Peasants' production systems and the integration of incentives for watershed protection. A case study in Guatemala

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INTRODUCTION

Legal and policy frameworks for sustainable production systems in Guatemala

The study region, the Departamento de Alta Verapaz, is located in the eastern tropical and temperate highlands of Guatemala. Large-scale deforestation in Alta Verapaz began in the late 1950s when the government, in lieu of land reform, encouraged landless peasants to migrate to the department. Between 1987 and 1995, the annual deforestation rate was 1.1 percent of the total forested area, equivalent to 1860 ha per year (Jolom-Morales, 1997). Degradation and loss of forest cover is caused mainly by forest clearing for cash crop production (e.g., cardamom and coffee), local demand for construction, illegal logging, rising demand for commercial forest products (particularly of the reserve's primary and old-growth forest), slash-and-burn expansion to grow subsistence crops (e.g., corn and beans), extraction of firewood (the only domestic fuel used by rural inhabitants), and finally the clearing of forest areas for the grazing of cattle (Secaira, 2000).

Deforestation is a major threat not only in the study region, but in all of Guatemala. IIEE/ WRI (1986) estimated the annual rate of deforestation at 2.0%, i.e., 90,000 hectares of forest are lost each year. In Guatemala, the once-vast rainforest, dubbed by environmentalists the western hemisphere's "second lung," could disappear within 20 years if deforestation practices continue at their current rate.

In Central America, a promising approach to promote forest conservation and combat land degradation is research on and promotion of sustainable agroforestry and animal husbandry systems (MALAVASI AND KELLENBERG, 2001). However, the adoption of sustainable production systems that promote environmental protection is often associated with increased costs or forgone income at the farm-household level, at least in the short-run (MÁNEZ COSTA, 2001). Thus, the adoption of ecologically sustainable production systems is hampered by the fact that its costs are borne by the farmer, whereas the positive external effects of more environmentally friendly farming are predominantly treated as a by-product not to be compensated by the national or global society.²

In recognition of the need to internalize positive externalities of sustainable agriculture and agroforestry production systems, pioneers in forest conservation, e.g., in Costa Rica and El Salvador, have implemented environmental services payment programs during the last ten years that seek to maintain socially optimal forest cover by compensating peasants for the external benefits provided by their farming systems (CHOMITZ ET AL., 1999).

In Guatemala, measures to promote environmental protection have been limited so far to the establishment of protected areas reflecting different conditions and degrees of protection. Moreover, the various poverty-reduction strategies have only focused on improving the economic conditions of the rural population without explicitly

² «In general , the cost of biodiversity conservation is imposed on local communities, while most of the benefits accrue to a much broader community". (BHATTARI AND HAMMIG, 1998)
considering its impact on the environment. Thus, environmental, economic and social policy objectives are pursued by single policy instruments and projects instead of integrated ones. There are hardly any projects in Guatemala that seek to directly address the trade-offs and synergies in smallholder agriculture between economic development in rural areas, poverty reduction and environmental protection.

The short-run trade-offs between the income needs of peasants and environmental sustainability could find a convergence in the mechanism of payments for environmental services (PES). Developing payment systems in which land users are compensated for the environmental services they deliver could be a way for society at large to compensate for the perceived benefits of agro-forestry production systems. Compensatory payments for environmental services to smallholders could potentially contribute to the achievement of all three objectives of the critical triangle of rural development (Vosti and Reardon, 1992): poverty reduction, economic development and environmental protection.

The legal framework enabling the possibility of payments for environmental services that we explore in this paper has already existed in Guatemala since the mid-nineties. Guatemala signed the “Convenio Centroamericano de Biodiversidad” (CCB) in June 1992, and the “Convention on Biological Diversity” (CBD) in 1995. Since then, Guatemala has compelled itself to initiate a process for developing a regulatory framework and policies for biodiversity protection. Both conventions, CCB (art. 10, 11 and 13 b) and CBD (art. 11)³ foresee the creation of a monetary mechanism or other adequate incentives to preserve biodiversity, as well as the incorporation of biodiversity conservation in the national jurisprudence. Both conventions focus on the integration of biodiversity concerns into policy-making by promoting the conservation and sustainable use of biological diversity of ecosystems and the fair and equitable sharing of benefits arising from their use.

The legal framework for the PES is not only provided in these two conventions, but further strengthened by the Law on Decentralisation recently enacted on 15th of April, 2002. This law makes policy measures possible that seek to empower the municipal and local governance structures for rural development and environmental protection.

