WILLINGNESS TO PAY FOR ENVIRONMENTAL SERVICES AMONG SLASH-AND BURN FARMERS IN THE PERUVIAN AMAZON: IMPLICATIONS FOR DEFORESTATION AND GLOBAL ENVIRONMENTAL MARKETS

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INTRODUCTION

Traditional approaches to halting tropical deforestation by small-scale farmers have primarily focused on increasing the private benefits of sustainable alternatives, such as agroforestry (Current, et al., 1985), or on increasing the costs of deforestation by correcting domestic policy distortions (Vosti, et al., 1997). This study seeks to enhance the effectiveness of these approaches by investigating whether the global environmental values of forests can be captured by farmers in developing countries. Specifically we investigate the possibility of small-scale farmers in the Peruvian Amazon supplying carbon sequestration services.

International trade in carbon sequestration services is permitted under the Clean Development Mechanism of the Kyoto Protocol to the Climate Change Convention (1997). If gains to trade exist, farmers in developing countries could be compensated for increasing forested areas on their farms, by carbon emitters in developed countries.

We use the Contingent Valuation Method (Freeman, 1994; Mitchell and Carson, 1989) to elicit the compensation required by farmers to switch to a land use system which would lower carbon emissions. These values are then compared to the cost of emission reduction by switching to cleaner fuels.

Our estimates of the cost of supplying carbon sequestration services through forestry activities is one of the rare estimates relating to small-scale farmers (Ridley, 1997). Furthermore, while other studies have based their estimates on the average costs of projects promoting forestry activities, our study elicits the marginal cost of emission reducing land use change, directly from farmers through the use of the Contingent Valuation Method (CVM). We use CVM rather than land prices to estimate the compensation required, primarily because we hypothesize that forested land may provide non-market local benefits to forest dwellers, in the form of environmental services (such as soil recuperation, shade or preservation of habitat for game animals) or bequest or option values. A second reason is that land markets in the area are very thin, which is not surprising, given low population densities and the paucity of formal land titles. The involvement of farmers in determining required levels of compensation is likely to facilitate implementation and should also ensure that the welfare of resource-poor farmers is at least maintained, while environmental improvement occurs.

Ours is also one of the very few CVM studies of the welfare change from forestry activities, from the perspective of farmers in developing countries. Shyamsunder and Kramer (1996) used CVM to estimate the opportunity cost of forest preservation in Madagascar. Our study extends their work by separating out economic gains or losses, from any possible environmental benefits farmers may obtain from the change in land use.

CONTINGENT VALUATION ESTIMATES

Proposed Land Use Change

The study site is the rural area influenced by the city of Pucallpa in the Ucayali Region of the Peruvian Amazon and consists of settlements stretching back from the main road connecting Pucallpa to Lima.

Satellite images from 1993 show that 70% of the area is deforested (Fujisaka, 1996). The population density is around 5 persons/km^2 (INEI, 1995). Slash-and burn farmers who migrated to the area during the last three to four decades, clear a small area of logged-over primary forest or secondary forest on their farms and plant annual and semi-perennial crops for about two years, after which the land is left fallow for about three years, while another part of the farm is cleared for agriculture. This land use system is unsustainable because fallow periods are too short to fully recuperate the soil.

The land use change for which the compensation is elicited is two-fold: replacement of slash-and-burn agriculture by (i) preservation of natural forest on one hectare of the farm, on which extraction of forest products is totally prohibited and (ii) a simultaneous shift to a multi-strata agroforestry system, which combines crops with useful tree species which mimic natural succession (Nair, 1993), on another hectare of the farm. The proposed change in land use is conceived as a first step, which if eventually extended to most of the farm, would result in a land use system in which most species are conserved and the impact on natural biophysical processes is minimized through forest preservation, while simultaneously farmers' requirements for agricultural and forest products is satisfied through the adoption of agroforestry. The substitution of slash-and-burn agriculture by agroforestry is expected to result in a net increase in carbon sequestration, because of the higher aboveground biomass of agroforestry systems. In the case of forest preservation, although the net carbon balance of mature forests is approximately zero, protection of forests from land conversion prevents carbon emissions, which would occur if forested land were converted to slash-and-burn agriculture. Thus, compensation for avoiding emissions through forest preservation is justified if the forest is genuinely under threat and if "leakage" does not occur, i.e. another area of forest is not cleared as a substitute. Forests in our study area are clearly under threat, as the deforestation data show. Our proposed land use change also attempts to reduce "leakage" by simultaneously providing a viable alternative to deforestation: agroforestry supported by payments for sequestration services. An alternative would be to tax farmers for deforestation. This is considered undesirable in the case of small-scale farmers because of equity considerations and enforcement difficulties (Schneider, 1995).

