# Payments for Environmental Services as a Mitigation Option for Climate Change

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**Abstract**

Globally, the forest cover is decreasing, especially in tropical developing countries, which experience high rates of deforestation. Land use changes and deforestation contribute with more than 15% of the green house gases emissions. Therefore, solutions are explored for deter land and forest conversion and find strategies for projects which can sequester and conserve stocks of carbon. Payments for Environmental Services (PES) schemes constitute a way to cope with these problems and promote the conservation of natural resources using market-based incentives. Through empirical evidence from Peru, this study assesses the impact of payments for carbon reductions and analyzes factors which can contribute to the adoption of these projects. For this study, a combination of qualitative and quantitative research design is selected. The qualitative research assess the institutional arrangements, whereas the quantitative part investigate at the household level, the potential of these payments as an incentive for the adoption of forest-based projects as well as their ability to contribute to forest preservation and poverty alleviation. Household behavior is envisaged to analyze with a linear programming model, using the MPMAS (Mathematical Programming Based-Multi-Agent System). The input data for the model was obtained in a household survey using a sample of 163 households. The preliminary results indicate that carbon payments would increase the income of the farmers, thus could contribute to increase the adoption of these projects. The institutional arrangements of the community in Piura could be useful for the carbon project implementation and further PES projects. Peru´s institutional framework for PES schemes is diverse. While at the international level, Peru has ratified important agreements related with forests, climate change, at the country level, the Peruvian forestry governance lacks on an effective mechanism to implement environmental policies, as well as appropriate control systems.

*Keywords:* Climate Change, Peru, Payments for Environmental Services (PES), Linear Programming, MPMAS.

## 1. Introduction

In many tropical countries, projects to protect or increased carbon stocks, receive high development relevance. The payments could generate significant revenue, contribute to alleviate poverty and preserve other ecosystem services (Baker, 2010).

Peru has 54% of its territory covered with forests while around 48% of the population lives in poverty (FAO, 2009; INEI, 2007). The rate of deforestation is increasing, reaching approximately 150,000 hectares per year (Velarde, et al., 2010). Deforestation and land use changes account for around 50% of Peru's greenhouse gas emissions (MINAM, 2009). Most of its deforestation is the result of subsistence agriculture (slash-and-burn/ fallow techniques), which is attributed to the migration of farmers from the highlands (Velarde, et al., 2010). Moreover, forest areas are also confronted with the problem of illegal coca cultivation.

PES has been promoted as an environmental policy instrument for climate change mitigation and as a tool to finance conservation and management of natural resources in developing countries (Pascual et.al, 2010; Wunder, 2005). A number of studies show that they can improve the welfare of the rural people and play a role in solving social conflicts (Wunder, 2005; Pagiola, et.al 2005; Cacho, et.al 2003). Nevertheless, the impacts of PES on poverty depend on whether the poor can benefit from markets for environmental services (Scherr, et.al 2007).

Institutional factors play an important role in be involved in and benefit from these schemes (Smith & Scherr, 2003; Bracer et al. 2007). Some studies show that PES schemes can strengthen existing institutions for ecosystem conservation; through the provision of a framework for management and regulation, as well as provides incentives to behavioral change (Corbera, et.al 2009; Engel, et. al 2008). As PES schemes entail the participation of various stakeholders, transaction costs might provide a barrier to entry for some of them (Scherr, et al. 2007). This is considered in the theory of institutions of which the transaction cost theory constitutes an important component (North, 1990). In case of PES schemes, they are associated with costs of drawing attention to potential buyers, costs of working with project partners and costs of ensuring parties accomplish their obligations (Bracer et al., 2007). The participation of local communities can lead to a reduction in transaction costs, especially information costs, monitoring costs and enforcement costs are lowered (Smith & Scherr, 2003).

At present, efforts to mitigate greenhouse gas effects trough establishment of forest based systems are in process, involving poor rural communities, but it would be necessary to determine whether these projects can contribute to the reduction of poverty and increase farmers' income. This study deals with these questions. The objective is to explore the potential impacts of these payments and the institutional settings that could contribute with these projects.

## 2. Study Area

The present study was carried out in Peru, where two case studies of forest-based projects oriented to timber production and carbon markets were selected.

The project "*Ignacio Tavara Dry Forest Reforestation, Sustainable Production and Carbon Sequestration"* is established in 8989 ha of the communal land of the Ignacio Tavara Pasapera Community. It is located in Chulucanas District, department of Piura. This project was registered in 2009 with the Clean Development Mechanism (CDM) of the UNFCCC and it employs native species from the dry tropical forest.