³ CCB:
Articulo 11. Los Estados miembros tomarán las acciones pertinentes para incorporar a las respectivos políticas y planes de desarrollo, los lineamientos para y el valor socioeconómico de la conservación de los recursos biológicos.

Articulo 10. Cada Estado miembro de este marco regional, se compromete de acuerdo a sus capacidades, programas nacionales y prioridades, a tomar todas las medidas posibles para asegurar la conservación de la biodiversidad, y su uso sostenible, así como del desarrollo de sus componentes dentro de su jurisdicción nacional, y a cooperar en la medida de sus posibilidades en las acciones fronterizas y regionales.

CBD:
Articulo 11: Cada Parte Contratante, en la medida de lo posible y según proceda, adoptará medidas económica y socialmente idóneas que actúen como incentivos para la conservación y la utilización sostenible de los componentes de la diversidad biológica.
Yet, while Guatemala now disposes over a legal framework enabling environmental protection, the practical implementation of these laws lags behind.

**Research area**

Our research area is the Mestelá river watershed. It is located 17 kilometers south of Coban, the capital of Alta Verapaz. The altitude of the Mestelá watershed ranges from 1400 to 2600 m ASL. The natural vegetation in the area is typical of a cloud forest. It has all but disappeared, except for areas more difficult to access for forest exploitation and farming. Yet, the remaining cloud forests hold precious biological diversity. Secondary forests under continuous extractive use can be found as “forest islands” distributed over the fragmented landscape.

Next to the biological diversity in the research area, its hydrological functions (Bruijnzeel, 1990) are regarded as one of the major reasons why deforestation needs to be reduced. The Mestelá river watershed provides 48.6 % of the drinking water for the city of Cobán. Four hundred twenty families living in three communities located in the watershed have a direct impact on the water flow of the Mestelá River and on the city of Cobán’s water catchment points. The main environmental services that the Mestelá watershed forest and agricultural ecosystems offer are the conservation of the water quality and quantity and the reduction of sediments in the water flow. Thus an important argument at the local level for forest conservation and water-conserving agricultural systems is their hydrological contributions.

Upper watershed farmers of Mestelá applying soil conservation measures and re-vegetating the landscape are producing services for downstream people, helping to increment the water harvesting benefits, meanwhile costs remain at Mestelá. PES could manage the trade-offs among environmental options and strategies within farming systems and the distribution of net benefits between Mestela farmers and water consumers in the city of Coban. The livelihood implications of PES are to correct the divergence between the private and social costs and benefits of “producing and consuming” water and to provide the farmers of Mestela with an economic alternative to devastating and transforming forest and perennial vegetation areas into farmland (KAHN, 1998).

**Research objectives**

Biological diversity as a global public good as well as the provision of drinking water as a local public good are the major environmental services fulfilled by cloud forests, secondary forests and sustainable agricultural production systems in the research area. Yet peasants in the research area may incur considerable opportunity costs when conserving forests or adopting more environmentally sustainable production practices such as hedgerows, multi-cropping and tree crops.

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4 Data obtained from the municipality of Coban.

5 Environmental measures of upper watershed farmers of Mestela signify not only conserving cloud forest, but also revegetating the landscape. Against annual crops, not only cloud forest but also perennial vegetation helps in the area to capture additional water supply from the atmosphere (comp. WRI, 2002)
As a prerequisite for the implementation of a mechanism for the payment of environmental services, it is important to estimate these opportunity costs for different farm-household types. Samples of the behavior in subsistence-oriented farming systems in this area have been occasionally researched. Therefore, an in-depth understanding of production and consumption decisions will allow a better perception of the real patterns of resource use.

Taking the case of the Mestelá watershed as an empirical example, the paper develops a methodological approach that attempts to quantify the income losses incurred by peasants when practicing different water-conserving production measures. Second, we discuss the possibilities of compensating the peasants for these costs by introducing the policy instrument of “payment for environmental services” (PES) (MÁÑEZ COSTA, 2003).

In the following chapter, we present our method of data collection and conduct descriptive data analysis to categorize four different farming systems in the area. We further distinguish environmental measures that are already practiced by farmers in the area. In chapter 3, a linear programming model for the four farming systems is developed. The model is used to estimate the opportunity costs, i.e., the farmers’ forgone private income when implementing various environmental measures. Exemplary simulation with respect to conserving secondary forests, assuming different levels of payment for environmental services will be shown. The paper concludes with a discussion of the potential arising from implementing payments for environmental services.

