Payments for environmental services in Costa Rica: increasing efficiency through spatial differentiation

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Abstract

Costa Rica was the first developing country to have implemented a nation-wide program of payments for environmental services. We analyze whether the efficiency of the program could be increased through better targeting techniques and propose a targeting mechanism which takes into account the spatial diversity of service provision and opportunity cost. Given a fixed budget we show that selecting sites according to their service delivery potential increases the amount of contracted services. The efficiency increase is even more pronounced when opportunity costs are taken into account and payment levels are varied accordingly. We also observe that the use of the above mentioned concepts decreases the average area of the selected, sites which might indicate that the proposed approaches encourage participation of the poor.

Keywords: conservation, payment, environmental services, targeting, Costa Rica

JEL: Q23, Q57

1. Introduction

In 1996, Costa Rica implemented a national program of payments for environmental services (PES). Program participants are paid for the delivery of carbon, water, biodiversity and scenic beauty services. The payment is a fixed per ha amount independent of the quality and amount of environmental services delivered. Besides legal and formal requirements which have to be met by any applicant, the forest sites are selected on the basis of predefined program areas. Sites inside these program areas qualify for participation, those outside do not, although exceptions are made. Assuming that more complex spatial differences do exist we argue that the efficiency of the PES program might be increased by paying more attention to actual service delivery of a site and by making not a fixed, but a flexible payment according to the sites' opportunity cost as they might be lower in remote or less productive areas. As the total budget is independent of the spatial distribution of the payments, flexible payments would allow to contract more area (if average payments decreased), and/or sites with exceptionally high service values but high opportunity costs. The objective of this paper is to present a concept of how spatial differences could be integrated into the selection process and whether this integration potentially leads to efficiency gains in terms of secured environmental services per dollar spent. It should be made clear at this point that the objective of this paper is not to present a ready to implement forest site selection tool. Many of our assumptions are somewhat arbitrary and data is sometimes coarse. There do exist many other ways to select and integrate data. In a real world application data and assumptions would need to be adapted to the requirements and circumstances of the individual case.

Several other attempts have been made to improve targeting of the Costa Rican PES program. Most of these attempts focused only on one environmental service or, if several environmental services were taken into account, they did not include a cost component. For example, BARTON et al. (2003) show a selection mechanism for biodiversity services including cost estimates. POWELL et al. (2000) identify gaps in the Costa Rican protected area system for adequate representation of biodiversity. IMBACH BARTOL (2005) integrate various environmental services in his targeting approach as well as estimates for the risk of deforestation but does not include a cost component. Our approach in many ways reflects the one applied by IMBACH BARTOL (2005) but, in addition, includes a cost component while missing deforestation estimates. We also employ other assumptions and use in some respects a different data base.

The remainder of the article proceeds as follows. In a background section we provide more detailed information on the PES program in Costa Rica. We then describe the study area including land use specific characteristics revealed in our field survey. Subsequently, the targeting concept and selection data will be presented which is followed by a section, in which the scenarios for the analysis are defined. We then present the results of the different selection scenarios and offer concluding remarks in the final section.

2. The Costa Rican PES program

The forestry law 7575 from 1996 prepared the ground for the implementation of the Costa Rican PES program, subsequently, the first payments for environmental services were made in 1997 (FONAFIFO, 2006). Payments are made exclusively to private landowners. The program recognizes the environmental services (carbon, biodiversity, water and scenic beauty services) generated by forest and agroforestry ecosystems only. Payments are made in return for land use activities which help to maintain the ecosystems and thus the delivery of their environmental services. Acknowledged land use activities are i. protection of natural forest, ii. establishment of timber plantations, iii. natural forest regeneration and iv. establishment of agroforestry systems.[1]

The Costa Rican PES 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 timber plantation expenditures were considered deductible from the income tax (ORTIZ, 2002). However, because many landowners 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 credit certificates which could be cashed in or used in other financial transactions, were issued to those who had made reforestation investments. They were accessible to a broader population of landowners. In 1990, in addition to the existing CAF, two new versions of forest credit certificates were introduced. They were called "Certificado de Abono Forestal por Adelantado" (CAFA) and "Certificado de Abono Forestal para Manejo" (CAFMA). In the case of CAFA, payments were made upfront, enabling especially small land holders to pay for reforestation investments when they would not dispose of financial resources otherwise. On the other hand, CAFMA supported the sustainable management of existing natural forest. In 1995 the family of forest credit certificates was further extended by the introduction of CAFMA-2000. These certificates compensated landowners who were willing to refrain from any natural forest exploitation and instead ensured 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, signed with the International Monetary Fund, obligated Costa Rica to eliminate subsidies such as the certificates. PES do not qualify as subsidies because of two fundamental differences. First, the justification for payments changed from support for the timber industry to the provision of environmental services. Secondly, the source of financing changed from the government budget to an earmarked tax and payments from 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, 2005).

[1] In our analysis we only focus on protection and regeneration of natural forest.