Welfare Measures

The required compensation for economic losses implied by changes in land use without taking into account environmental benefits, can be defined as:

$$V\left(M + WTA_0, \mathbf{S}, L_1, E_0\right) = V\left(M, \mathbf{S}, L_0, E_0\right) \tag{1}$$

where the RHS is the indirect utility function for a representative farmer. M is income, **S** a vector of individual characteristics, L_0 the area currently available for agriculture and E_0 the current level of environmental services provided by forests. L_1 = land available for agriculture after the proposed land use change, which is less than before, because land has to be set aside for forest preservation and agroforestry. The reduction in available land is less for agroforestry than for forest preservation, because agroforestry includes some agricultural activities. WTA_0 is the minimum compensation required to leave the farmer as well-off as before land use change, without taking environmental benefits into consideration. When the change in environmental benefits is also taken into consideration, the welfare change is:

$$V\left(M + WTA_1, \mathbf{S}, L_1, E_1\right) = V\left(M, \mathbf{S}, L_0, E_0\right) \tag{2}$$

where E_1 = the extra environmental benefits available after land use change and WTA_1 is the minimum compensation required to leave the farmer as well-off as before land use change, taking both economic losses and environmental benefits into account.

The value of environmental services (WTA_0 - WTA_1) can be expressed as an indirect WTP, that is the maximum amount farmers are willing to pay for the environmental services of forests. This implies that the payment vehicle for the WTP for environmental services is expressed in terms of a reduced compensation.

Methodological framework

A full discussion of the methodological framework is given in Smith, et al. (1997). The main points are summarized here.

The simulated market in the CVM survey is based on the emerging market in carbon sequestration services. Farmers are presented with a possible future project in which utility companies in developed countries, driven by emission reduction targets, are willing to compensate farmers who make the proposed land use change. Farmers are asked to bid for a fixed annual payment for each hectare of preserved forest and separately for each hectare of agroforestry. Payments would cease if these areas are cleared for slash-and burn. Farmers are reminded that they are competing against alternative suppliers of carbon sequestration services and that there is no guarantee that their bids will be acceptable.

The compensation each farmer requires for economic losses resulting from preserving one hectare of forest and shifting to agroforestry on one hectare (WTA_0) is first elicited. Farmers are then asked by how much (if anything) they are willing to discount the compensation required because of the environmental services resulting from the proposed land use change. This discounted value provides an estimate of WTA_1. The difference between WTA_0 and WTA_1 provides an implicit WTP for environmental services, in the form of foregone compensation.

Open ended questions (OEQ), rather than dichotomous choice questions (DCQ) were found to function adequately, because bargaining, rather than fixed prices, is the norm in local transactions. The use of a WTA format is justified because farmers are being asked to change land use on their own farms (Mitchell and Carson, 1989).

Personal interviews were carried out at the homes of 214 respondents, with extensive use of pictorial aids. Special survey techniques capitalizing on our knowledge of the local culture were used to elicit values. The concept of valuing a non-market good in monetary terms was communicated after extensive pre-testing, by eliciting farmers' asking wage for a day's hard labor in the sun and comparing it to their asking wage for working in the shade.

