30 (100%)	9 (30.0%)	21 (70.0%)	90 (100%)	38 (42.2%)	52 (57.8%)
Mean ($)	73.36	15.58	98.12	102.01	23.76	159.19

* Mean between adopters and non-adopters are significantly different (ANOVA). OC=Opportunity Cost, TC=Transaction Cost, PC=Protection Cost, Perc.=Perception Approach, Rent=Rent Approach, Flow=Flow Approach

Other participation cost estimates do not or only partly confirm expected trends: Looking at the Rent approach estimates, there is indeed a majority of non-adopters with opportunity costs larger than 42$ (71.4%). This result is reinforced when transaction and protection costs are added to the opportunity cost estimates of the Rent approach increasing the percentage of non-adopters with participation costs larger than 42$ to 85%. However, there appears to be a general overestimation of costs in the Rent approach because a similar majority of non-adopters has costs higher than 42$, and adopters and non-adopters have almost identical means of participation costs: 108.65$ and 109.46$, respectively, if only opportunity costs are considered; and 118.53$ and 120.49$, respectively, if protection and transaction costs are added.

According to the cost estimation of the perception approach (excluding and including protection and transaction costs), mean participation costs of adopters (63$ and 73$, respectively) are substantially lower than those of the non-adopters (91$ and 102$, respectively). Yet, these differences are not significant. Considering perception approach estimates with all costs, a slight majority of non-adopters (57.8%) has participation costs higher than 42$. However, a vast majority of adopters (70%) also have participation costs higher than 42$.

The results in Table 53 are based on hypothetical adoption replies and can therefore be biased compared to real adoption (Six 1975). Bias could be induced, for example, by two phenomena described in literature: (i) 'agreeing tendency' and (ii) 'social-desirability-response-set' (Schnell et al. 1999). The phenomena have been explained with a desire for social recognition, lack of confidence and the fear of negative consequences. It is possible that some interviewees in the survey "agreed" to hypothetical adoption to please the interviewer, even if the cost-benefit ratio was not favorable for adoption. However, these phenomena still do not explain why there would be non-adopters with costs below 42$. It is difficult to determine whether any of these phenomena played a role in the land holders' replies and therefore no attempt was made to correct for this potential bias. The survey also identified some real adopters. Real adopters are defined as those land holders who at the time of the interview had part of their land in the PES program. Among the 178 interviewees there are 9 (5.1%) real adopters and 169 (94.9%) real non-adopters. Among the 120 interviewees who gave an estimate of their perceived opportunity cost there are 4 (3.3%) real adopters and 116 (96.7%) real non-adopters. The small number of real adopters limits statistical reliability, but a descriptive comparison of real adopters with costs might give clues about the existence of bias among the hypothetical adopters.

The descriptive comparison of *real* adoption decisions with participation costs is presented in Table 54. Compared to the hypothetical adoption decisions in Table 53, the following main differences can be detected: (i) the means of the Flow approach estimates (with and without transaction and protection costs) between adopters and non-adopters are no longer significantly different. (ii) Using the Flow approach estimates (with and without transaction and protection costs), the majority of adopters has participation costs smaller than 42$. (iii) For all six participation cost estimates the adopters' means are smaller than the non-adopters' means, though none of these differences are significant. While these observations have to be interpreted with care due to their lack of statistical reliability, they appear to point into the right direction and may suggest that a bias in hypothetical adoption could be the cause for costs to be insignificant in the above model.

Table 54 Comparing real adoption decisions with participation cost

OC(Flow) (n=178)	9 Real Adopters (5.1%)			169 Real Non-Adopters (94.9%)		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	9 (100%)	6 (66.6%)	3 (33.3%)	169 (100%)	90 (53.3%)	79 (46.7%)
Media ($)	53.53	6.11	148.36	56.76	-17.85	141.75
OC(Rent) (n=178)	**9 Real Adopters (5.1%)**			**169 Real Non-Adopters (94.9%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	9 (100%)	3 (33.3%)	6 (66.6%)	169 (100%)	56 (33.1%)	113 (66.9%)
Media ($)	61.68	28.06	78.49	111.79	30.90	151.88
OC(Perc.) (n=120)	**4 Real Adopters (3.3%)**			**116 Real Non-Adopters (96.7%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	4 (100%)	2 (50.0%)	2 (50.0%)	116 (100%)	56 (48.3%)	60 (51.7%)
Media ($)	45.34	0.00	90.68	85.45	17.09	149.25
OC(Flow)+PC+TC	**9 Real Adopters (5.1%)**			**169 Real Non-Adopters (94.9%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	9 (100%)	5 (55.6%)	4 (44.4%)	169 (100%)	82 (48.5%)	87 (51.5%)
Media ($)	61.54	7.90	128.59	67.64	-11.74	142.46
OC(Rent)+PC+TC	**9 Real Adopters (5.1%)**			**169 Real Non-Adopters (94.9%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	9 (100%)	2 (22.2%)	7 (77.8%)	169 (100%)	31 (18.3%)	138 (81.7%)
Media ($)	69.69	32.77	80.25	122.67	34.23	142.54
OC(Perc.)+PC+TC	**4 Real Adopters (3.3%)**			**116 Real Non-Adopters (96.7%)**		
	All	**< 42$**	**> 42$**	**All**	**< 42$**	**> 42$**
# absolute (rel.)	4 (100%)	2(50.0%)	2 (50.0%)	116 (100%)	45 (38.8%)	71 (61.2%)
Media ($)	53.08	7.91	98.25	96.28	22.83	142.84

* Mean between adopters and non-adopters are significantly different (ANOVA). OC=Opportunity Cost, TC=Transaction Cost, PC=Protection Cost, Perc.=Perception Approach, Rent=Rent Approach, Flow=Flow Approach

6.5 Summary

At the beginning of this chapter it was assumed that participation costs as they were calculated in this study (from monetary flows in the past, i.e. Flow approach) are an insufficient measure to explain a land holder's decision to enroll land in PES. Expected future costs and benefits were instead assumed to be a better measure which, however, involves considerations of risk and information in addition to monetary flows in the past. Moreover, non-monetary values such as traditions were assumed to influence the land holder's decision. To test the validity of these assumptions an adoption model was constructed from variables that proxy participation cost, risk, information and non-monetary values. The model explained up to 73.5% (Nagelkerkes R^2) of adoption variance. The results confirm that adoption is not determined by participation costs alone. Risk and information proxies play a significant role. Non-monetary benefits, however, could not be shown to significantly explain adoption. The results were confirmed by some of the explanations that hypothetical non-adopters gave in the field survey for rejecting PES. The Flow approach estimates had an unexpected positive effect on adoption when used as a proxy for participation costs in a simple adoption model. A detailed comparison of cost estimates with hypothetical adoption decisions could not dissolve this contradiction although a comparison with real adoption decisions tended to reveal less contradicting results.

7 Conclusions

It could be shown for the case of Costa Rica's PSA program, exemplified by the Nicoya Peninsula, that a targeting process that integrates spatial data potentially achieves much higher financial efficiency in environmental service provision than a selection system that is based solely on priority areas. All considered targeting approaches led to higher environmental service efficiency compared to the Baseline approach. Yet, the spatial attributes (benefits, risks and costs) contribute very differently to the efficiency increase: While the integration of environmental service scores led to moderate efficiency increases, the integration of participation costs boosted efficiency, largely due to decreasing average payments and, consequently, increasing total contracted area. The use of deforestation probabilities, on the other hand, barely improved efficiency, as this attribute shows little variation between sites in the study region. Nevertheless, in each country or region the potential efficiency impact of each spatial attribute depends largely on its variation in space and its correlation to other attributes which may differ across regions and also with scale. Deforestation rates, for example, may likely be the key criterion in countries or regions with higher and regionally more variable deforestation threats than observed in Costa Rica.

Watershed protection is often the only fund-generating environmental service and may therefore, in practice, often function as an 'umbrella service'. Focusing selection only on water services gave water services a sharp increase and the overall environmental service efficiency considerably increased in the flexible payment approaches - though to a far lesser extent than in the multiple service approaches. Hence, if multiple service provision is the goal, the water-only selection cannot compete with the integrated service-selection approaches. However, if water users are the only service buyers a single-service focus is a legitimate option that still offers interesting side benefits.

Payment differentiation might encounter several obstacles such as the identification of a reliable, sufficiently precise and cost-effective method to determine micro level participation costs. Two possible alternative approaches were tested here: The 'Rent' approach which derived cost estimates from annual land rents, and the 'Model' approach which predicted per hectare returns of land with easy-to-obtain and difficult-to-manipulate variables such as soil quality. None of the two approaches appeared to sufficiently well predict net returns but this judgment depended largely on how close the original cost estimates from the 'Flow' approach were to the true costs. Therefore, the plausibility of the Flow approach estimates was tested by (i) comparing them directly to returns as they were perceived by the landholders themselves and by (ii) constructing a production model with data that the estimates are based upon. Both tests confirmed the plausibility of the estimates. Based on the presented results the two approaches for cost estimation cannot be recommended for practical implementation in PES programs. Further research would be necessary to confirm these findings.

Considering the difficulty to determine micro-level monetary participation costs it was questioned whether estimates that are based on monetary flows in the past without consideration of personal land holder characteristics explain land use decisions sufficiently well. It was assumed that future considerations such as risk and information issues would be necessary to obtain a better estimate of *expected* participation costs. In addition, non-monetary values such as personal preferences may influence land use decisions. The assumptions were tested with an adoption model. The model showed that risk and information issues played significant roles in explaining adoption. Non-monetary values were not significant in the model, but in interviews land holders indicated them to influence adoption, too. Approaches that estimate the monetary costs of participation only (like the Rent and Model approaches that were tested here) can therefore be concluded to not reliably determine the payment level that would be necessary to induce the land holders' PES participation. The adoption results somewhat challenge the targeting tool's alleged potential to increase efficiency since the payment levels that were used for the tool were based on purely monetary observations in the past. It is likely though that the real willingness to accept also exhibits a strong variability across land holders in which case similar efficiency gains are likely to be maintained although the actual parcel selection might be different.

Inverse auctions present an alternative that could take all significant determinants into account. In principle, inverse auctions aim to induce property owners to reveal their real willingness to accept. However, in practice this is not always achieved (Ferraro 2008). There are examples of the successful use of auction systems in developed countries such as the United States (e.g. Claassen et al. 2008), but no such examples exist for developing countries. Technically, it appears that an auction system could easily be integrated into most currently practiced PES programs. If landowners have to apply formally for program participation (as is the case in Costa Rica's PSA Program), their bid could be part of the application process. Auction systems might also be a powerful way of making payment differentiation politically acceptable, because service sellers suggest the price themselves. The applicability, impediments, and challenges of auction systems for PES programs in developing countries certainly deserve further attention in future research.