CONCEPTUAL FRAMEWORK

The theoretical framework for analyzing the concept of “payments for environmental services (PES)” as an economic instrument for environmental management draws from the utilitarian approach in economics, specifically the theory of externalities, based mostly on Pigou’s (1932) exposition of potential market failures when a externality is present (CARLSON, 1993). From an economic point of view, the positive externalities of an agroforestry farming system are activities that contribute to the preservation and conservation of natural capital. Small farmers in a watershed who implement re-vegetation measures and soil conservation measures, which we assume to be positive externalities, cannot add to their income the ex-situ benefits of their practices. Yet, these measures increase water the supply so that the benefits not only accrue to the farmers but also to society. The decline of such environmental services can be directly linked to the loss of productivity and natural capital. To avoid such a situation, it is necessary to estimate the changes in the management of farming

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6 “Careful analysis of the microeconomic behavior of smallholder farmers is thus central to understanding the roots of environmental degradation, the deepening poverty, and design of appropriate policies and strategies for reversing the problem” (SHIFERAW, B.; HOLDEN, S.T., 1997)

7 Externalities are positive or negative effects of an activity of an agent upon others or upon the activities of others, which are not factored into market prices. The idea of “internalizing externalities” is an attempt in economics to reduce such distortions in the price system.

8 Refering in the case of Mestela to revegetation measures as well as the non-use of pesticides.
systems by offering environmental services. It is also essential to calculate the opportunity costs of the preventative expenditures needed to avert natural capital loss in order to advise decision makers in environmental management (Hearne, 1996).

Chomitz et al. (1999) proposed the creation of incentives and compensation mechanisms for internalizing the positive externalities of farming, making a link between theoretical economics and the real world, assuming that forest would be better maintained if forest owners were compensated for all the services they provide (Chomitz, Brenes and Constantino, 1999). Based on this assumption, the calculation and the determination of the opportunity costs of preventative measures in the watershed is essential for the development of win-win options in Mestelá. (Klapka, Scheumann and Schliep, 2001). In our case, the economic evaluation of such opportunity costs is performed using the method of linear programming (Panell, 1997). This method derives shadow values for the introduction of a new or the extension of existing farming activities. These values can be interpreted to be opportunity costs, i.e., the loss of income occurring when introducing or extending certain activities such as environmental measures into an existing farming system. Linear programming for the calculation of opportunity costs is a widely used method for modeling farm resource use. Linear programming has been chosen as a proper modeling technique of farm behavior because the farm’s income is linear in output prices and quantities (Cervigni, 2001).

Box 1. Linear programming

Linear programs are characterized by the following properties:

- Optimization of a problem/mathematical program: The problem involves finding the best value for a given objective, subject to a given set of constraints.
- Deterministic: The behavior of the model is completely determined, that is, there is no probability contributing to the objective or constraints.
- Proportionality: Each variable contributes in direct proportion to its value.
- Additivity: The variables in the objective and each constraint contribute the sum of the contributions of each variable.
- Divisibility: The variables can take on continuous values subject to the constraints.

Any function satisfying the proportionality and additivity properties is called a linear function, and will always have the form

\[ f(x_1; \ldots; x_n) = a_1x_1 + \ldots + a_nx_n + d \]

Source (see footnote 9)

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DATA COLLECTION AND THE CATEGORIZATION OF FARMING SYSTEMS

The data collection was carried out during two periods: from May to September 2001, as well as from April to July 2002. Simple random sampling was applied to select 46 out of a total of 420 families residing in the three communities in the research area. SIAS (Sistema Integrado de Asistencia Sanitaria) was the source of the sampling frame.10

In this random sample, semi-structured interviews were carried out with the heads of the households. An interview guide was prepared beforehand as a framework for the interviews. The majority of the questions were revised and improved during the pre-testing phase. The interview guide focused on four areas of interest: land, the demographic structure, livestock and the productive processes. The semi-structured interviews made it possible to gather in-depth information on these topics and enabled us to understand better the problems and potentials of farming communities and households in the research area better. This data was obtained in 2001. The data from the semi-structured interviews was used later to categorize households into four groups.