Results

The average farm size for the sample is 29 ha. Land is mainly acquired through occupation of forested land. The government eventually legalizes occupied land if farmers begin cultivating the land and obtain documents from the community certifying their intention to remain on the land. The majority of farmers (56%) have these informal certificates from the community. An additional 26% have legal land titles. The few farmers who have no documents are planting trees on the land to establish recognition of their intention to remain on the land. Most farmers appear to be well established in the area. Only 35% had previously occupied another farm.

The survey generated a high degree of interest, with 72% of farmers describing it in superlative terms. The response rate was very high: only 15 farmers were unable to answer one or more valuation questions. Answers to questions on the use of forests reveal that farmers appear to deforest, not because it is their preferred use of forests, but because of the lack of alternatives. Forests as a source of crop land is never mentioned in open-ended questions and is selected by only a minority, when this use is presented as an option. Although consumptive uses of forests dominate, it is notable that 76% of farmers have some knowledge of non-consumptive environmental services, such as air purification and shade. Environmental services related to the quality of life are mentioned more frequently than those related to agricultural productivity. Farmers' environmental knowledge is obtained both informally and from projects, the media and schools. After farmers receive further information about environmental services, during the survey, there are notable increases in the number of farmers mentioning option values and indirect uses relating to agricultural productivity (Smith et al., 1997).

The average WTA_0 (that is the annual compensation required without taking environmental values into consideration), is \$218 for preserving a hectare of forest and \$138 for converting one hectare to agroforestry. The statistically significant difference between the two values is consistent with the lower (short term) economic loss of conversion to agroforestry, compared to forest preservation. Median WTA values - \$195 for forest preservation and \$117 for agroforestry - are not very much lower than the means indicating that outliers are not overly influencing average estimates (Table 1).

The mean indirect WTP values for local environmental services (WTA_0 - WTA_1) is \$67 for forest preservation and \$41 for agroforestry. The statistically significant difference of \$26 reflects the higher environmental benefits generated under pure forest preservation. Thus, contrary to conventional wisdom, resource-poor farmers in the Peruvian Amazon appear to be willing to forgo significant amounts of potential income in order to obtain the local environmental services of forests.

Valuation functions are estimated to explain the determinants of WTA and WTP estimates and thus test the validity of the estimates. Included regressors are given in Table 2. For WTA, these include sociological variables, such as education; variables reflecting the opportunity cost of setting aside land (such as variables reflecting the cultivation of cash crops); an income proxy (represented by the quality of housing); the extent of deforestation and a number of dummy variables.

Ordinary Least Squares estimates (OLS), corrected for heteroskedasticity, are reported in Table 3 for the WTA valuation function.. All significant variables have the expected effect on WTA. A strong positive link is revealed between the opportunity costs of setting aside land and the size of the compensation demanded. Also farmers who have deforested more, require a higher compensation to preserve their remaining forested areas, while farmers who are better off, require a lower compensation.

Regressors for the WTP valuation function include sociological variables; proxy variables for income generated from the farm (such as size of farm); variables depicting use of forest products; variables reflecting stated attitudes to forests and a variable identifying non-transient farmers (number of years in previous location).

Regression results, given in Table 4, show that WTP for environmental services has a powerful association with attitudinal variables, even after controlling for education. This confirms that farmers are generally consistent between attitudes and behavioral intentions. Non-transient farmers are willing to pay significantly more for environmental services, which is consistent with the fact that they may have more opportunities to enjoy environmental benefits that may be noticeable in the medium or long run. The larger the extent of deforestation that has already occurred, the larger the perceived values of forest environmental services. These results indicate that resource-poor farmers in the Peruvian Amazon appear to derive positive benefits from forest environmental services and that these benefit estimates are significantly influenced by variables that reflect non-use values. This justifies the use of CVM for estimating the compensation required for land use change and implies that forest preservation can benefit not only the world community, but also resource-poor farmers in developing countries.

Confidence intervals for the mean and median valuation estimates are constructed from the four regression models, to take account of differences between true and reported valuations (Smith et al., 1997). Upper and lower bound estimates of the true values (taking measurement error as well as model error into account) are given in Table 1.