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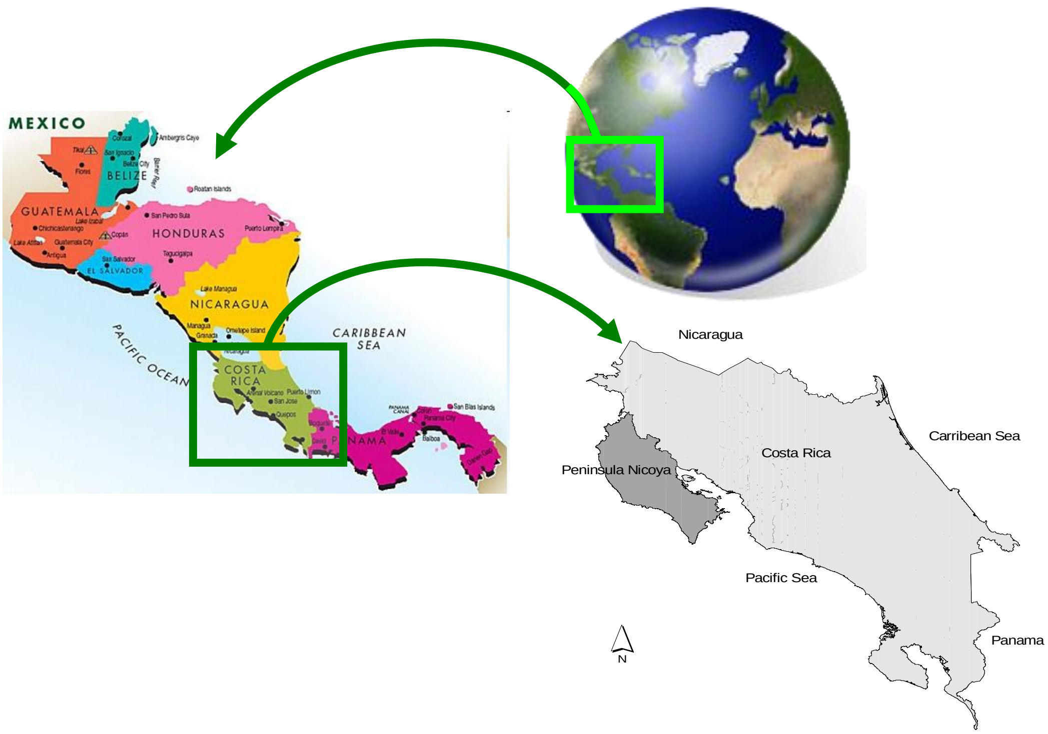
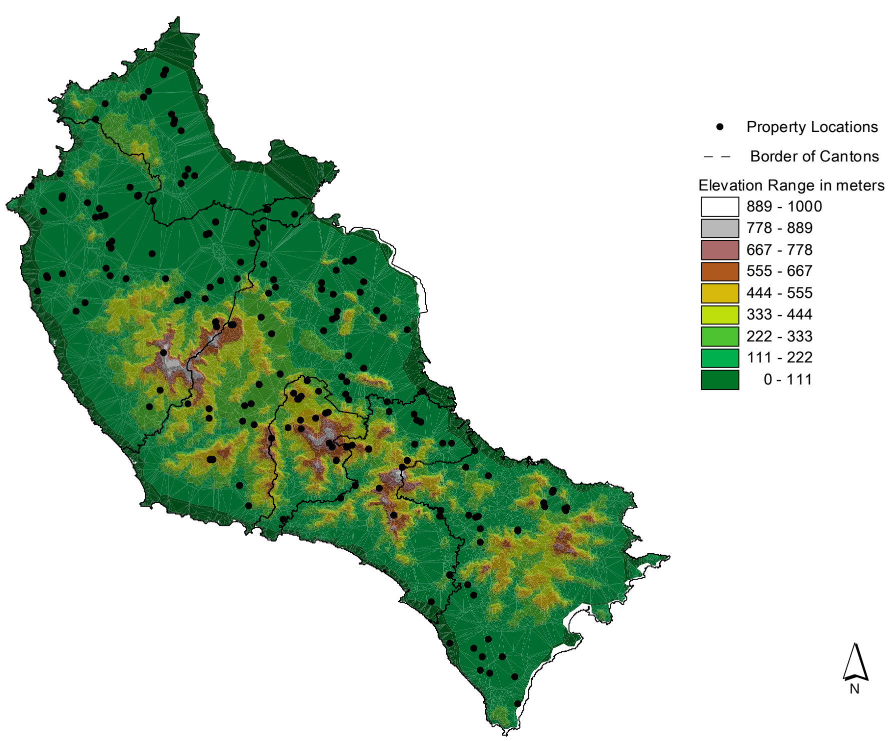
Appendix I (Maps)

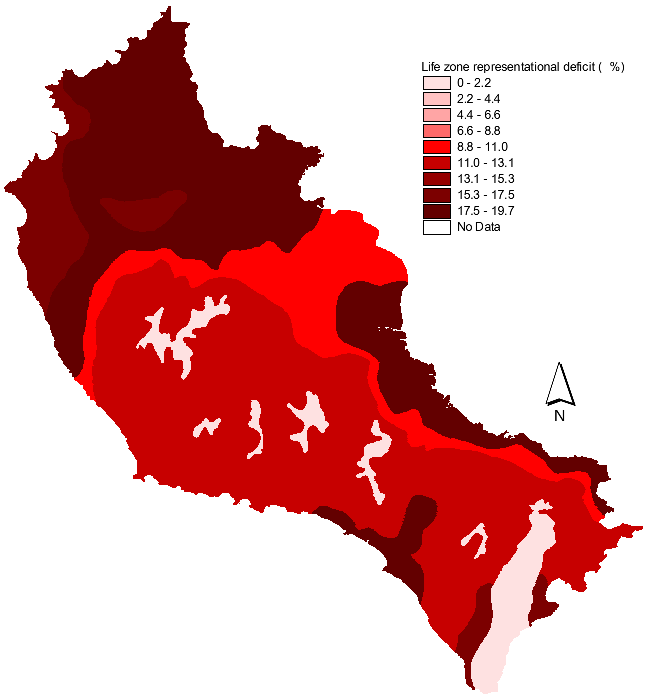
Map 1 Location of Study Area



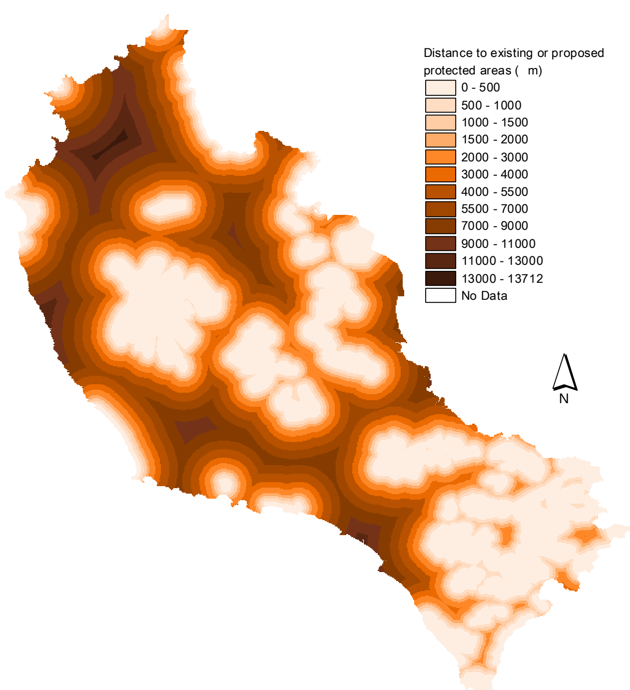
Map 2 Locations of Interviewed Properties on Nicoya Peninsula



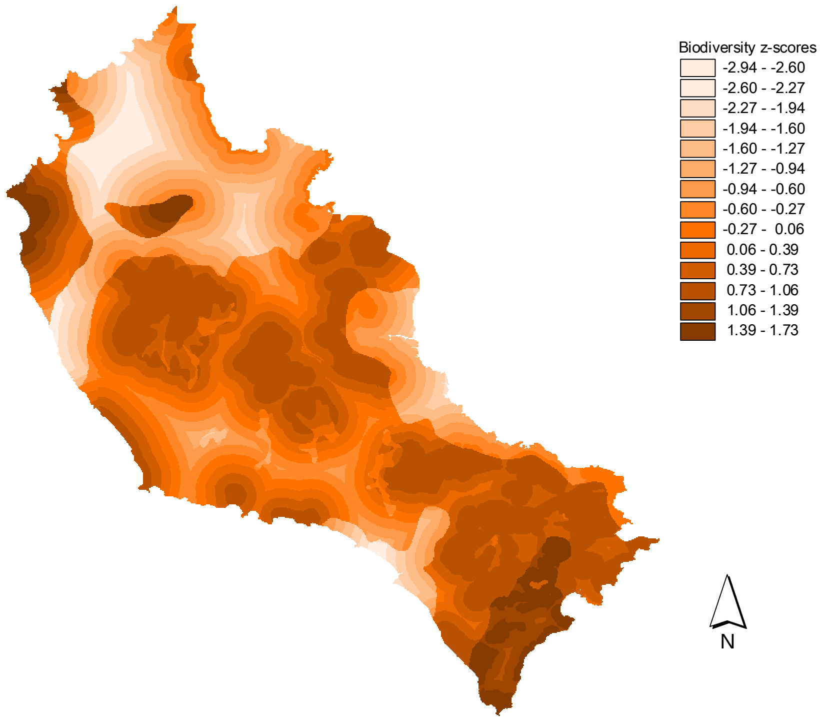
Map 3 Lifezone Representation Deficit in Percentages