During the second field research phase in 2001, detailed structured questionnaires were applied to a random sub sample of these 46 households. This data was crucial for defining costs, inputs and outputs of different production activities as well as the constraints for labor, capital and land that were fed into the construction of the linear programming models. For each of the four household types, we developed a linear programming model that aimed to represent the average household for that group. Thus, for example, the land area available for farming for a particular type of household was calculated to be the average land area possessed by all of the sample households belonging to this type.

In the second period of the data collection, the findings obtained from the first LP simulations were compared with the actual economic situation. Secondary and additional data were also gathered to further improve and validate the models.

Categorization of farming systems

Following Chayanov’s theory of the peasant household (CHAYANOV, 1986), we categorized households along their major production constraints, i.e., the availability of land and forest and the use of family labor on and off-farm. In addition, we also took into account whether the household held livestock. Based on these criteria, four different groups were distinguished representing the different farming systems in the research area (see Table 1).

The categorization of the farming households into four different types was motivated by the fact that household behaviour is conditioned by differences in underlying production and consumption constraints. Thus, households react differently depending

10 SIAS is the health care system of Guatemala. It works at a local level distributing the population in 10,000 people per jurisprudence. Every single household of every jurisprudence gets registrated in a list with an individual number. We used the SIAS-Infrastructure for the data collection.
on their economic constraints that are mainly land, labour and capital. Given the imperfections of the food markets in rural Guatemala, households of the area initial do not behave like cash profits maximizers, but instead seek to secure their basic food needs through home production. Once they have secure subsistence households start maximizing profits. This implies that production and consumption decisions are non-separable in the semi-subsistence households in the research area, a crucial characteristic that is taken into account in the linear programming model by introducing minimum constraints for food production.

Table 1. Farming system classification

<table>
<thead>
<tr>
<th>Farming System</th>
<th>Aa</th>
<th>Ab</th>
<th>Ba</th>
<th>Bb</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poorest land-scarce</td>
<td>25</td>
<td>50</td>
<td>100</td>
<td>200</td>
<td>cuerdas</td>
</tr>
<tr>
<td>farmers (n=7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land scarce spec. veg.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>farmers (n=14)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable farmers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Livestock and maize</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>farmers (n=7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>farmed land</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>labor in own farm</td>
<td>3.4</td>
<td>8.8</td>
<td>14</td>
<td>20.1</td>
<td>c/w ratio</td>
</tr>
<tr>
<td>labor out farm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>per month</td>
</tr>
<tr>
<td>livestock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pigs</td>
<td>17</td>
<td>12.3</td>
<td>3.5</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>cattle</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Possession of</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>primary forest</td>
<td>0</td>
<td>0</td>
<td>30</td>
<td>45</td>
<td>cuerdas</td>
</tr>
<tr>
<td>secondary forest</td>
<td>0</td>
<td>12</td>
<td>33</td>
<td>55</td>
<td>cuerdas</td>
</tr>
</tbody>
</table>

Source: own research

The sample households were divided into two groups, A and B. The main criteria for distinguishing between the two groups were the number of months working on-farm. The households included in the group A worked on the average 6 months off-farm, while those in the group B worked less than four months off-farm.

The households belonging to group A did not possess any forest and little land. Because of this, they did not keep livestock and used their scarce land exclusively for subsistence food as well as cash crop production. The possession of arable land ranged between 25 and 60 cuerdas, i.e., between 2.84 and 6.80 acres. Because of the land constraint, the households belonging to group A did not earn much cash income from farming and were dependent on selling their labour at least part of the year. In

11 comp. THORNER, 1986

12 comp. SHIFERAW, B.; HOLDEN, S.T., 1997. According to them, “this is mainly because production and resource use decisions are likely to be affected by non-profit considerations such as preference for home production of staple food, leisure consumption and other goals”

13 The household act as “producers and consumers, meaning that their consumption and labour supply decisions are not independent of production and labour demand decisions” (MLAY AND NHANTUMBO, 1999)

14 One acres is 8.8 cuerdas.
group A, we found many households where men worked on the coffee and cardamom plantations in the region, whilst women remained on-farm and carried out the subsistence production. They concentrated their efforts on the production of staple food, i.e., maize and beans. The daily cash income was earned by women mostly through the sale of vegetables and fruits as well as handicrafts in the local markets.