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 are no longer made for sustainable management of natural forests. In the same year, the establishment of agroforestry 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 credit certificate system made payments for 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. They were raised by approximately 50% and were established in dollars, and not as before in local currency. Whereas before annual net payments decreased due to controlled continuous mini step deflation, today net payments more or less maintain constant. For the land use activity, 'forest protection' annual payments for contracts signed in 2005 were of 21,000 ¢/ha/year[2] which at the end of 2005 was the equivalent to about 42 US$. In 2006, the payment was raised to 65 US$/ha/year (FONAFIFO, 2006). Before 2006 applications for participation were already three times larger than the PES budget could afford. The drastic payment raise of 2006 will probably cause even higher demand among landowners 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. Thus, these new circumstances make the necessity to improve the program's targeting mechanism all the more prevalent in order to most efficiently spend the restricted budget.

In order to participate in the program, landowners have to apply to FONAFIFO. FONAFIFO is the main actor in the program. It is the entity which defines program areas, processes and approves applications, controls and monitors landowners´ abidance of program rules. Application paper work and necessary technical studies sometimes impose high transaction costs on the applicant. A number of forestry organisations offer services, taking over most of the burdensome paper work and technical assistance. For these services they charge the applicant a percentage that can represent up to 18% of the program payments (FONAFIFO, 2005).

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[2] Exchange rate 31/12/2005: 1US$ = 497 Costa Rican Colones (¢).

Besides legal and formal requirements which have to be met by any applicant, the forest sites are selected on the basis of predefined program areas. Sites inside these program areas qualify for participation, those outside do not, 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), ii. areas under influence of the Huetar Norte Forest Program, iii. Areas which are given a special function for the protection of water resources, iv. private property within protected wildlife areas, and v. cantons with a Social Development Index (IDS in Spanish) of less than 40%. Priority is also given to sites with expiring PES contracts (MINAE, 2005).

To date, the bulk of financing for the PES 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, 2005).

3. Study area

We focused our work on the Nicoya Peninsula in the northwest of Costa Rica. 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 we did not include the islands in the present study. The TCA is not a protected area, but an administrative unit, in which the governmental institute 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 – 35.9 °C and average monthly lows ranging from 19.9 – 21.8 °C (INSTITUTO METEOROLOGICO NACIONAL, 2006). Topography ranges from 0 – 1,018 m (Cerro Azul) above sea level (SINAC, 2006). The main economic activities are tourism and agriculture. In terms of land extension, agriculture is predominated by cattle farming, mostly beef production. But where soils are suitable and where irrigation water is accessible, melons, rice, sugar cane and other crops are also cultivated. In 2004, FONAFIFO assigned a total of 181 PES projects on an area of 12,244 ha to the TCA (FONAFIFO, 2004).

As part of the present study, we conducted a survey with 178 cattle holders on the Nicoya Peninsula in 2005. The results of this survey describe specific socioeconomic and land use characteristics of the region which increase the understanding of local conditions and also support some of the assumptions which we make in this paper.

Farm area and land use. The 178 farms included in the survey had a total area of 12,078 ha. Property sizes varied between 3 and 3,000 ha with a mean of 67.9 ha. Regarding the variable 'land use', it was reported mostly to be used for pasture (65%) with a mean pasture area of 43.9 ha. Twenty-six percent of the land use was forest, 5% was young secondary forest re-growth (so called 'tacotales'), annual crops were found to be on 2%, forest plantations on 2% and perennial crops on 0.3% of total land area (table 1).

Table 1. Farm area and land use (in ha)

Variable	n	Mean	S.D.	Var (n-1)	Min	Max	Sum	Sum (%)
ha total	178	67.9	231.8	53,715.7	3.0	3,000.0	12,077.5	100.0
ha annual crops	178	1.4	8.4	70.4	0.0	100.0	240.0	2.0
ha perennials	178	0.2	0.9	0.8	0.0	8.0	34.0	0.3
ha pasture	178	43.9	139.8	19,544.6	2.0	1,800.0	7,814.2	64.7
ha tacotales	178	3.2	9.2	85.1	0.0	50.0	563.1	4.7
ha plantations	178	1.3	7.9	61.8	0.0	100.0	237.6	2.0
ha primary forest	178	7.2	33.9	1,150.2	0.0	400.0	1,287.0	10.7
ha secondary forest	178	10.6	59.3	3,511.9	0.0	700.0	1,885.1	15.6
ha other	178	0.1	0.6	0.4	0.0	7.0	16.6	0.1

Source: own data

Cattle production. Regarding the variable 'production emphasis', 77% of the interviewed farmers stated to have predominantly beef cattle, while 21% stated to have predominantly mixed breeds. None of the interviewees reported having predominantly dairy cattle, and in three cases the type of production could not be determined. The farmers held a total number of 6,330 cattle at the time of the interviews. With total pasture area being 7,814 ha this makes an average of 0.8 animals per ha (this number includes animals of all ages and weights). On average farmers owned 35.8 heads of cattle ranging from zero (for some who had just sold all livestock at the time of the interview) to a maximum of 406 animals. Most commonly sold products, besides cattle, were dairy products including milk, cheese and cream and animal feed such as hay bales or standing grass by temporarily renting land to other cattle owners.