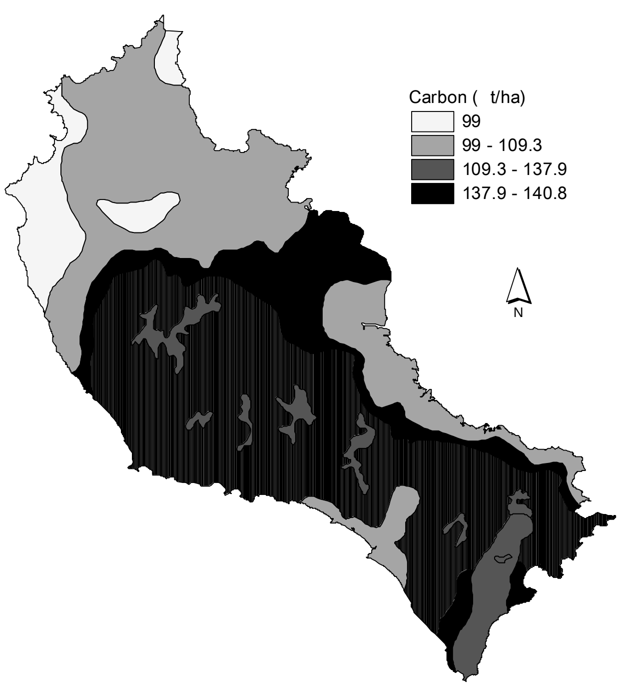
Map 4 Distances to Existing and Proposed Protected Areas



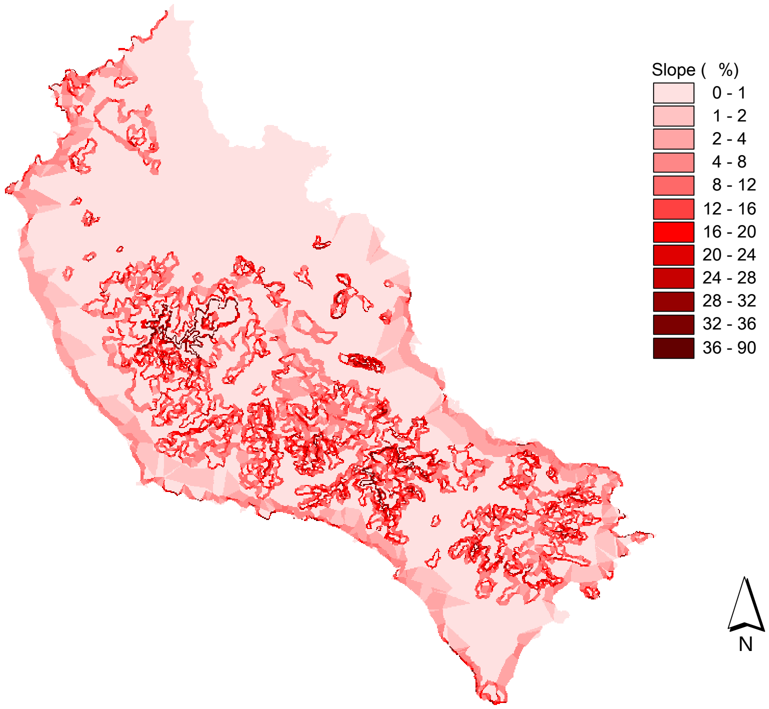
Map 5 Biodiversity Service z-Scores



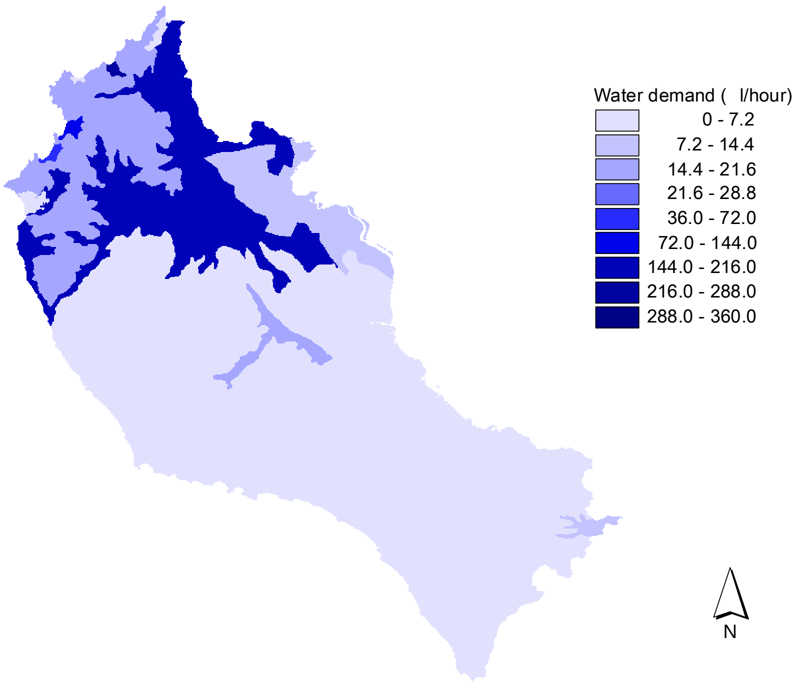
Map 6 Carbon Storage Potentials in Tons per Hectare



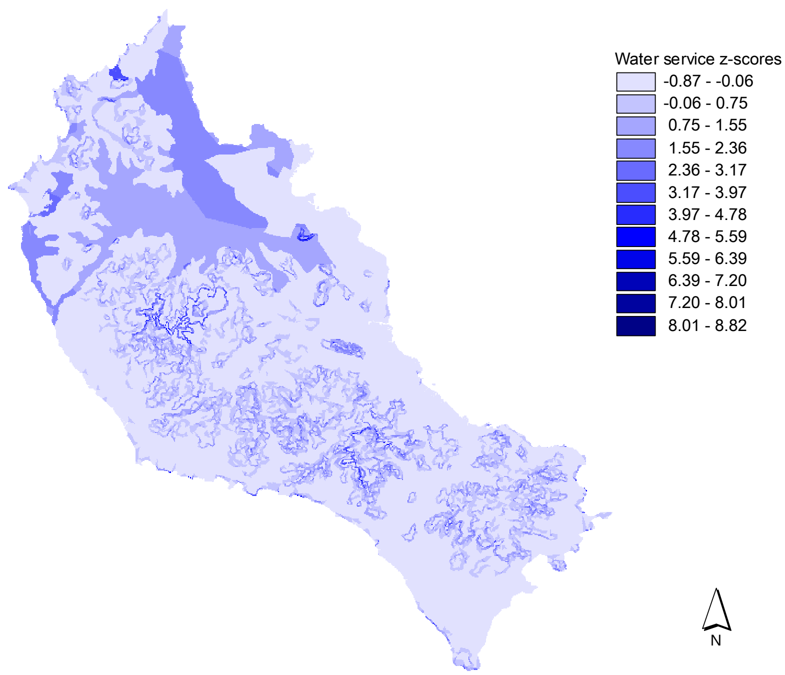
Map 7 Slope in Percentages



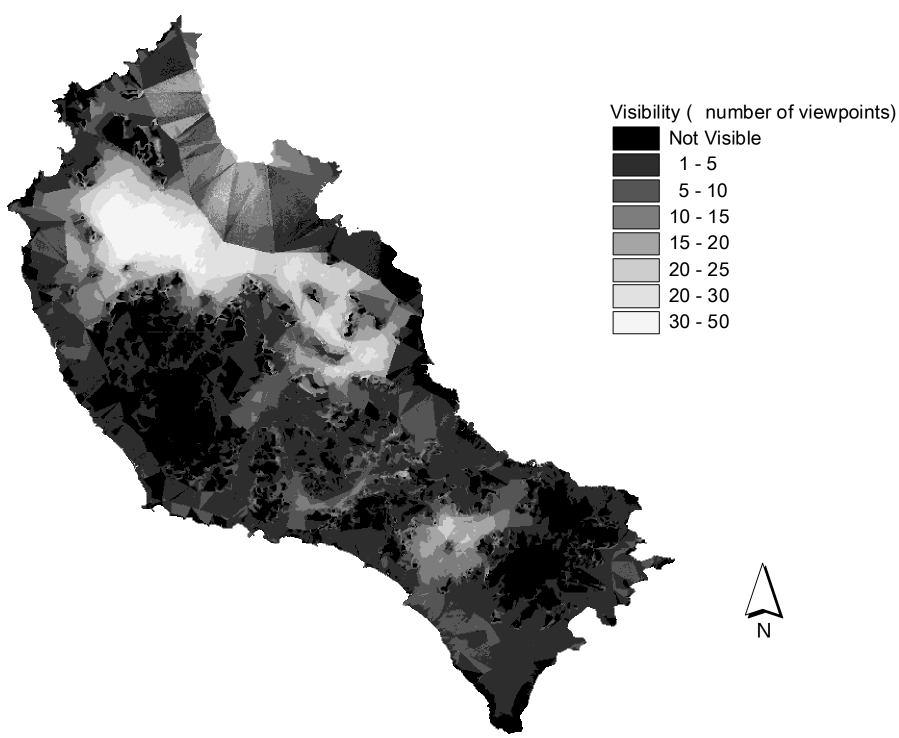
Map 8 Groundwater Demand in Liters per Hour