The project *Reforestation of Degraded Areas in Campo Verde with Native Species*" is located in the district of Campo Verde, department of Ucayali (Peruvian Amazon). The carbon project belongs to a private enterprise which owns 16000 ha of degraded land, of which 2600 hectares have been reforested with tropical species. This project has sold already some Voluntary Emissions Reductions (VERs) to voluntary markets.

# 3. Methodology

## 3.1. Data Collection and Research Design

The data collection was done in 2010, using a combination of qualitative and quantitative research design.

The qualitative research concentrated on the institutional setting for natural resource management. For this purpose, in-depth and key interviews were done.

For the quantitative research, 163 household interviews have carried out using a detailed structured questionnaire. For each individual household all the necessary data for household modeling was collected in this survey. Secondary data provided by the NGO AIDER and SFM BAM enterprise was employed in order to quantify the amount of carbon sequestrated for each project. The AR-AM003 methodology "Afforestation and reforestation of degraded land through tree planting, assisted natural regeneration and control of animal grazing", approved under the CDM by the UNFCCC for forest projects, was used.

## 3.2.Farm Household Modeling

Linear programming (LP) model was chosen to evaluate the behavior of the farmers and their resource allocation. LP is a mathematical approach for achieve the best outcome, such as maximize profit or minimize costs, in a mathematical model (Hazell & Norton, 1986). For this purpose, the Mathematical Programming-based Multi Agent System, (MP-MAS) will be used, which shares features with other bio-economic farm household models. At the core of the MAS is the MP matrix that simulates the decision-making of individual farm households (Schreinemachers & Berger, 2011). As an input for the model, the gross margins for the main cropping activities were calculated. The model is designed to maximize the total gross margin of the farm by finding the optimal set of the different agricultural activities under the respective restrictions such as farm size, suitability of the land for various crops, credit limit, and family work force. Risk is not accounted in the model and the time horizon in simulations is 20 years in Piura and 30 in Ucayali.

In a simplified form the model can be written as follows:

$$\text{Max } Y = \sum_{j=1}^{n} Cj\ Xj \quad \text{(equation 1)}$$

Such that

$\sum_{j=1}^{n} aijXj \leq bi$ all $i$ = 1 to m

And

$Xj \geq 0,$ all j = 1 to n

Where:

$X_j$ = the level of the *j*th farm activity (i.e. hectares), *n* is the number of possible activities

$c_j$ = the gross margin of a unit of the *j*th activity

$a_{ij}$ = the technical conversion factors or quantity of the *i*th resource required to

produce one unit of the *j*th activity. *m* is the number of resources.

$b_i$ = the amount of the *i*th resource constraint available

# 4. PRELIMINARY RESULTS

## 4.1. Carbon Sequestration Potential

The net carbon accumulation in Piura is 499,376 tones $CO_2$ in a 20 year project, whereas in Ucayali is 153,430 tones $CO_2$ in 30 years (AIDER, 2010). The resulting payments for carbon sequestration in turn depend then on the carbon accumulation, the time span of the project and the Certified Emissions Reductions (CER) and Verified Emission Reductions (VER) prices. The prices for CER and VER vary considerably on carbon markets. A price of 5 USD per tCO2e is comparable to the lowest price, whereas 30 USD represents the trading prices in the European Climate Exchange for 2011 – 2012 allowances in February 2011.

## 4.2. Farm Households

Both areas are predominantly rural regions. More than 80 percent of the farmers depend on agricultural activities as their main income source. In Piura, more than 95% of the agricultural area is allotted to annual crops, mainly cowpeas and beans, watermelon and maize. Cowpea is cash crop destined to local markets, whereas the other crops are use for home consumption. In Campo Verde - Ucayali, 20% of the land is dedicated to agriculture activities, 34 % of grasslands and the remaining land is cover by forest. The most important cash crops are cassava, palm oil and cacao, citrus and to a lesser degree pepper, camu-camu. Cassava and banana are the most important staple food in the area.

The model is based on empirical household data. The main activities are annual crops, perennial crops and livestock activities. The model look to find the best combination of activities (output-output relations), but assumes input-output relationships (production functions). The main constraints are land, labor and capital. Table 4.2.1 summarized the characteristics of the households.