Property characteristics. In many cases farms only have poor infrastructure services. According to the farmers´ statements, 24% of the farms were not accessible all year round with a normal two-by-four vehicle, and 7% of the farms were not accessible all year round with a four-by-four vehicle. Electricity is not available on 21% of the farms, 24% of the farms have no water pipe system, 59% lack telephone services, and 46% street lighting.

Socioeconomic data. The mean age of the farm owners in our sample is 58 years, ranging from 25 to 90 years. Level of education in this group is in general low. Six percent of interviewees had never attended primary school. The great majority of interviewees (70%) had only received primary school education, yet only 35% completed primary school. For 11% the highest educational level had been secondary school, even though only three percent completed it. Finally, only 8% received higher education from a technical college or university. Regarding the variable 'monthly monetary household expenditure', 80% of interviewees reported a total expenditure between 100 and 400 US$. Seven percent reported spending less than 100 US$, while 14% reported more than 400 US$[3] of household expenditure. The mean number of household members, reported by this sample, is 4.0 ranging from one to a maximum of ten persons in one household. Only 48% of the households reported under-aged members. The maximum number of under-aged household members reported was four.

Labor distribution. As can be expected from the predominance of pasture land, farmers reported dedicating the largest part of their labor on the farm to cattle and pasture management (92.2%, in average of working hours). In exactly 50% of the cases the interviewed farm owner received also labor from other family members. 35% of interviewees reported dedicating part of their labor to off-farm economic activities such as own businesses (e.g. shops, transport services), regular employment or as day laborers. Yet, a total of 64% said they would have off-farm incomes. In addition to the mentioned off-farm economic activities, other sources of off-farm income reported include the following: i. pensions, ii. financial help from non-household family members and iii. regular salaries from household members. As a result, farmers stated to earn on average 58% of total income with farm activities. With respect to pasture land, the calculated mean per ha return is 56.94 US$. Even though this is above the payment offered in the PES program in 2005, a total of 96 farms stay below the offered payment of 21,000 colones.

This last observation in particular, but also other observations described above, give us reason to believe that land – in many cases – could be included into the PES program

[3] Please note that percentages are rounded to integers and therefore do not always add up to 100.

at a lower price if payments were allowed to be flexible. Even though in our analysis participation is exclusively based on calculated per ha returns, other factors might also influence decision making towards PES participation. For example, data shows a high mean farm owner age with few young people living in the household and a relatively high incidence of off-farm economic activity and income, with frequent financial support from non household family members. All this points to the fact that cattle farming in Nicoya Peninsula does not seem to be a particularly profitable farming activity and does not offer future perspectives to the younger generation. If this is true, then decision making could favor PES participation as this could provide a substantial additional future pension-like income in rural households, especially for the elderly.

4. Concept and data

We assume that property owners are always willing to participate if the payment exceeds the sum of their opportunity, conservation and transaction costs:

(E 1) $\sigma = 1$ if $C_{opp} + C_c + C_t < C_{payment}$

where $\sigma_i \in \{0;1\}$ with 1 = success (decision to participate), 0 = otherwise
C_{opp} = Opportunity Cost
C_t = Transaction Cost
C_c = Conservation Cost
$C_{payment}$ = Payment

We estimate the transaction cost for the applicant to be 18% of the payment (7.20 US$ at payment level of 40 US$). This is the maximum percentage which intermediaries between the landowner and FONAFIFO may charge for their services (see above), an option taken advantage of by many farmers. The per ha transaction costs therefore do not decrease with increasing contract size. Based on our survey data, we calculated an average cost for conservation obligations and activities of a little less than 3 US$/ha. In the analysis we therefore apply an estimated rounded transaction and conservation cost of 10 US$/ha.

In the budget calculations for the analysis, we only considered payments made directly to landowners, per contract transaction costs which have to be born by the selection agency are not considered in the budget. In this, we are consistent with Costa Rica's current PES program which does not consider per contract transaction costs in the selection procedure. Yet, in order to judge the efficiency impact of the presented selection mechanism in a real world application, implementation and running costs would have to be considered.