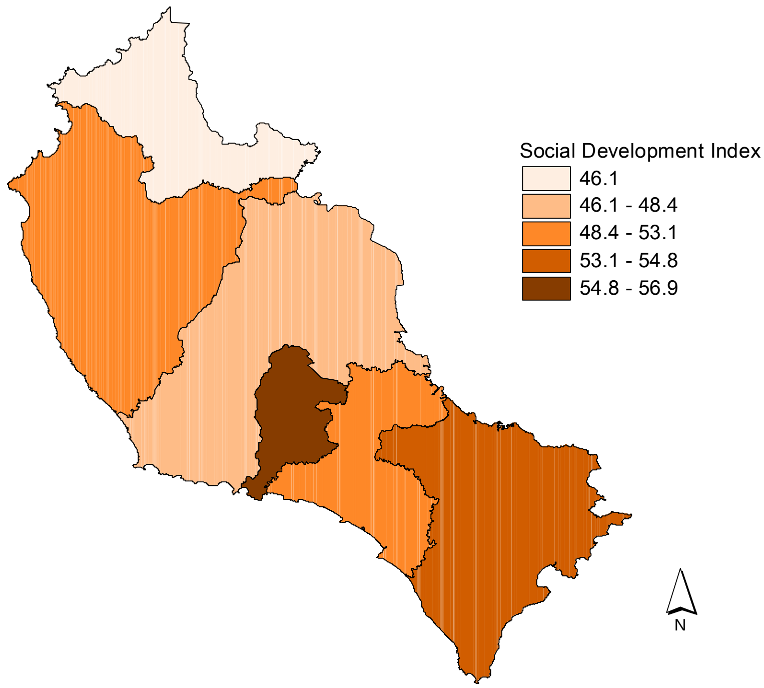
Map 9 Water Service z-Scores



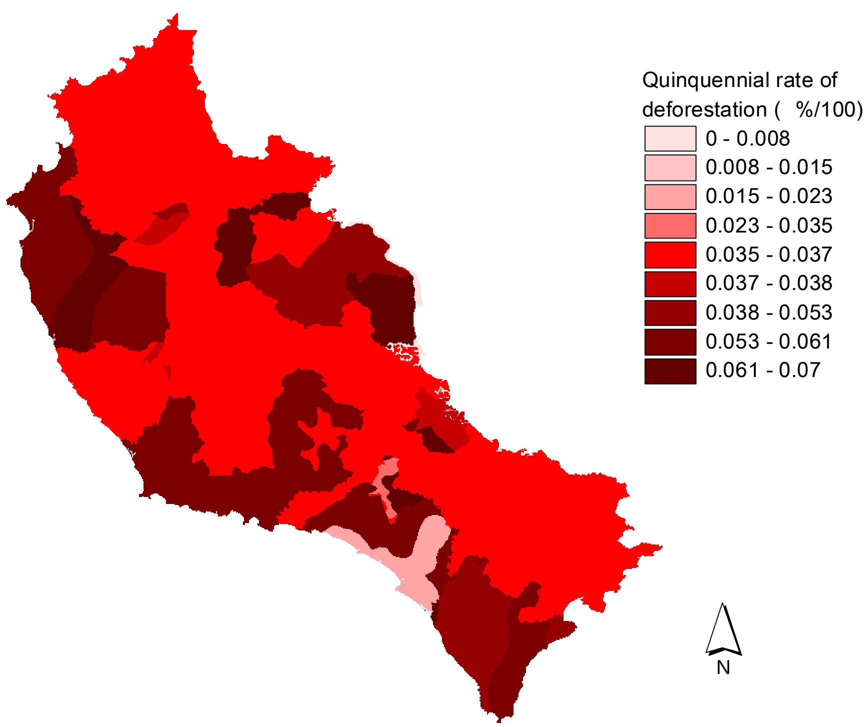
Map 10 Visibility of Pixels in Number of Viewpoints



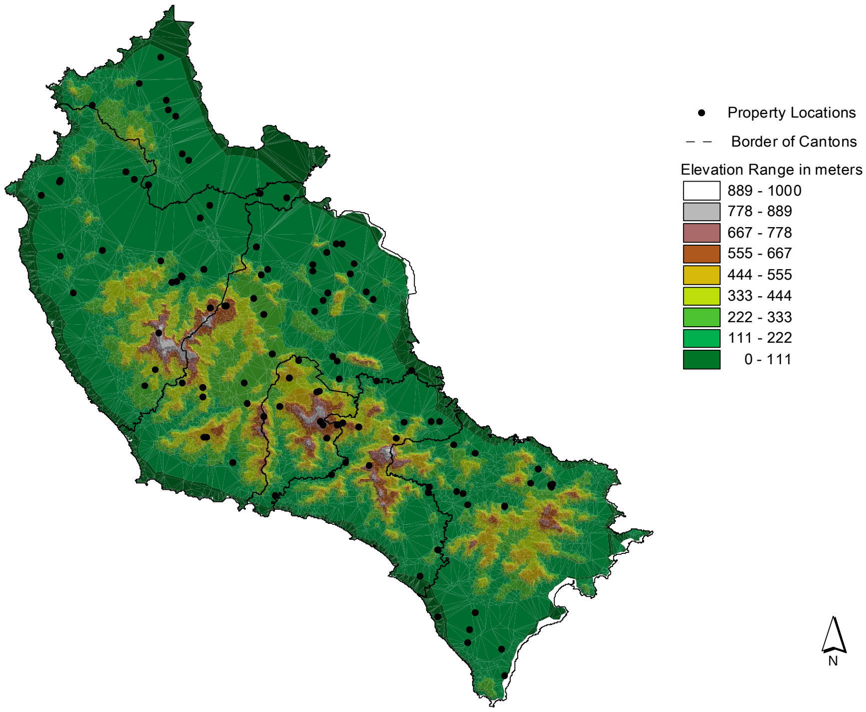
Map 11 Social Development Index (IDS)



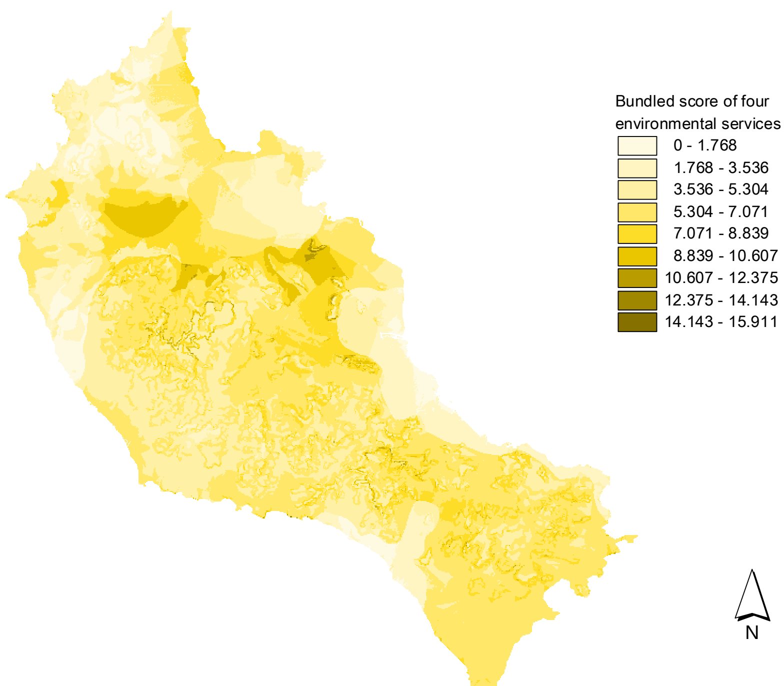
Map 12 Five-year Rate of Deforestation in Percentages * 100^{-1}



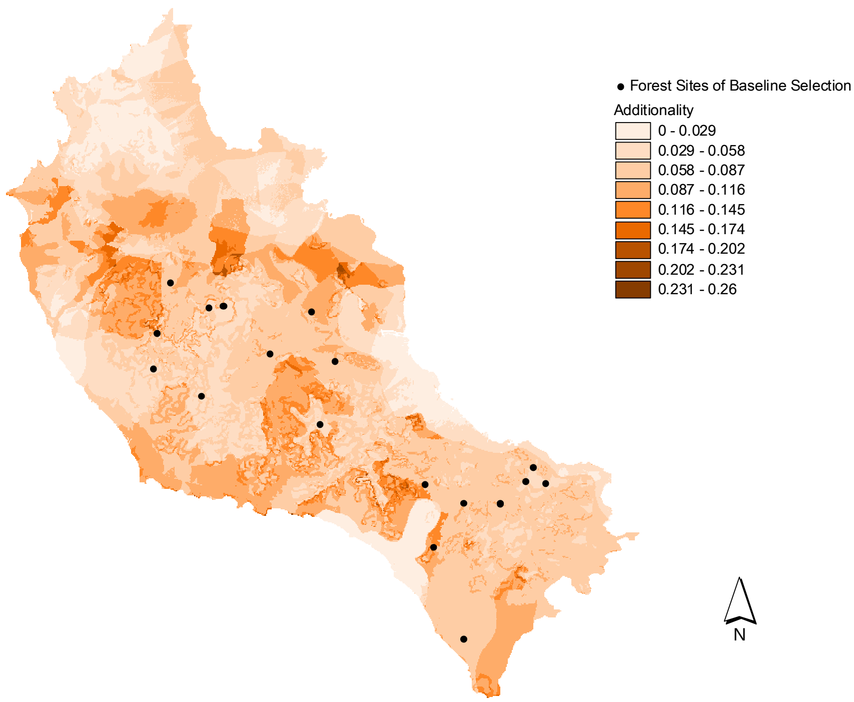
Map 13 Location of Forest Parcels on Nicoya Peninsula



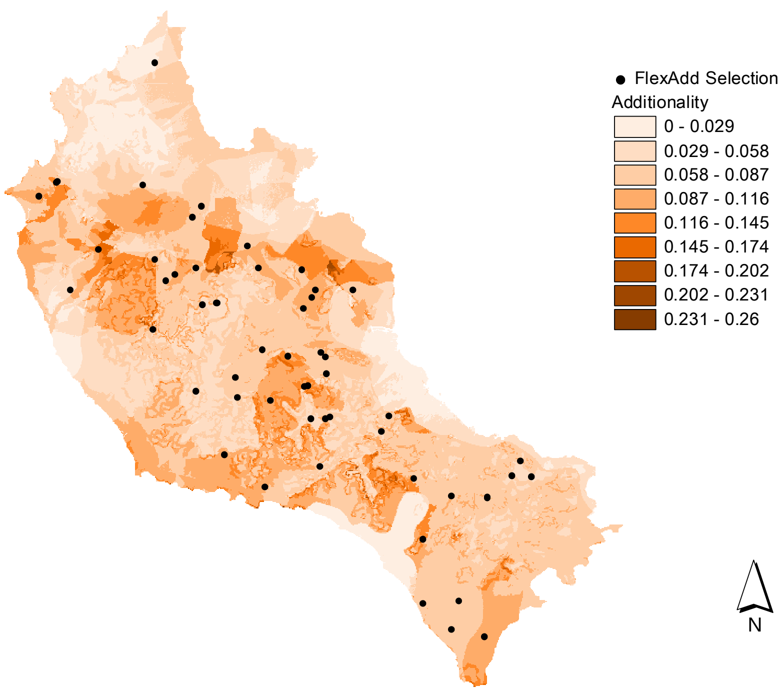
Map 14 Bundled z-score of four Environmental Services