**Table 4.2.1. Characteristics of Different Household Classes**

| | Piura | Campo Verde |
|---|---|---|
| Total Land (ha) | 2.5 | 39.9 |
| Cultivated Land (ha) | 1.82 | 7.8 |
| Grassland (ha) | 0.78 | 13.8 |
| Forest (ha) | 0.06 | 19.3 |
| Family Size (members) | 5.2 | 4.47 |
| Age (years) | 29.8 | 28.3 |
| Analphabetism | 40% | 20% |
| % migrant households | 3% | 44% |
| Family labor days per month | 68.9 | 58.8 |
| Credit Limit (soles) | 2500 | 7400 |

Source: Own data

In Piura the baseline income of a household is around 3800 soles per year, whereas in Campo Verde is 5200 soles per year. To assess which impact carbon payments have on the pursuit activities, different scenarios will be tested. In these scenarios new activities will be introduced into the baseline model. The payments for carbon sequestration will be added to the equation 1. With the introduction of the payments: USD 5, 15 and 30 USD, the rise in total gross margin increase in 4%, 10% and 20% in Piura. In Campo Verde, the rise in total gross margin could be in the range of 5%, as the project belongs to a private enterprise. Here, villagers benefit mainly from the generation of employment, which is more than 200 wages per day, reached 500 at the peak season. More analysis is necessary in this item, as well as to develop a scenario with payments for avoiding forest conversion.

### 4.3. Impacts and Incentives for Forest-Based Projects

In both areas, forests play an important role in household´s livelihood. Farmers mentioned that individual payments in cash or in kind could act as incentives for spread forest projects in the communities. Differences were founded for village payments, while in the Ignacio Tavara´s community, which has a strong social organization, 55% of the respondents agree with communal payments, in Campo Verde only 28% of responders concur. Most concerns are arising about whether communal projects will be carried out according to their objectives and funds could be handled efficiently and distributed fairly. Farmers though that financial support is the most important incentive for forest-based projects, followed by training and strengthened social organization. They mentioned that these projects could generate employment, reduce deforestation and protect the remaining forest. Thus, most of them would like to participate in the projects. Regarding to enforcement and incentive measures to stop villagers cutting trees in the forest, most of them considered that payments is the best solution, following by individual payments of penalty and physical punishment.

### 4.4. Institutional Arrangements for Carbon Sequestration Projects

Participative governance involves different stakeholders, where all parties join in a common decision making process to achieve agreement. Ballet et al (2007) mentioned that local communities are progressively considered as the most efficient grassroots level to minimize social costs and maximize social welfare. The two cases studies are using this concept to assess the institutional arrangements and searched if they can provide a framework for active involvement of stakeholders in the project.

Although in Campo Verde, we did not found communal organizations dealing with carbon projects, some local organizations are working in agricultural activities like Campo Verde Beekeeper Association and the Organic Farming Producers. In one village, a rural patrol is working properly against illegal logging activities. According to local authorities, villagers are interested in forest-based projects.

In Piura, the Ignacio Tavara community was involved in the project´s formulation, holding the rights to the sequestered carbon. The stakeholders signed a formal agreement, where they compromise to use the revenues from CERs to cover operational costs, as well as fund social projects. As we mentioned in the section 2,

transaction costs of carbon projects could be reduce with communal agreements, where monitoring and enforcement are key issues for the success of these projects. We founded that the Representative Board and the Rural Patrol (Ronderos) are dealing successfully with these activities in the area, but more support is necessary to backed up their efforts.

## 5. Preliminary Conclusions

The case studies show that carbon payments would increase the income of the farmers, thus could contribute with the adoption of these projects. The degree of participation would depend on the price of carbon and other factors such as transaction costs and economic conditions.

In Piura, the present institutional arrangement of the community could be useful for the carbon project implementation and further PES projects. It seems that they could provide a framework based on their traditional rules and regulations. It addresses illegal logging activities and is involved in rule enforcement. Extractive activities have declined since the establishment of rural patrols and environmental awareness has increased. Nevertheless, the institutional framework needs to be strengthened and the information flows have to be improved.

Although Peru has ratified important agreements at the international level, at the country level, the Peruvian forestry governance lacks on an effective mechanism to implement environmental policies and appropriate control systems.

During this research, over expectations about the benefits from carbon market credits were founded in smallholder farms. An information campaign addressed that carbon payments are not the panacea is particularly necessary, as well as promotion of financial mechanisms for carbon sales that are inclusive and not exclusive.

## 6. Outlook

The single agent-single decision linear programming model will be updated, including in detail livestock and off-farm income activities. Various scenarios will be developed, considered impacts in changing more carbon prices, depressed cash crops prices and payments for avoiding deforestation.

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