We focus on the selection of sites for the activities of forest protection and natural forest regeneration. We value every applying site individually and compare it with competing sites. This procedure can be applied within priority areas but it is also possible to abandon the concept of priority areas completely (as we do here), assuming that any given site delivers environmental services. In our tool design, potential PES sites are selected on the basis of the following criteria: i. water service provision, ii. biodiversity service provision, iii. carbon sequestration service provision, iv. scenic beauty provision, v. social development index and vi. opportunity cost. While the first four criteria measure environmental services, the fifth criterion measures a social service. We combine all services to a single score. Given a fixed budget, the tool selects sites seeking to maximize the total service score. All data sets were transformed to grid data with a 30x30m pixel size. Each data set is measured in its own unit. To make the service-provision datasets comparable we standardize the measurements into z-values resulting in scores with a mean equal to zero and standard deviation (S.D.) and variance equal to one. The z-value normalization for data sets with higher values preferred to lower values has the following formula:

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

with x_i being the observed value of the i^{th} site. For data sets with lower values preferred to higher values the z-normalization has the following formula:

(E 3) $$z = \frac{\text{mean} - x_i}{\text{S.D.}}$$

Biodiversity. The biodiversity data set consists of three subsets intending to reflect two basic principles in conservation: representation and connectivity. The first subset describes the representation of lifezones (HOLDRIDGE, 1967)[4] in the current system of protected areas such as national parks. We are aiming to protect 20% of the original land area of each lifezone. If a lifezone is not sufficiently represented within the protected area system, PES seeks to complement this missing gap on private property. The bigger the gap, the higher the score that will be given to a lifezone. Of the 24 life zones in Costa Rica eight can be found on the Nicoya Peninsula. The missing

[4] "Rejecting the temperate latitude bias of Merriam's life zones, L.R. Holdridge devised a life zone classification in 1967 more appropriate to the complexities of tropical vegetation. [...] The Holdridge system was intended to be applicable to the entire globe. However, it is primarily used by investigators in the New World tropics" (WOODWARD, 1996: 1).

difference to fulfill 20% representation ranges between 3.1% and 15.4%. The connectivity criterion is taken care of by two subsets. One measures the distance to already existing protected areas as well as to officially acknowledged biological corridors (GARCÍA, 1996). Another subset measures the distance to existing patches of forest using forest cover data from 1997 (ORTIZ, 2004). The smaller the distance, the higher the score in order to increase connectivity. An average score was calculated from the normalized values of all three data sets giving equal weight to any of the three data sets. This weight distribution is arbitrary; weights could, as mentioned before, also be distributed differently.

Carbon. For the carbon data set, each Holdrige lifezone is assigned a per ha amount of carbon that can potentially be stored. It is important to point out that we consider the sum of already stored carbon on a site, plus the potential for additional future sequestration. This procedure is not in line with the Kyoto Protocol which has so far only included 'afforestation' and 'reforestation' projects as eligible for the first Kyoto Protocol period from 2008 to 2012 (PEDRONI, 2003). We argue, however, that avoided deforestation and thus avoided carbon release equally contributes to the prevention of further climate warming. We further assume that sites have the same storage potential for carbon as an untouched primary forest, i.e. we assume that forest will grow back to its original, natural state. In most cases that will not be true and consequently, we are overestimating potential carbon storage on sites with secondary or no forest cover. Our estimates for carbon storing potential are based on biomass data for each lifezone (CCAD, 1998) and corrected assuming a carbon content of 50% in biomass (IPCC, 1996). Carbon storage potentials range from 99.0 to 140.8 t/ha.

Water. The water data consists of two subsets, one for slope and one for the intensity of water use per aquifer. Slope percentages were derived from an elevation model of the area which was in turn derived from the contour line file of the Atlas Digital 2004 (ORTIZ, 2004). The data on water use was compiled by IMBACH BARTOL (2005) and sums up water consumption (private, agricultural and industrial) from all registered wells in liters per second. IMBACH BARTOL (2005) also compiled the aquifer map used to calculate the per ha water consumption for each aquifer. The higher per ha consumption of an aquifer, the higher is the score for a site that corresponds to that aquifer. This procedure is based on the assumption that forest cover is always beneficial for the provision of water services, an assumption which is not always correct and has been contested in literature (e.g. BRUIJNZEEL, 2004). Yet, basing our assumption on the precautionary principle we find it appropriate even though the forest water relation has not entirely been described. An average score for water service provision was calculated from the two information layers, giving equal weight to each subset. Weights could, as mentioned before, also be distributed differently.

Scenic beauty. Scenic beauty services were estimated on the basis of two assumptions: i. Forest can only be appreciated as a contribution to scenic beauty if visible and ii. forest is always preferable to see in comparison to other land uses. The second assumption would not, for example, hold in western Europe where a mixture of different landscape elements is preferred to forest only landscapes. Yet, as we do not have access to landscape planning data nor studies on landscape preferences we uphold this simplifying assumption. Forest viewability is calculated for defined viewpoints on the map. Even though it would be ideal to include any point on a landscape weighted by the intensity, by which people frequent this point (e.g. roads, dwellings, public sites, tourist destinations, beaches), lack of data and limitations in computer capacity made it necessary to simplify and reduce the number of viewpoints. We, therefore, limited viewpoints to the national roads and distributed points at about every 1.5 km along the roads. The resulting viewshed provides for each pixel the number of points, from which the pixel can be seen. The higher the visibility of a pixel, the higher is its score. The visibility in our viewshed calculation ranges from 0 to 42.