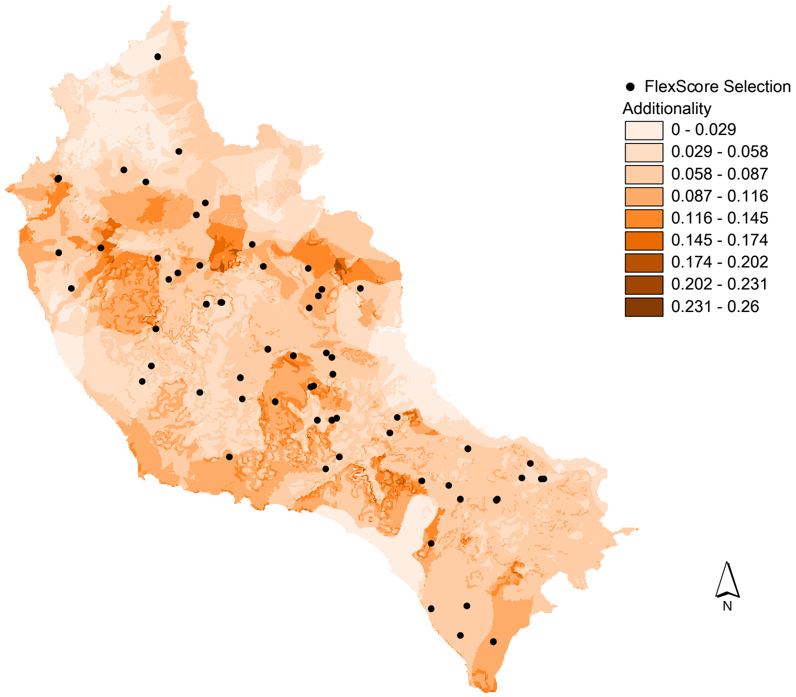
**Map 15	Site Selection of Baseline Approach and Bundled Additionality**



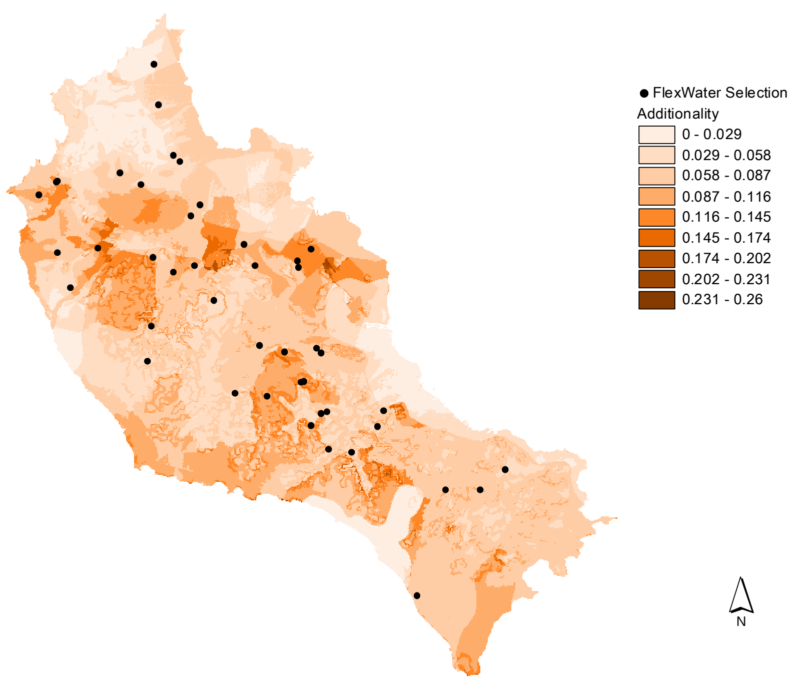
**Map 16	Site Selection of FlexAdd Approach**



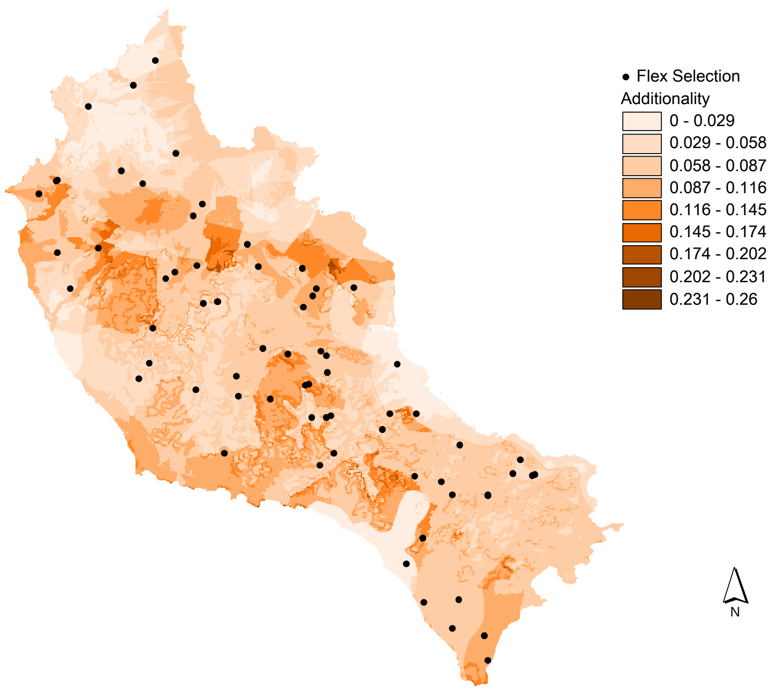
Map 17 Site Selection of FlexScore Approach



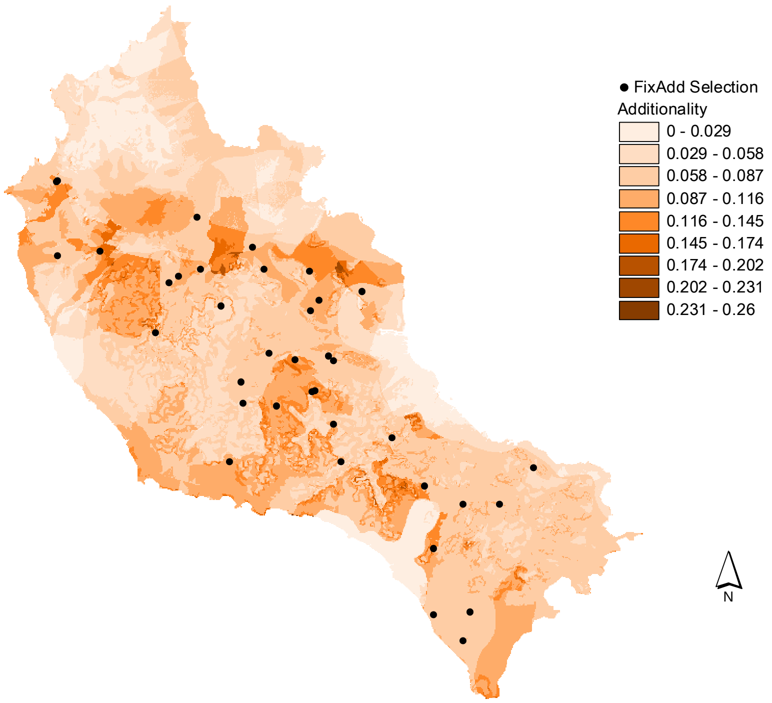
Map 18 Site Selection of FlexWater Approach



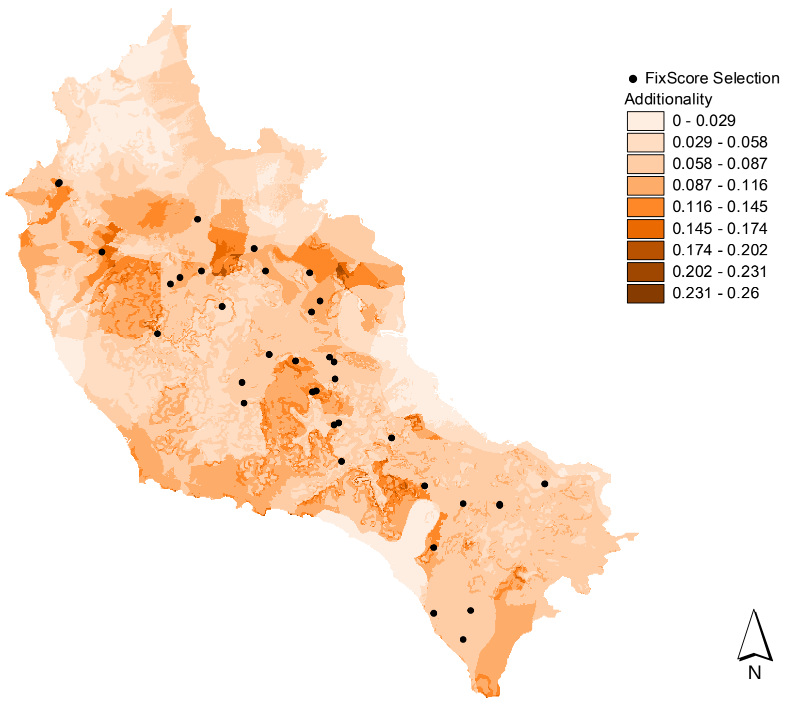
Map 19 Site Selection of Flex Approach



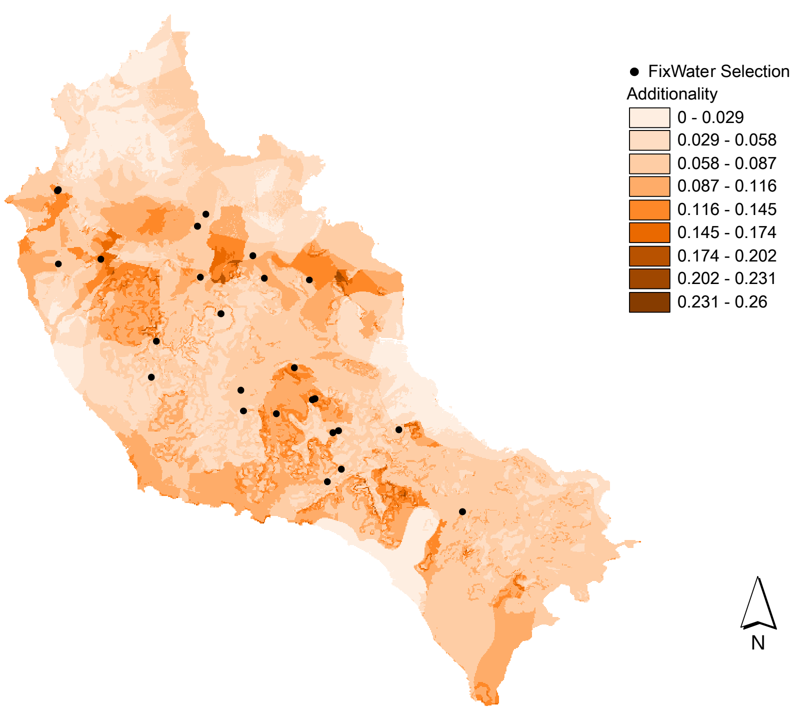
Map 20 Site Selection of FixAdd Approach



Map 21 Site Selection of FixScore Approach



Map 22 Site Selection of FixWater Approach



Appendix II (Questionnaire)

Número de Encuesta: ____________ ***Coordenadas: ________________, USR_________________***
Original de la Lista *0 Si* *0 No* → ***Nombre del productor (apuntelo aparte)***
Número de telefono: (apuntelo aparte)
Encuestador: ___________________

Fecha: ______________ ***Horas: _____:_____ - _____:______*** ***Duración: _______min.***

Descripción subjectiva del productor por el encuestador para recordar mejor:

Tipo de vía: 0 carretera de asfalto – circulación de todo tipo de vehiculo – todo el año
0 carretera de lastre tipo primario – circulación de todo tipo de vehiculo – todo el año
0 carretera de lastre o tierra tipo secundario – circulación de todo tipo de vehiculo – todo el año
0 carretera de lastre o tierra tipo tercero – **no permite** circulación de 4x2 (automovil) todo el año
0 vías angostas que sirven de servidumbre

Sevicios I: Acera: 0 Si 0 No Cordón / Caño: 0 Si 0 No

Buenos días/tardes. Soy estudiante del CATIE (Centro Agronómico Tropical de Investigación y Enseñanza) en Turrialba, Cartago. Estamos realizando una encuesta en la zona de Guanacaste con propietarios de tierra mayor a 3 ha. El fin de esta encuesta es aumentar la claridad sobre el uso de la tierra, el manejo de la tierra, los beneficios que brinde la tierra a sus propietarios, así como la relación del propietario con el bosque.