GAINS FROM TRADE IN CARBON SEQUESTRATION SERVICES

Following Boscolo et al. (1997), carbon sequestration is measured as net carbon accumulation (NCA) i.e. the difference in carbon stock over time for each type of land use (slash-and-burn, forest preservation and agroforstry). Carbon sequestered through land use change (NCA_{ij}) is taken as the difference in NCA between slash-and-burn and forest preservation or agroforestry.

$$NCA_{ij,t+1} = \left(C_{j,t+1} - C_{j,t}\right) - \left(C_{i,t+1} - C_{i,t}\right) \quad (3)$$

where $NCA_{i,j,\ t+1}$= difference in net carbon accumulation between land use j and land use i in time period t+1, where, j = 1 = forest preservation, j = 2 = agroforestry, i = slash-and-burn.

Natural forest in the Pucallpa region stores some 180 tC/ha. in aboveground biomass (Ricse et al., 1996). Root biomass is estimated as 20% of above ground biomass (Schroeder and Winjum, 1995). The same proportion is used for the other land uses. Soil carbon under forest and all other uses is estimated at 50 tC/ha. In accordance with usual practice in the area, slash-and burn agriculture is assumed to consist of two years of cropping, followed by three years of fallow. Cropped fields are estimated to have 10 tC/ha and 2 tC/ha (above and below ground respectively). Fallows are estimated to accumulate biomass at the annual rate of 10 tC/ha. (Szott et al., 1994; Woomer et al., 1996) and 20% of that below ground. Biomass production for multistrata agroforestry systems is estimated to be at an annual rate of 10 tC/ha. (Schroeder, 1994). Net carbon accumulation by products of slash-and-burn and agroforestry are not taken into account in these calculations.

The global benefit from carbon sequestration resulting from land use change is calculated as the Present Value (PV) of the differences in NCA due to land use change weighted by the discounted shadow price of carbon. The time horizon is taken as 15 years, to represent the likely duration of a carbon sequestration project.

$$PVG_{ij,t+1} = \sum_{t=0}^{15} P_{t+1} NCA_{ij,t+1} \qquad (4)$$

where PVG_{ij} = Present value of global benefit from land use change ($/ha) and P_t = discounted shadow of carbon in time period t

For the discounted shadow price of carbon, global damage cost estimates from Fankhauser (1995) are used for the calculations in row 1 of Table 5. Fankhauser (1995) derives the present value of the cost of damage by using a stochastic model of the relationship between emissions and atmospheric concentration, which in turn affects temperature and therefore damage costs. Discounted global damage estimates increase over time from $20.3/tC in 1991-2000 to $27.8/tC in 2021-2030. Increases are due to increases in world population and wealth (and therefore the cost of damage) over time, as well as the increasing impact of emissions on atmospheric concentration, as emissions build up over time.

Given the controversy surrounding estimates of global damage, we vary the most controversial element of the discount rate: the utility discount rate or the rate at which society discounts future consumption relative to current consumption. Row 1 in Table 5 uses Fankhauser's estimates in which the utility discount rate is randomly varied between zero, 0.5% and 3%. In row 2, Fankhauser's estimates of the shadow price of carbon at a fixed utility discount rate of 3% is used. This higher discount rate lowers the shadow price to $5.5/tC in 1919-2000 and $8.3 in 2021-2030.

Results show that the PV of the global benefit from forest preservation is 12% higher than the benefit from agroforestry, under the higher shadow price of carbon. The higher value for forest preservation is due to the prevention of emissions resulting from deforestation, which are achieved in the first year and therefore have a higher value relative to later emission reductions. The difference between the global benefits of forest preservation and agroforestry falls to about 7% under a lower shadow price for carbon.

The local cost of land use change is calculated as the PV of farmers' median bids for changing their land use system (WTA for economic losses minus WTP for environmental services: Table 1). Transactions costs of organizing farmers and monitoring for compliance are excluded from these calculations. Discount rates of 30% and 20% are used, representing the discount rates of small-scale farmers in developing countries (Cuesta et al., 1994). Results based on median bids by farmers as well as the upper and lower bounds are given in rows 3 and 4.