Social Development Index (IDS, in Spanish). The IDS is a summary indicator which measures the social differences between geographical areas of 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, 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 fairly evenly distributed. It ranges from 46.1 to 56.9 (MIDEPLAN, 2001). In the present Costa Rican 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, we consider the relative social development level of a site compared to competing sites. Consequently, the lower the IDS, the higher is the score given to a site as the payments are thought to compensate for low social standards.

Opportunity cost. Data on opportunity costs were collected in a field survey. Figure 1 shows the location of the properties of the interviewees. We focused on pasture land as we assumed that if land use change towards or away from natural forest takes place pasture lands would be the most likely alternative land use. This is because land use generally changes from agriculture through pasture to forest on a soil quality scale from high to low. Our data allows the calculation of opportunity costs of forest conservation for i. land use change from “pasture” to “natural forest” and ii. non-realization of land use change from “natural forest” to “pasture”. In both cases we assume that "natural forest" has a commercialization value of zero. This is because logging and timber commercialization of forested areas is prohibited by law unless a forest management plan has been certified and issued by Costa Rican authorities which allows selective logging of individual trees. However, very few such management plans have been issued in recent years and there is relatively low incidence of rule violations in the study area, even though there are reported exceptions. While this might imply that land use change from natural forest to pasture does not take place, gradual land use changes are frequently observed, though equally prohibited. They start with the elimination of forest undergrowth and evolve through cattle invasion and light cropping activities to pasture land with scattered tree vegetation.

It has to be pointed out that we calculated an average opportunity cost for the pasture land of each farm and did not consider differences of land productivity within the farm. This means that the most profitable areas on a farm are under- and the least profitable areas are overestimated. In a real world decision a property owner would only submit those areas to the PES program which are less profitable than the PES payment. Yet, in our analysis only the entire area of pasture and forest can be selected and not parts thereof. GPS co-ordinates of each property were recorded at the time of the interview at the spot where the interview took place. As we did not dispose of complete farm co-ordinates we estimated farm extension by drawing a circle, adjusted to the size of the pasture and forest area of the property, around the taken point. This is a simplification which may distort results in the analysis.

Score. The average score (u_x) is derived from the normalized scores of all environmental services for each pixel (x):

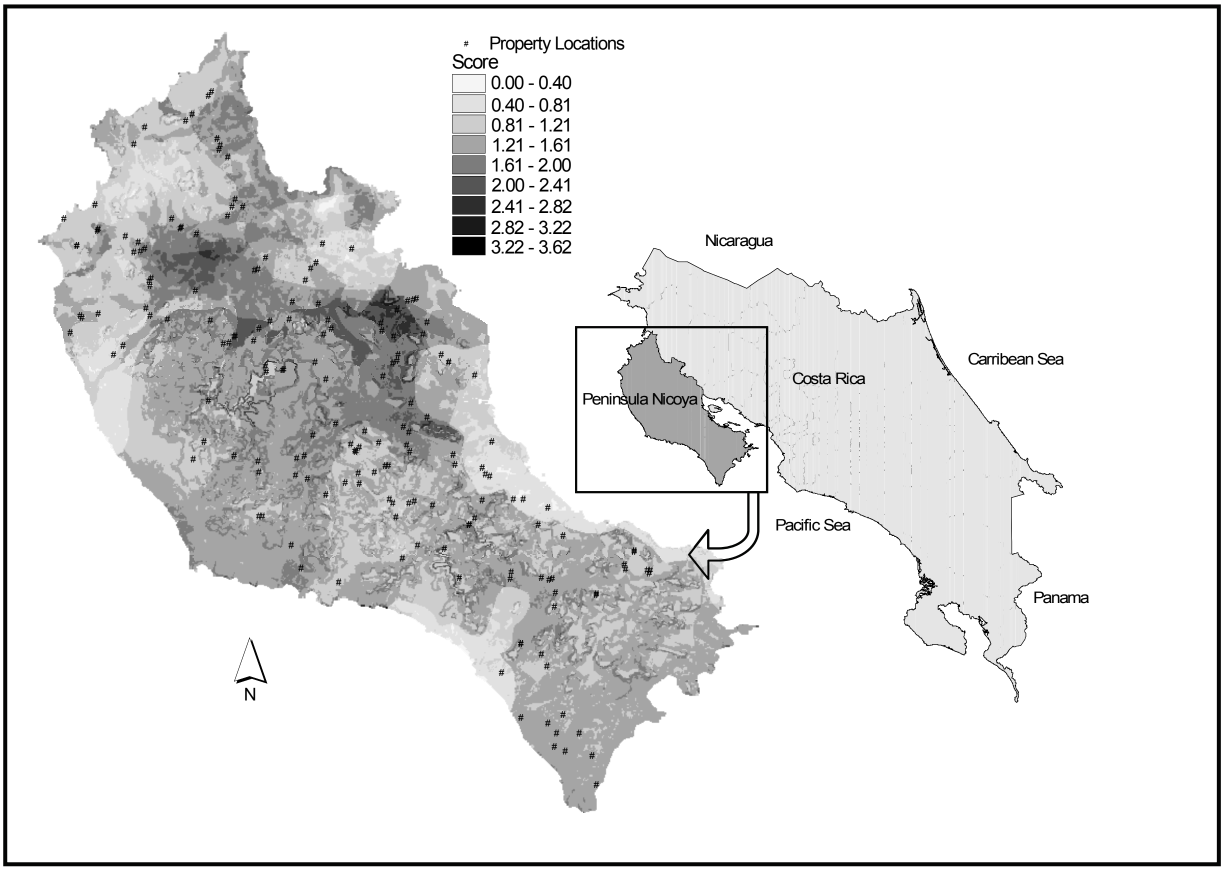
(E4) $u_x = (b_x + w_x + c_x + l_x + s_x)/5$