La información solicitada para este estudio será tratada de forma confidencial y no se utilizará para otros fines. La información será analizada únicamente en forma grupal. Entonces, no nos referimos a repuestas individuales de un propietario específico. Este estudio es realizado por Tobias Wünscher, estudiante alemán de la Universidad de Bonn, Alemania, en colaboración con el CATIE. Si tiene alguna duda, puede llamar al 828 6229 y hablar con Tobias Wünscher.

La duración de la encuesta es de aproximadamente 45 minutos. Todas las preguntas de esta encuesta se refieren al año 2004. En la encuesta se usa la palabra "finca" para todo tipo de propiedad (terreno, propiedad, etc.). Le agradecemos su colaboración y apoyo.

1 Ud. Es dueño de esta finca?

0 Sí → Ud. Es el único dueño de esta finca o hay más propietarios?
0 único
0 más dueños → cuántos? _____________
0 No

2 Ud. Es la persona que principalmente maneja y toma las ecisiones que afectan la finca?

0 Si → Qué relación tiene con el (los) dueño(s)? _____________________________ *(solo si el no es dueño)*
→ Quién más toma ecisiones? _____________________

0 No → (*termine la encuesta)*

3 Ud. Posee / maneja / tiene acceso a cuántas fincas?

1. __________ ha/mz → ubicación? ___________
2. __________ ha/mz → ubicación? ___________
3. __________ ha/mz → ubicación? ___________
4. __________ ha/mz → ubicación? ___________

4 Ud. Dedica sus horas de trabajo únicamente a actividades en **su(s) finca(s)** o tiene otras actividades fuera de **la(s) finca(s)** (p.ej. empleado público, peón, otro negocio) ¿

0 únicamente en la(s) finca(s)
0 también otras actividades → cuales? ______________________________________

5 Hay ingresos de su casa/hogar/familia, que <u>no</u> provienen de **su(s) finca(s)** (p.ej. trabajo como peón, otro negocio, empleado, ingresos de su esposa/o, pensiónes, parientes) ?

0 Sí → de cuáles actividades/fuentes? _______________________________
0 No

6 Qué porcentaje de los ingresos de su casa/hogar/familia provienen de **su(s) finca(s)**? _____%

(Asegúrese que casi todas las preguntas siguientes sólo se refieren a la finca donde se encuentran en ese momento. Se seleccionará la finca que está más cerca del lugar de la entrevista, que tenga un mínimo de 3 ha y que tenga la mayor importancia económica de todas las fincas.)

Información general de esta sola finca

7 Ubicacion de esta sola finca:

Provincia: ______________________
Canton: ______________________
Distrito: ______________________
Caserío/Pueblo: ______________________

8 Cuál es el área total de esta sola finca? ___________ ha / mz

9 Cuál es el área de:

Cultivos anuales	___________	ha / mz
Cultivos perennes	___________	ha / mz
Pasto	___________	ha / mz
Tacotales / Charrales	___________	ha / mz
Plantaciones forestales	___________	ha / mz
Bosque primario	___________	ha / mz
Bosque secundario	___________	ha / mz
Otro, ________________	___________	ha / mz

10 Una semana típica de 7 días está compuesta de cuántos días...

trabajando para **esta sola finca**? _________ días
trabajando para actividades **fuera de esta sola finca**? _________ días
tiempo libre? _________ días

En un día trabajando para **esta sola finca** cuántas horas trabaja? _________ horas / día

*(Total de horas por semana trabajando para **esta sola finca**: ______________horas / semana)*

11 Del tiempo trabajando para actividades en **esta sola finca**, que porcentaje de su tiempo dedica a:

Ganadería ______________%
Cultivos anuales ______________%
Cultivos perennes ______________%
Plantaciones forestales ______________%
Bosque primario / secundario ______________%

Otro, ________________ ______________%

12 Además de Ud., hay otros miembros de la familia que participan en las labores de esta sola finca sin recibir un sueldo?

0 Si 0 No

			% de tiempo dedicado a...				
Miembro (hermano, hijo, etc.)	**días por semana**	**horas por día**	**Ganadadería**	**Cultivos anuales**	**Cultivos perennes**	**Plantaciones forestales**	**Bosque**

13 Cuáles de los siguentes servicios tiene en su finca?

Alumbrado 0 Si 0 No
Teléfono 0 Si 0 No
Electricidad 0 Si 0 No
Cañería 0 Si 0 No

14 Cuáles son sus fuentes de agua en la finca / para el ganado?

0 Acceso a agua del AyA / pueblo
0 Pozos
0 Ríos / Quebradas / Nacientes / Lagunas → cuántos meses por año tienen agua? _____________meses
0 Lluvia permanente
0 Estanque de captación de agua
0 Otro, especifique_____________________

15 Ud. tiene.....

Cañería de riego / canales de riego? 0 Si 0 No
Bombas de agua? 0 Si 0 No

16 En esta finca hay accesso de automovil (4x2) durante todo el año? 0 Sí 0 No

17 En esta finca hay accesso de carro 4x4 durante todo el año? 0 Sí 0 No

18 Ha comprado terreno adicional a la finca en los últimos 5 años?

0 Sí → en qué año? 200______

→ cuántas hectáreas? _________ha → cuánto pagó Ud.? _______________¢/ha

→ de los siguientes usos del suelo, para qué es apto el terreno adicional?

Cultivos anuales	______ ha
Cultivos perennes	______ ha
Pasto	______ ha
Charrales / Tacotales	______ ha
Plantaciones forestales	______ ha
Bosque natural	______ ha
Otro, especifique __________________	______ ha

0 No

19 Tiene una idea de cuál es el precio de mercado en esta finca de acuerdo al uso de la tierra?

Cultivos anuales	__________________ ¢ / ha
Cultivos perennes	__________________ ¢ / ha
Pasto	__________________ ¢ / ha
Charrales / Tacotales	__________________ ¢ / ha
Plantaciones forestales	__________________ ¢ / ha
Bosque primario	__________________ ¢ / ha
Bosque secundario	__________________ ¢ / ha
Finca en total	__________________ ¢

0 No tengo idea

20 Por favor, podría hacer un dibujo / plano de su finca en este hoja? Por favor, indique:

1. Uso actual del suelo	**2. Pendientes del terreno**	**3. Capacidad de uso del suelo**
cultivos anuales	plano	**1 excelente** (casi todo uso, principalmente cultivos anuales)
cultivos perennes	levemente ondulado	**2 muy bueno optimo** (casi todo uso con limitaciones leves)
pasto	ondulado	**3 muy bueno** (cultivos anuales todavía possible, muy bien para pasto)
tacotales/charrales	quebrado	**4 bueno** (pasto muy adecuado, cultivos anuales difíciles)
plantaciones forestales	muy quebrado	**5 regular optimo** (pasto adecuado)
bosque primario		**6 regular regular** (pasto possible, más adecuado manejo de bosque)
bosque secundario		**7 malo** (solo manejo de bosque)
		8 muy malo (solo sirve para protección de bosque)

4. Largo de los caminos públicos que atraviesan o limitan su finca

Plantaciones Forestales

0 **No tiene plantaciones forestales**

21 Cuáles especies de plantaciones forestales tiene (p.ej. Teca), en cuál año sembró cuánta área, etc.?

	Especie(s)	**ha / mz**	**año de siembra**	**4x4 4x3 3x3**	**altura max.**	**año de medida**	**crecimiento/estado***	**año final aprovechamiento?**	**Expectativa de venta en pulgadas (PMT)**
1									
2									
3									
4									

* uniform (1), recto (2), torcido (3), inclinado (4), mortalidad presente (5), espacios con árboles muertos (6), otro especifique (7), Presencia de enfermedades (8): * hongos (a), hormigas (b), otros insectos, especifique (c)

22 A cuál mercado quiere vender?

0 Aserradero → a cuántos km se encuentra de la plántación?_________km
→ Cuanto cuesta el transporte al aserradero mencionado? _____________________
0 Intermediario
0 Otro, especifique _____________________

23 Quiere vender........ 0 en pie? 0 troza? 0 tabla?
0 no sé 0 otro, especifique _______________________

24 Mantiene un plan de reforestación? 0 Si → *(pidelo para solicitar info de pregunta 0)*
0 No

25 Cuáles actividades realizó para la plantación de mayor importancia? (*la más grande que tiene minimo de 3 años*)

Número de plantación: ¢	**Especie(s):**	**Año de siembra:**	**Precio 1 jornal:**
	Jornales totales / contratados	**Gasto materiales**	**Comentario**
Año 1			
(1) Preparación del terreno			
(2) Ahoyado			
(3) Compra y transporte de plántulas			
(4) Siembra			
(5) Rodajea / Chapea			
(6) Abonar			
(7) Control quimico herbicida			
(8) Control quimico pesticida			
(9) Mantener Rondas			
(10) Vigilancia			
(11) Cercas			
Otro:_______________________			
Año 2			

	Jornales totales / contratados	Gasto materiales	Comentario
Año 3			
(5) Rodajea / Chapea			
(6) Abonar			
(7) Control quimico herbicida			
(8) Control quimico pesticida			
(9) Mantener Rondas			
(10) Vigilancia			
(11) Cercas			
(12) Raleos **(intensidad: ____/ 9)**			Ingreso:
(13) Podas			
(14) Otro: ___________________			
Año 4			
Año 5			
Año 6			
Año 7			
Año 8			
Año 9			
Año 10			
Año 10-30			

Bosque primario / secundario

0 **No tiene Bosque prim. / sec.**

26 Cuáles son los beneficios que tenía en 2004 por tener bosque?

Beneficios domesticos	**Cantidad**	**Cuánto (¢) pagaría en el mercado?**	**Comentario**
Postes para cercas			
Madera para construcción			
Frutas			
Caza			
Pastoreo			
Actividades recreativas personales			
Otro, ________________			

Beneficios comerciales	**Cantidad**	**Cuánto le pagaron (¢)**	**Comentario**
Postes para cercas			
Madera para venta			
Frutas			
Animales cazados			
Pastoreo			
Turismo			
Otro, ________________			

27 Cuáles son los gastos tenía Ud. en el 2004 por tener bosque?

Tipo de Gastos	**Gasto (¢) (materiales y mano de obra contratada)**	**Comentario**
Hacer rondas		
Vigilancia		
Impuestos territorial		
Otro, _______________		
...		