Results show that the PV of farmers' bids is 76% higher for forest preservation than for agroforestry, a difference which is considerably larger than the difference in the PV of carbon sequestration services of these two land use changes. As a result, the ratios of global benefit to local cost (given in rows 5-8) are more favorable for agroforestry than for forest preservation. Benefit/Cost ratios (B/C) are highly sensitive to the shadow price of carbon. At the higher shadow price of carbon, global benefits are 5 to 12 times more than local costs, implying that the benefits are high enough to justify the payments requested by farmers, even if B/C ratios are reduced fourfold to account for transactions costs and the uncertainty surrounding carbon sequestration estimates. At the lower prices of carbon, however, B/C ratios fall to around 2, implying that payments requested by farmers may be too high in relation to the global benefits of carbon sequestration alone, particularly in the case of forest preservation. It should be noted that these estimates exclude other environmental benefits of forest preservation (such as habitat preservation), which if taken into account, may increase benefit/cost ratios to acceptable levels. Farmers' bids are also likely to fall if the extraction of forest products is not totally prohibited in preserved areas. This indicates the importance of investigating the compatibility of forest product extraction with carbon sequestration and other environmental services.

We next compare the cost of carbon sequestration through land use change to the cost of emission reduction by utility companies. Cost/tC through land use change is calculated by dividing the annual payment required by farmers by the annuity value of changes in NCA brought about by land use change. Following Ridley (1997), NCA in each time period is weighted by the shadow price of carbon in that time period normalized by the price in the first time period. NCA_{ij} is discounted at a social discount rate of 4.4% (Ridley, 1997). Results given in rows 7 and 8 in Table 5 show that the cost/tC ranges from $8 to $10 for forest preservation and agroforestry, under both high and low carbon prices. These figures are comparable to cost estimates from other forestry based carbon sequestration projects in developing countries. In an analysis of eight developing country carbon sequestration forestry projects, the cost/tC was $12, ranging from $3 to $35 (Ridley, 1997). Swisher and Masters (1992) report similar figures, ranging from $3 to $25.

Swisher and Masters (1992) analysis of emission reduction costs for a US utility company shows that by partially substituting natural gas for coal, emissions could be reduced by 35% at a marginal cost of $100/tC and by 40% at a marginal cost of $200/tC. Of this, the first 8% could be achieved at negative cost by investing in energy end-use efficiency improvements. These costs of reducing carbon emissions through fuel switching are comparable to those obtained in Ridley's analysis of fuel switching projects in nine countries giving an average cost/tC of $165, ranging from $50/tC to $429/tC. These figures indicate that, if emission reduction targets are set at sufficiently high levels, substantial gains to trade appear to exist, even if our estimates are increased fourfold to account for transactions costs and the uncertainties connected with sequestration estimates.

CONCLUSIONS

Our study strikes an optimistic note within the generally pessimistic scenarios on tropical deforestation. The possibility of mutually profitable trade in carbon sequestration services appears to exist between carbon emitting companies and small-scale farmers, provided emission reduction targets are set high enough. This market-based approach could fundamentally alter the economics of forested land versus other land uses and thus considerably enhance the effectiveness of traditional efforts to save tropical forests. Farmers incur substantial opportunity costs in switching from slash-and-burn to forest preservation and agroforestry. Thus, it is crucial to investigate whether the potential benefits from these land use systems can be increased without compromising their environmental services. In addition to carbon sequestration, other environmental services of forests also need to be considered when designing improved forestry-based systems, in order to ensure that global benefits from land use change are large enough to justify the compensation required by farmers. Contrary to conventional wisdom, slash-and burn farmers are willing to forego substantial amounts of potential income in order to obtain the local environmental benefits of forests. Thus global trade in carbon services could benefit not only the world community, but also resource-poor farmers.

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