We further divided group A into two different farming systems, “Poorestland scarce farmers” and “land scarce specialized on vegetable farmers”, as follows, depending on the criteria “forest tenure”:

- The households belonging to the subgroup “Poorestland scarce farmers” worked on the average 50 days per person and year on-farm, whereas the households belonging to “land scarce specialized on vegetable farmers” worked more than 100 days per person and year.
- Seasonality of on-farm work: “Poorestland scarce farmers” worked only in April when maize needed to be sown and again during the maize harvest in October. “land scarce specialized on vegetable farmers” worked during January to May on their own farms cultivating vegetables and fruits.
- Production of cash crops: “Poorestland scarce farmers” did not produce any cash crops but handicrafts, whereas “land scarce specialized on vegetable farmers” produced vegetables and fruits for the local market.

The farmers in group B owned between 150 and 300 cuerdas, i.e., between 17 and 34 acres. In addition, they owned secondary forest and livestock and had access to primary forest. Their main income was derived from the sales of crops (mainly vegetables) and livestock. All of the family members, independent of gender, were active on-farm.

As with group A, we further divided group B into two different farming systems: “vegetable farmers” and “livestock and maize farmers”. The key criterion for this division was work off-farm (see table 2).

The main differences between the farming systems are:

- Farming system “livestock and maize farmers” did not work off-farm. The farmers belonging to the farming system “vegetable farmers” spent the months between June and September (months with less on-farm activity) working off-farm, mostly on coffee plantations.
- Cash crops production: While the farming system “vegetable farmers” income was a combination of vegetable, fruit and livestock sales, the farming system “livestock and maize farmers” only sold livestock and maize.

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15 About 300,000 workers (11% of the total active population of Guatemala) are annually employed by coffee plantations and about 1,000,000 seasonally. (ANACAFE, 1999)
Environmental Services

After having categorized the farming systems, we analysed the different environmental measures that peasants already put into practice (see table 3). These environmental measures for the peasants of Mestela are: secondary forest and natural reforestation, fruit trees intercropped with annual crops, trees in lines, living barriers, living fences, block planting, terraces and not using of Pesticides.

Table 2. Environmental measures currently used in the four farming systems

<table>
<thead>
<tr>
<th>Farming Systems</th>
<th>2er. Forest</th>
<th>Inter-Crop</th>
<th>Trees in lines</th>
<th>Living Barriers</th>
<th>Living Fences</th>
<th>Block Planting</th>
<th>Terraces</th>
<th>No Pest.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>AB</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BA</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bb</td>
<td></td>
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</tr>
</tbody>
</table>

Footnote to table 2: the shade degree is related to the impact on water quantity improvement. There is no directly study done on these environmental measures but the literature gives indications about it. (comp. Bruinjzeel, 1990, Clark et al. 2000 and Haber, 2000)

All of the listed environmental measures are already implemented within the farming systems of Mestela. Almost all of the implemented environmental measures serve to conserve soil through re-vegetation. They affect the water catchments capability of the research area positively and protect the soil against soil run-off and erosion. Thus we assumed that these measures contribute to the improvement of water quantity and quality. Moreover, they result in more diverse agro-ecological landscapes with beneficial effects on biodiversity.

From Table 2 one can see that the environmental measures currently used by the farmers are correlated with the farming system classification. This is not surprising as the classification of the farming systems was based on the underlying prime production constraints, i.e., family labor and access to land and forests. For example, farming system “Poorestland scarce farmers” represents the “poorest peasants” in the area with little of arable land, low-income, lack of livestock and extreme dependency on earning wages off the farm, as well as no access to forestland. Thus, due to land scarcity, “Poorestland scarce farmer” is not likely to carry out the environmental measure “secondary forest and natural reforestation.” Presumably because of the high poverty level and low access to capital, “Poorestland scarce farmers” did not use “terraces” for soil conservation, as it requires considerable labour efforts as well as capital inputs. Another example was given us as a reflectance of cash income access.

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16 “Theory suggests that, in the absence of market, policy or institutional failures, landowners would be inclined to adopt soil conservation practices that lessen the impact of the on-site costs that result from soil degradation.” (AYLWARD ET AL. 1995)
which again reproduced the correlation between farming systems and environmental measures, namely the use of pesticides and fertilizer. Only a few farmers do not use pesticides because of the income constraint. These farmers belong to the group A.