La Ganadería

28 Cuál es la producción principal de su ganadería?

0 Leche
0 Carne *(producción directa con animales de engorde, pero también producción de cría, terneros, toretes, toros)*
0 Leche y Carne *(no aplica la producción de leche solo para gastos de la casa)*

29 Cuántas cabezas de ganado tiene (vacas secas, vacas en ordeño, novillos/-as, terneros/-as, bueyes, toros)?:

Total	__________________	cabezas
Vacas de leche (en ordeño)	__________________	cabezas
Vacas de leche (secas)	__________________	cabezas
Vacas de cría	__________________	cabezas
Novillas	__________________	cabezas
Novillos / Toretes	__________________	cabezas
Terneros/-as	__________________	cabezas
Bueyes	__________________	cabezas
Toros	__________________	cabezas

30 Costos variables durante el 2004

Tipo de Gastos	Cantidad / Frequencia / Costo por unidad (¢)	Costo Total (¢)
Inseminación artificial / Monta natural?		
Veterinario / Medicina?		
Vacunas		
Desparasitantes		
Fumigación / Bañar		
Medicina para Renquera		
Mastitis		
Otro, ___________________		
Suplementos		
Melaza / Miel		
Gallinaza		
Sal mineral		
Minerales		
Caña / pasto de corta		
Concentrado / Granos		
Semolina		
Pacas / Silage		
Azufre / Vitaminas		
Otro, _________________		
Seguros de animales		
Impuestos territorial		

31 Ud. utiliza electricidad en la ganadería, p.ej. para cercas, bombas de agua, corral, ordeño?

0 Si → Cual fue el costo de electricidad para la ganadería en el 2004? _________________ ¢
0 No

32 Ud. utiliza agua en la ganadería, p.ej. para los animales, limpieza, riego?

0 si → Cual fue el costo del agua para la ganadería en el 2004? _________________ ¢
0 no

33 (Esta pregunta ya no hay)

34 Cuál era su gasto total en **mano de obra contratada** en la ganadería en 2004 (para las actividades de abonar, chapear, fumigar, mantener cercas, mantener rondas, lechería)?

Gasto total _________________________ ¢

35 Ud. abonó los pastos en el 2004? 0 Sí 0 No

Costo total de abonar: ___________ ¢					
ha abonadas: ___________ha					
	tipo de costo	cantidad	precio	total (¢)	comentario
1	abono				
2	maquinaria				
3	mano de obra contratada				
4	otro,________				

36 Ud. chapeó los pastos en el 2004? 0 Sí 0 No

Costo total de chapear: ___________ ¢					
ha chapeadas: ___________ha					
	tipo de costo	cantidad	precio	total (¢)	comentario
1	maquinaria				
2	mano de obra contratada				
3	otro,________				

37 Ud. fumigó los pastos en el 2004? 0 Sí 0 No

Costo total de fumigar: ___________ ¢					
ha fumigadas: ___________ha					
	tipo de costo	cantidad	precio	total (¢)	comentario
1	quimicos				
2	maquinaria				
3	mano de obra contratada				
4	otro,________				

38 Ud. mantenió las cercas durante el 2004? 0 Sí 0 No

Costo total para mantener cercas: ___________ ¢					
Mantenimiento cercas					
	tipo de costo	cantidad	precio	total (¢)	comentario
1	alambre				
2	postes				
3	grapas				
4	mano de obra				

39 Ud. mantenió las rondas durante el 2004? 0 Sí 0 No

Costo total de mantener rondas: ___________ ¢					
Mantenimiento rondas					
	tipo de costo	cantidad	precio	total (¢)	comentario
1	quimicos				
2	maquinaria				
3	mano de obra contratada				
4	otro,________				

40 En el 2004 pagó Ud. por alquiler de pasto? 0 Sí 0 No

Costo total de alquiler pasto: ____________________¢				
Alquiler				
	Número de animales	cuántos meses	precio por mes y animal (¢)	total (¢)
1				
2				
3				

41 En el 2004 pagó Ud. por compra de ganado? 0 Sí 0 No

Costo total por compra de ganado: ____________________¢				
Comprar ganado				
	Tipo de animal (e.j. ternero, novillo, etc.)	Número de animales	Cuánto pagó por animal (¢)?	Gasto transporte si no esta ya incluido (¢)
1				
2				
3				

42 En 2004 cuáles productos de su ganadería vendió?

Ingreso total por ganadería: __________________¢				
Producto	**Cantidad**	**Cuánto le pagaron (¢)?**	**Gasto transporte si no esta ya incluido (¢)**	**Comentario**
Leche				
Queso				
Heno / pacas				
Silage				
Alquiler de pasto				
Toros				
Bueyes				
Novillos / Toretes				
Novillas				
Vacas				
Terneros/-as				
otro,____________				

43 Cuánto cree Ud. es su ganancia en el 2004 (beneficio económico en ¢) por hectárea de pasto en su ganadería. Podría darnos una estimación approximadamente? ________________________¢ / ha

0 No tengo idea

Charrales / Tacotales

0 **No tiene Charrales / Tacotales**

44 Sus Charrales / Tacotales también forman parte de su pastoreo?

0 Si → Supongamos que Ud. no tendría los charrales / tacotales en su finca. En cuánto tendría que reducir sus cabezas de ganado para alimentarlos? Reducir por ___________ cabezas; me quedarían ___________ cabezas

0 No

45 Después del uso para pastoreo, cuáles otros beneficios le daron los charrales / tacotales en 2004?

Beneficio domesticos	**Cantidad**	**Cuánto (¢) pagaría en el mercado?**	**Comentario**
Postes para cercas			
Madera para construcción			
Frutas			
Caza			
Pastoreo			
Actividades recreativas personales			
Otro, _______________			

Beneficio comerciales	**Cantidad**	**Cuánto le pagaron (¢)**	**Comentario**
Postes para cercas			
Madera para venta			
Frutas			
Animales cazados			
Pastoreo			
Turismo			
Otro, _______________			

46 Cuáles son los gastos que representaban para Ud. los charrales / tacotales en el 2004?

Tipo de Gastos	**Gasto (¢) (materiales y mano de obra contratada)**	**Comentario**
Hacer rondas		
Vigilancia		
Impuestos territorial		
Otro, ______________		
...		

WTA

47 Ha escuchado hablar del programa de Pago por Servicios Ambientales (PSA)? 0 Sí

0 No → *(sigue con)*

Me gustaría resumir brevemente las condiciones del programa de PSA:

- El Estado esta interesado en conservar / aumentar el área de bosque.
- Por un contrato de 5 años Ud. se compromete a proteger el bosque.
- Ud. puede incluir terrenos de bosque asi como terrenos de otros usos (p.ej. pastos) para renovación natural de bosque
- Protección significa que es, prohibido meter ganado, sacar madera u otros productos, poner fuegos, cazar, además tiene la responsibilidad de asegurar que otras personas no lo hagan. Tambien hay que mantener rondas para evitar fuegos, poner rotulos y en algunos casos poner/mantener cercas (depende de cercanía de ganado).
- Ud. puede solicitar la renovación del contrato después de 5 años. Sin embargo, el Estado no garantiza la renovación.
- Por su compromiso el Estado le pagará una compensación durante los 5 años del contrato. El monto es variable dependiendo de la zona.

48 Tiene/tenía alguna parte de su finca en el programa de PSA?

0 Sí → cuántas hectáreas tiene/tenía en cuál modalidad de PSA, en qué años las incluyó, cuánto le pagan/pagaban por ha y año, cuál era/había sido el uso antes de incluirlas al PSA?

					En cuál modalidad?				
	ha	años	¢/año/ ha	uso antes de PSA*	Protección/ Renovación	Plantación/ Reforestación	Plantación ya establecida	Plan de manejo	Agroforestería (# árboles)
1		-							
2		-							
3		-							
						(sigue con 55)	*(sigue con 55)*	*(sigue con 55)*	*(sigue con 55)*

* bosque primario/secundario (1), charrales/tacotales (2), Pasto (3), cultivos perennes tal como cafe (4), Cultivos anuales (5), plantaciones forestales (6)

0 No → (*sigue con 55)*

49 Del monto, lo cuál Ud. mencionó que le pagan/pagaban por año y hectária, cuál parte gasta/gastaba para:

Regente forestal? ______________ ¢ / año
Intermediario (Centro Agrícola, ONG, otra organisación, etc.) ______________ ¢ / año
Hacer/mantener rondas ______________ ¢ / año
Hacer/mantener cercas ______________ ¢ / año
Hacer/mantener rotulos ______________ ¢ / año
Otro, especifique __________________ ______________ ¢ / año

50 Ud. paga/pagaba menos impuestos por tener área bajo PSA? 0 Sí → cuántos menos? ____________ ¢ / año
0 No

51 Por qué no incluyó más área al programa de PSA?

0 He solicitado para más área pero no me lo aprobaron
0 No conocía el programa muy bien, quería ver si me funciona
0 La rentabilidad de las otras partes de mi finca es mayor que el pago de PSA
0 Otro, especifique ___________________________

52 *(Esta pregunta se refiere solo para él que tenía pero ya no tiene área en PSA):*

Por qué ya no tiene área en PSA? 0 No me renovaron el contrato
0 otro, especifique ________________________________

53 Si Ud., bajo las condiciones de 2005 (21 000 ¢/ha/año, respectivamente 17 500 ¢/ha/año), podría incluir cualquier cantidad de hectáreas de su finca al PSA (modalidad protección/renovación natural), cuántas hectáreas incluiría **en total**? ______________ ha/mz

a. (*Si es cero ha/mz)*: Por qué? ____________________________

b1. (Si es más que cero): Qué tipo de área Ud abandonaría para ponerles bajo protección en el programa de PSA?