where b_X = Score of biodiversity service in pixel x
w_X = Score of water service in pixel x
c_X = Score of carbon service in pixel x
l_X = Score of scenic beauty service in pixel x
s_x = Score of poverty alleviating services (IDS) in pixel x

Again, we are giving equal weight to each one of the services as we assume to have no particular service preferences. Weights could be distributed differently. Scores are numbers without unit.

Figure 1 presents the distribution of score values. Areas are shaded from light to dark grey. The conservation of lighter areas secure less environmental services (lower scores) than the conservation of darker areas (higher scores).

Figure 1. Location of study area and interviewed properties as well as distribution of service scores on Nicoya Peninsula



Source: own data

5. Scenarios

We run three different scenarios in order to compare the impact of different kinds of selection processes. Our scenarios are: i. Baseline Scenario ('Baseline'), ii. Fixed Payment Score ('FixScore') and iii. Flexible Payment Score ('FlexScore'). Whereas the Baseline Scenario reflects largely the selection system currently employed by FONAFIFO, the other two scenarios show the alternative selection processes and differ in whether the payment is fixed or flexible.

The Baseline Scenario differs from the selection procedure employed by FONAFIFO mainly in that we assume to have no budget limit. In our scenario every property inside the priority areas will be selected as long as its per ha return on pasture land plus conservation and transaction costs is lower than the PES payment. To formalize, a site i is selected if a.) $i \in P$ and b.) $C_{opp} + C_t + C_c < C_{fix}$ where P is the universe of points within priority areas and C_{fix} is the fixed payment of 40 US$/ha/year. Total expenditure (C_{budget}) is:

$$\text{(E 5)} \quad C_{budget} = \sum_{i=1}^{n} б_i \, a_i \, C_{fix}$$

where a_i is the total pasture and forest area of the property i and $б_i$ is its selection decision. $б_i \in \{0;1\}$, $б_i = 1$ if the conditions a.) and b.) are fulfilled, $б_i = 0$ otherwise. The resulting expenditure (C_{budget}) will serve us as the budget limit in the other scenarios. As the farm location is only determined by a point it might occur that parts of the farm lie outside the priority areas even though the point co-ordinates lie inside.

In the **'FixScore'** scenario we are no longer restricted to the predefined priority areas but can select sites from the entire study area. In this scenario, we select properties on the basis of their score values. In order to maximize the total score with the given budget (C_{budget}) and a fixed payment level we select the properties with the highest average environmental service scores. To formalize:

$$\text{(E 6)} \quad \max_{б} \left\{ U = \sum_{i=1}^{n} б_i \, (a_i \bar{u}_i) \right\}$$

$$\text{(E 7)} \quad \text{Constraint: } \sum_{i=1}^{n} б_i \, (a_i C_{fix}) \leq C_{budget}$$

where U is the sum of scores of all selected sites and $\bar{u}_i$ is the average score of the property i. In practice, the property with the highest mean score will be selected first, followed by the site with the second highest mean score and so forth. We follow this procedure until the budget is depleted. However, in the case that the remaining budget is too small to pay for the site with the next highest average score, we skip that site and look for the next following site which is small enough to be afforded by the remaining budget, and so forth.

In the '**FlexScore**' scenario the payment is no longer fixed at 40 US$ per ha but now is equal to the site's average opportunity cost of forest conservation plus transaction and conservation costs. Unlike in the FixScore scenario where each site was selected on the basis of only one variable (score), in this scenario each site is selected on the basis of the two variables (score and costs). In order to maximize the total score with the fixed budget (C_{budget}) but flexible payment levels we need to select sites on the basis of their score/cost ratio. To formalize:

$$\text{(E 8)} \quad \underset{б}{\text{Max}} \sum_{i=1}^{n} б_i \left(a_i\bar{u}_i / C_i\right)$$

Where C_i is the specific required payment level and equal to the sum of C_{opp}, C_t and C_c of site i. This means that sites with a low average score but also with a low C_i still maintain a high score/cost ratio and thus can compete with sites whose average scores and C_i are high. In practice, the site with the highest score/cost ratio would be selected first, followed by the site with the second highest score/cost ratio and so forth, until the budget is depleted. If there is a remaining budget we proceed as described above. An overview of the various scenarios and their main differences is given in Table 2 in the following section.