**Recent behaviour of the farmers after the coffee crisis**

The current crises on the world coffee markets and the corresponding decline of coffee prices have seriously worsened the wage-earning potential of the Mestelá seasonal labourers. About 68 percent of the sample households were found to engage in wage-labour activities linked to coffee farming. Thus, the coffee crisis led to a considerable decline in income in many Mestelá households. Hence, as a response to this crisis, the farmers were increasingly forced to use the remaining forestland for food crop cultivation. In this context, it is well-known facts that in such ecologically fragile areas as cloud forest, if the soils lose their vegetation cover then they are greatly exposed to the leaching and eroding effects of rain. Indeed in Mestelá it was observed that farmers started to cut and burn new surfaces for staple crops production. Moreover, they sold timber to traders in order to compensate for the loss of off-farm cash income. About 76% of the sample farmers were found to view timber as precautionary savings.

Over the years, the research area Mestelá witnessed the following:

- The forest degrading activities in the River basin Mestelá have caused forest decline and a reduction in the perennial vegetation. About 47.4% of the total surface of the basin is categorized as being over utilized.

- Since 1994, the water flow experienced a reduction from an initial water flow of 70 l/sec to 32 l/sec in 2000. During the dry season, Cobán now experiences frequent irregularities in its tap water supply.

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17. "Ground cover, rather than canopy, is the chief determinant of erosion" (Wiersum, 1984, cit WRI. 2002)


20. Due to the soil type building terraces on this area is linked to high cash expenditure but also to high transaction cost because Q’eqchi Farmers are not familiarized with these techniques. A calculation from a local NGO gave us a price to build a cuerda of terraces of 280 quetzales a year.

21. About 4000 mm/year.

22. GTZ (1997) declared that agriculture and continuous extractive use of wood have provoked soil degradation

23. Data obtained from the Municipality of Cobán – Summer 2001
Measuring the demand of water

As the inhabitants of Cobán are faced as water consumers with these deteriorating conditions in their water supply, we explored their willingness to pay (WTP) for environmental services.

The interview for the WTP-Questionnaire was elaborated in two steps:

- First we tried to create an instrument that could be understood by the interviewed persons and that also could give us a range of payments we could ask about. The first interview guide was done on focus groups with different social status and different areas in Coban. The interviews were “open-end”. The information about the creation of scenarios for the second interview guide was created with the obtained information from the focus groups.
- Second we elaborated a WTP-questionnaire to capture the water consumer surplus. We presented them a scenario with the actual data about water quality and quantity of Coban (see above) and explain them the role of vegetation in the water catchments area and for what the obtained money would be used. We asked them about the WTP for better quality and quantity of water. The amount of the fees varied between 5, 10, 15, 20, 25, 30 and 35 quetzales over the actual water fee.

This survey found out that the population is fully aware of the environmental problems linked to the loss of vegetation cover and forest. About 96 % of the respondents believed that the degradation and deforestation of the river basin is the primary cause for the infrequent and low quality of the water supply. About 63 % of the respondents were willing to pay more for the provision of water. These additional payments could be used for the provision of the above-mentioned environmental services provided by farmers in the Mestela watershed. Those among the respondents who were not willing to pay more for tap water were among the poorer segments of the urban population. Using a contingent valuation method, we obtained a median WTP amount of 25.32 quetzales per month per household. This is almost double the actual median payment of 12 quetzales per month and household. The city of Coban has 4109 households that receive their water from the Mestelá watershed. Thus, simple calculus would yield an additional amount of 104,039.88 quetzales per month that could be potentially used to compensate farmers in the Mestala watershed for conserving forests and soils through adequate agro-forestry measures so as to improve the quality and quantity of water. Based on our survey results, we estimate the average household income in the Mestala region at 1800 quetzales per month. Thus, if the municipal government were to raise the water charges to about 25 quetzales per month, each household in the Mestala region could obtain up to 130 quetzales per month. Of course this simple calculation only demonstrates that the willingness to pay on the part of urban water consumers is considerable and could contribute a considerable share of rural incomes. Compensation, however, should be linked to the opportunity costs incurred by farmers.

24 We defined water quality as the future possibility of drinking tap water without cooking it or filtering it (Nowaday it is impossible to drink tap water without getting sick. This is a known problem for the citizen of Coban). Water quantity was defined as a continuos and stable flowing of water during all the year as opposed to the today’s circumstances of instable water flowing.
arising from environmental measures and should also be dependent on the hydrological contributions of these measures. However, other contributions derived from environmental measures such as biodiversity and landscape enhancement may also be figured in when deciding on which environmental measure to support through direct payment to farmers implementing those measures. In the following chapter, we explore the former aspect as a crucial prerequisite for the design of a decentralized payment system for environmental services.