0 área que ya esta / estaba en PSA ________ ha/mz
0 bosque primario /secundario ________ ha/mz
0 charrales / tacotales ________ ha/mz
0 plantaciones forestales ________ ha/mz
0 pasto ________ ha/mz
0 cultivos perennes ________ ha/mz
0 cultivos anuales ________ ha/mz
0 otro, especifique: ___________ ________ ha/mz

b2. (*Si es más de la que tiene/tenía en PSA):*

Por qué incluiría más de las que tiene/tenía en PSA? ________________________________

54 Si aumentaran el pago a 30 000 ¢/ha/año (respectivamente 25 000 ¢/ha/año) cuántas hectáreas incluiría al PSA (modalidad protección/renovación natural) **en total**?___________ ha/mz

a. (*Si es cero ha/mz)*: Por qué? ____

b. (*Si es más que cero)*: Qué tipo de área Ud abandonaría para ponerles bajo protección en el programa de PSA?

0 área que ya esta / estaba en PSA ________ ha/mz
0 bosque primario /secundario ________ ha/mz
0 charrales / tacotales ________ ha/mz
0 plantaciones forestales ________ ha/mz
0 pasto ________ ha/mz
0 cultivos perennes ________ ha/mz
0 cultivos anuales ________ ha/mz
0 otro, especifique: ______________ ________ ha/mz

(sique con 66)

55 Por qué no ha incluido una parte de su terreno en PSA para la modalidad de protección/renovación natural?

0 He solicitado para participar en PSA, pero no lo aceptaron → (*sigue con 60)*
0 Estoy solicitando para participar en PSA → (*sigue con 60)*
0 Otro, especifique ________________________________ → (*sigue con)*

56 ////

57 Si le pagarían 21 000 ¢/ha/año, cuántas hectáreas estaría dispuesto a incluir en PSA (protección)?
__________ha/mz

a. (*Si es cero ha/mz)*: Por qué? ____

b. (*Si es más que cero)*: Qué tipo de área Ud abandonaría para ponerles bajo protección en el programa de PSA?

0 bosque primario /secundario ________ ha/mz
0 charrales / tacotales ________ ha/mz
0 plantaciones forestales ________ ha/mz
0 pasto ________ ha/mz
0 cultivos perennes ________ ha/mz
0 cultivos anuales ________ ha/mz
0 otro, especifique: ______________ ________ ha/mz

58 Si le pagarían 30 000 ¢/ha/año, cuántas hectáreas estaría dispuesto a incluir en PSA (protección)? ________ ha / mz

a. (*Si es cero ha/mz)*: Por qué? ____

b. (*Si es más que cero)*: Qué tipo de área Ud abandonaría para ponerles bajo protección en el programa de PSA?

0 bosque primario /secundario ________ ha/mz
0 charrales / tacotales ________ ha/mz
0 plantaciones forestales ________ ha/mz
0 pasto ________ ha/mz
0 cultivos perennes ________ ha/mz
0 cultivos anuales ________ ha/mz
0 otro, especifique: ______________ ________ ha/mz

(La siguiente pregunta es solo para los que no quisieran incluir ninguna parte de su terreno al PSA (modalidad protección/renovación natural):

59 Cuál sería el monto mínimo que le deberían pagar para incluir una parte de su terreno al PSA (modalidad protección/renovación)? __________________¢/ha/año

sigue con 66

- ***Para él que está solicitando para PSA:***
- ***Para él que ha solicitado para PSA, pero no lo aceptaron:***

60 Para cuántas hectáreas solicitó de PSA, en cuál modalidad, en qué año solicitó, cuánto le pagarían/habrían pagado por ha y año, cuál es/era el uso del terreno que quiere/quería incluir al PSA?

					En cuál modalidad?				
	ha	años	¢/año/ ha	uso antes de PSA*	Protección/ Renovación	Plantación/ Reforestación	Plantación ya establecida	Plan de manejo	Agroforesterí a (# árboles)
1		-							
2		-							
3		-							
						(sigue con 66)	*(sigue con 66)*	*(sigue con 66)*	*(sigue con 66)*

* bosque primario/secundario (1), charrales/tacotales (2), Pasto (3), cultivos perennes tal como cafe (4), Cultivos anuales (5), plantaciones forestales (6)

61 Del monto, lo cuál Ud. mencionó que le pagaríen/habríen pagado por año y hectária, cuál parte gastaría/habría gastado para:

Regente forestal? ______________ ¢ / año
Intermediario (Centro Agrícola, ONG, otra organisación, etc.) ______________ ¢ / año
Hacer/mantener rondas ______________ ¢ / año
Hacer/mantener cercas ______________ ¢ / año
Hacer/mantener rotulos ______________ ¢ / año
Otro, especifique __________________ ______________ ¢ / año

62 Ud. pagaría/habría pagado menos impuestos por tener área bajo PSA? 0 Sí → cuántos menos? ________ ¢/año

0 No

63 Por qué no solicitó incluir más área al programa de PSA?

0 Quería, pero me dijeron que no hay recursos para tanta área
0 No conozco el programa muy bien, quiero ver si me funcionará
0 La rentabilidad de las otras partes de mi finca es mayor que el pago de PSA
0 Otro, especifique ___________________________

64 Si Ud., bajo las condiciones de 2005 (21 000 ¢/ha/año, respectivamente 17 500 ¢/ha/año), podría incluir cualquier cantidad de hectáreas de su finca al PSA (modalidad protección/renovación natural), cuántas hectáreas incluiría **en total**? ______________ ha/mz

a. (*Si es cero ha/mz)*: Por qué?
____

b1. (Si es más que cero): Qué tipo de área Ud abandonaría para ponerles bajo protección en el programa de PSA?

0 área para que ya solicitó ________ ha/mz
0 bosque primario /secundario ________ ha/mz
0 charrales / tacotales ________ ha/mz
0 plantaciones forestales ________ ha/mz
0 pasto ________ ha/mz
0 cultivos perennes ________ ha/mz
0 cultivos anuales ________ ha/mz
0 otro, especifique: ______________ ________ ha/mz

b2. (*Si es más que el área para que ha solicitado PSA):*
Por qué incluiría más que el área para que ha solicitado PSA? ___________________________

65 Si aumentaran el pago a 30 000 ¢/ha/año (respectivamente 25 000 ¢/ha/año) cuántas hectáreas incluiría al PSA (modalidad protección/renovación natural) **en total**?___________ ha/mz

a. (*Si es cero ha/mz)*: Por qué? ____

b. (*Si es más que cero)*: Qué tipo de área Ud abandonaría para ponerles bajo protección en el programa de PSA?

0 área para que ya solicitó ________ ha/mz
0 bosque primario /secundario ________ ha/mz
0 charrales / tacotales ________ ha/mz
0 plantaciones forestales ________ ha/mz
0 pasto ________ ha/mz
0 cultivos perennes ________ ha/mz
0 cultivos anuales ________ ha/mz
0 otro, especifique: ______________ ________ ha/mz

Información personal

66 Cuál es su edad? ____________años

67 Ud. fué a la escuela? → Secundaria? → Técnico? → Universidad/Tecnológico?

0 Primaria incompleta
0 Primaria completa
0 Secundaria incompleta
0 Secundaria completa

0 Técnico incompleto
0 Técnico completo
0 Universidad / Tecnológico incompleta
0 Universidad / Tecnológico completa

68 Cuántas personas viven en su casa?

		Edades *(solo si son menor de 18 años)*
yo mismo	_____1_____	
esposo/-a (pareja)	___________	
hijos	___________	______________________________
otros	___________	______________________________
personas en total	___________	

69 Podría indicarme de la siguente lista cuál es el consumo* total por mes de su hogar/casa incluyendo todos los gastos de todas las personas que viven en su hogar/casa?

*Consumo incluye todos los gastos que no son para la finca: p.ej. alimentación, ropa, gastos escolares (escuela, colegio, universidad), gastos para el carro, electrodomésticos, útiles generales, arreglos/reparaciónes, medicina, médico, seguros sociales, regalos para amigos o familiares, luz, teléfono, agua, etc.

Consumo total por mes

0 menos que 25 000 colones
0 25 001 – 50 000 colones
0 50 001 – 100 000 colones
0 100 001 – 200 000 colones
0 200 001 – 300 000 colones
0 300 001 – 400 000 colones
0 400 001 – 500 000 colones
0 500 001 – 750 000 colones
0 750 001 – 1 000 000 colones
0 mas que 1 000 000 colones

70 Cuál es su grado de confianza en programas de instituciones estatales como el programa de PSA de FONAFIFO?

0 poco 0 moderado 0 mucho

71 Sabiendo que la tala de árboles es una actividad ilegal; Supongamos que Ud. realizara una tala de árboles por un razon lo que sea, cuáles de las siguientes consecuencias aplicarían a Ud?

0 Tendría buena consiencia
0 Tendría mala consiencia
0 Tendría ni buena ni mala consiencia
0 Mi consiencia dependería de la situación y del objectivo de la tala de árboles
especifique, ____
0 ninguna

(además):

0 Tendría miedo que lo denuncien ante la fuerza publica y de las consecuencias de la denuncia
0 Tendría miedo que sufra su reputación ante la comunidad
0 ninguna

72 Cree Ud. que la rentabilidad de su tierra va a aumentar, bajar o mantenerse igual en los próximos 10 años?

0 bajar	→	0 poco	0 moderado	0 mucho
0 aumentar	→	0 poco	0 moderado	0 mucho

0 Va a mantenerse igual

73 Supongamos que Ud. tendría 3 alternativas de ganar ingresos con una parte de su terreno activo. Cada alternativa tiene sus propios potenciales de ganar dinero pero tambien su propio nivel de riesgo. Cuál de las siguientes alternativas sería su preferida?

	100 000 ¢	**50 000 ¢**	**10 000 ¢**
Alternativa A	✔	---	✔
Alternativa B	✔	✔	✔
Alternativa C	---	✔	---