6. Results

Table 2 presents the most important findings from the three different scenarios previously described. In the Baseline Scenario a total of 69,476 US$ is spent. The expenditure is distributed over 24 sites and 1,737 ha. Total expenditure for the other scenarios is consistently slightly below the Baseline Scenario's expenditure. This is because only entire sites could be selected and not fractions of them, resulting in small remaining budgets not large enough to contract further entire properties. However, the remaining budgets are relatively small and have a maximum missing gap of 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. Yet, the average site area decreases from the Baseline to the FixScore and FlexScore scenarios. This means that smaller farms have higher score values and/or lower opportunity costs. If a negative correlation between farm size and poverty level could be established, this would indicate that poorer properties are increasingly included with the presented alternative selection approaches. To rule out that our site selection procedure towards the end of the available budget (i.e. skipping large sites that can no longer be financed by the remaining budget and selecting smaller sites instead) is not the main cause of decreasing average site size, we calculated the average site sizes also for the case that the remaining budget would not be used on less costly sites. The results show that the trend of decreasing average site size is not affected. In the FixScore scenario the skipping procedure slightly increased average site size from 43.3 to 43.4 ha. However, in the FlexScore scenario, the skipping procedure slightly decreased average site size from 43.4 to 41.7 ha. 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 our case, reaches up to 69.49 US$ per ha and year.

Table 2. Main differences between scenarios and principal results

	Baseline	FixScore	FlexScore
Payment	Fixed	Fixed	Flexible
Budget Limit	No	Yes	Yes
Selection Crieria	Priority Area	Mean Score	Score/Cost Ratio
Total Cost (US$)	69,476.40 (100.0%)	69,429.60 (99.9%)	69,471.26 (99.9%)
No. of Sites	24 (100.0%)	40 (166.7%)	82 (341.7%)
Area (ha)	1,736.9 (100.0%)	1,735.7 (99.9%)	3,417.8 (196.8%)
Mean Site Size (ha)	72.4 (100.0%)	43.4 (60.0%)	41.7 (57.6%)
Score (total)	27,421 (100%)	31,325 (114%)	55,724 (203%)
Score/$	0.395 (100%)	0.451 (114%)	0.802 (203%)

Source: own data

The Baseline approach contracts areas with a total score of 27,421. Relative to the Baseline scenario, the FixScore approach increased the total contracted score by 14% and the FlexScore increased total contracted score by 103%. 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. Similar to the increase of the total service score, efficiency in terms of contracted service score per dollar spent was also higher in the offered alternative approaches, an increase of 14% in the FixScore and of 103% in the FlexScore approach.

7. Conclusions

Based on our data and assumptions, we showed that the proposed alternative selection approaches can successfully increase the efficiency of the Costa Rican PES program in terms of contracted services per dollar spent. Both, the integration of spatial service data in the targeting process and the implementation of flexible payments, had positive effects on program efficiency more than doubling total contracted score in the FlexScore approach. We also observed a decrease of average contracted property size from the Baseline to the FixScore and FlexScore scenarios. Thus, the introduction of the new concepts increases the participation of landowners with smaller properties. If land size and wealth are positively correlated, the presented concepts would encourage participation of the poor. A possible explanation for this observation is that some environmental services are closely associated with remote and marginal land where poorer landowners with smaller properties can be found. This is true, for example, for steep slopes where forests may play a crucial role in erosion and land slide control. Another possible explanation for this observation is that the integration of the Social Development Index (IDS) in the targeting mechanism could have given priority to regions with generally small property sizes (if property size is correlated to IDS). But as the index on the Nicoya Peninsula does not have high variability, it is unlikely that this is the main cause of decreasing property size. Provided that land size and wealth are correlated, the decrease of average property size in the FixScore scenario could have a real poverty alleviating impact as the landowner gains the production rent of service delivery. In the FlexScore scenarios, however, as only costs are paid that are caused by program participation, the payments would not increase income. Yet, as a steady source of income they could have other beneficial effects especially for risk averse small holders.

In order to determine whether the presented selection mechanisms could actually be applied in the Costa Rican PES program, some further research would have to be undertaken. One of the issues that needs more clarification is how data can more easily be obtained. Conducting complex personal interviews in the field, as was done in this present study, to obtain, for example, opportunity cost data, is not a cost effective option for a functioning PES scheme. It would also have to be determined whether opportunity cost of forest conservation is the sole decision criterion for program participation or whether other variables, as was indicated above (see section "Study Area"), also influence this decision. The use of auction systems might potentially tackle both of these issues. They are hoped to make property owners reveal their real willingness to accept which should include consideration not only of the landowners´ opportunity cost, but all variables taken into account in the individual decision making process. There are examples for auction systems in developed countries such as Australia and the USA (WHITTEN and SHELTON, 2005; CLAASSEN et al., 2005). Defining the appropriate design for an auction system in a developed country is a challenge; it might be an even greater challenge in a developing country while no examples of such systems for developing countries are available. A final issue that requires further attention is that implementation and operating costs for the proposed approaches would have to be carefully estimated and weighed against efficiency gains.

References

BARTON, D.N., D. FAITH, G. RUSCH, J.O. GJERSHAUG, M. CASTRO, M. VEGA and E. VEGA (2003): Spatial prioritisation of environmental service payments for biodiversity protection. Report SNR 4746/2003. NIVA (Norwegian Institute for Water Research), Oslo, Norway.

BRUIJNZEEL, L.A. (2004): Hydrological Functions of Tropical Forests, not seeing the Soil for the Trees? In: Agriculture, Ecosystems and Environment 104 (1): 185-228.

CLAASSEN, R., A. CATTANEO and R. JOHANSSON (2005): Cost-Effective Design of Agri-Environmental Payment Programs: U.S. Experience in Theory and Practice. Presented at the Workshop on "Payments for Environmental Services (PES) – Methods and design in developing and developed countries" in Titisee, Germany, June 15-18, 2005.

CCAD (Comisión Centroamericana de Ambiente y Desarrollo) (1998): Estimación de la Cantidad de Carbono Almacenado y Captado (masa aérea) por los Bosques de Costa Rica. Comisión Centroamericana de Ambiente y Desarrollo, Costa Rica.

FONAFIFO (Fondo Nacional de Financiamiento Forestal) (2004): Letter from Ing. Jose Angel Jiménez Fajardo, in charge of the regional FONAFIFO office in Nicoya, to the director of the Tempisque Conservation Area, Emel Rodriguez Paniagua. Written 13.12.2004.

– (2005): Manual de Procedimiento para el pago de servicios ambientales 2005. FONAFIFO. Costa Rica.

– (2006): Pago de servicios ambientales. In: http://www.fonafifo.com/paginas_espanol/servicios_ambientales/sa_estadisticas.htm.

GARCIA, R. (1996): Propuesta tecnica de ordenamiento territorial con fines de conservacion de biodiversidad - proyecto GRUAS. Sistema Nacional de areas de conservacion (SINAC), Ministerio del Ambiente y Energía (MINAE), Costa Rica.

HOLDRIDGE, L.R. (1967): Life Zone Ecology. Tropical Science Center, San Jose, Costa Rica.

IMBACH BARTOL, P.A. (2005): Priority Areas for payment for environmental services (PES) in Costa Rica. Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Turrialba, Costa Rica.

INSTITUTO METEOROLÓGICO NACIONAL (2006): Promedios mensuales de datos climáticos de Nicoya. Instituto Meteorológico Nacional – Gestión de información y comercialización, Costa Rica.

IPCC (Intergovernmental Panel on Climate Change) (1996): Guidelines for National Geenhouse Gas Inventories: Workbook (Volume 2). Revised Version 1996. UNEP, WMO.

MIDEPLAN (Ministerio de Planificación Nacional y Política Económica) (2001): Índice de desarrollo social cantonal del año 1999. In: http://www.mideplan.go.cr/sides/social/10-01.htm (16.4.2006).

MINAE (2005): Decreto Ejecutivo 32 226. Ministerio de Ambiente y Energía (MINAE), Costa Rica.

ORTIZ, E. (2002): Sistema de Cobro y Pago por Servicios Ambientales en Costa Rica. Serie de Apoyo Académico N° 34. Escuela de Ingeniería Forestal, Instituto Tecnológico de Costa Rica, Cartago, Costa Rica.

– (2004): Atlas Digital de Costa Rica. Instituto Technológico de Costa Rica, Escuela de Ingeniería Forestal, Cartago, Costa Rica.

PAGIOLA, S. (2005): Payments for Environmental Services in Costa Rica. Presented at the Workshop on "Payments for Environmental Services (PES) – Methods and design in developing and developed countries" in Titisee, Germany, June 15-18, 2005.

PEDRONI, L. (2003): Ruling on the 'crunch issues' of land use, land-use change and forestry: impacts on project viability. In: International Journal of Global Energy 20 (1): 75-94.

POWELL, G.V.N., J. BARBORAK and M. RODRIGUEZ S. (2000): Assessing representativeness of protected natural areas in Costa Rica for protecting biodiversity: a preliminary gab analysis. In: Biological Conservation 93 (1): 35-41.

SINAC (Sístema Nacional de Areas de Conservación) (2006): Areas silvestres protegidas – Area de Conservación Tempisque. In: http://www.sinaccr.net/act.php.

WHITTEN, S. and D. SHELTON (2005): Market for ecosystem services in Australia: practical design and case studies. Presented at the Workshop on "Payments for Environmental Services (PES) – Methods and design in developing and developed countries" in Titisee, Germany, June 15-18, 2005.

WOODWARD, S.L. (1996): Holdridge´s Life Zones. In: http://www.radford.edu/~swoodwar/CLASSES/GEOG235/lifezone/holdrdge.html.

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