MODEL SIMULATIONS

In order to calculate the opportunity costs of implementing various environmental measures, a linear programming model (LPM) was used. The LPM provides a suitable analytical framework for representing the complex input-output relationships of farming systems and enabled us to model the production constraints (see Table 1) of the four different farming systems.

The model runs in XA-Solver with Excel-Interface spreadsheet.

Each environmental measure as every farming activity was considered alike, i.e., the computation for the different activities was calculated depending on the opportunity costs of labor per land unit per year.

Depending on the household type modeled, the main activities in the LPM amounted to 36, including crop and livestock production activities, miscellaneous activities for crop sales and home consumption, the environmental measures as shown in Table 3 and the seasonal sale of family labor off-farm as well as the hiring of labor for on-farm activities. We distinguished three seasons in the local labor market. The production constraints for each of the four types of farming systems were modelled as observed in the survey. For example, the LP matrix for type “Poorestland scarce farmers” contains 0.45 acres of arable land (see Table 1) and 12 person-months of family labor available either for on-farm or for off-farm employment. Food subsistence constraints were modelled as a minimum requirement of 0.520 kg per person/day of maize and 0.07 kg of beans per person/day. An important constraint was also the total amount of payments for environmental services that the inhabitants of Cobán were willing to pay, i.e., 104,039.88 quetzales.

The four models have a number of simplifying assumptions for the baseline scenario that need to be taken into account when interpreting the results. First, we assumed that the land is fixed in the short-run (i.e., no markets for land exist), although sales and rental of land were observed in the research areas. Second, we did not consider the differences in land quality mainly because of a lack of on-farm agronomic data for

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25 The XA Professional Linear Programming System is copyrighted and licensed software from Sunset Software Technology.

26 In rural Guatemala there is a calories intake of 1148 calories per day/person through maize consumption (Total:1994 calories per day/person). The consumption of maize in this area is higher than in the rest of Guatemala. The average for rural Guatemala is 318 gr pre person/day, but in poor areas men may consume about 600 gr. and women about 400 gr. (comp. FAO, Food and Nutrition Series No.25).
different soil types. Third, we assumed that farm households do not have access to formal credit that could be used for on-farm crop and livestock production or financing environmental measures. This is a realistic assumption as no credit program operated in any of the three villages. Most micro-finance programs in Guatemala cater to the urban and semi-urban non-farm enterprise sector. Fourth, we assumed certainty concerning crop prices, input-output relationships and, therefore, did not consider decision-making under risk.

We validated the models for the four household types by comparing the results obtained for the above baseline scenario with the information obtained through the primary and secondary data collection. In the baseline scenario, the models reasonably replicate the observed actual cropping pattern, amount of crop sales, seasonal income disparities and allocation of family labour between on and off-farm activities. Examples of the simulations are:

- When we simulate a higher availability of equity capital, the farming systems tend to increase animal husbandry (mostly cattle) and basic grain production, and the optimal farming system thereby moves towards the situation of the farming system “livestock and maize farmers” that has more equity capital than the other three systems
- When we simulate a lower availability of arable land, the model reacts as farming system “Poorestland scarce farmers”, selling its family labour more off-farm.

In the following, we present the findings that simulate a policy scenario of payment to farmers for converting current crop or grazing land into secondary forests. The policy scenario simulates the impact of different annual payment levels for the environmental measure “secondary forest or natural reforestation” on the different types of farming systems. From the theory, we can deduce that the four types of farming systems differ in their opportunity costs for environmental measures and, thereby, differ in their behaviour towards accepting a certain amount of payment. In the following, we will show the findings for types “vegetable farmers” and “livestock and maize farmers”.

Farming system “livestock and maize farmers” is less flexible. It obtains cash income by selling maize and beans as well as cattle. In comparison to the farming system “vegetable farmers”, the conversion of existing forest into farmed land is more labour consuming for “livestock and maize farmers”. This results in “livestock and maize farmers” owning more forest than the other systems and only on the basis of considerable payments is he willing and disposed to decrease the amount of cattle he raises and increase the environmental measure “natural reforestation.”

Figure 1 and 2 show the result of simulations in which the amount to be paid for one cuerda of farmland being used for secondary forest is gradually increased from 200 quetzales per cuerda to 700 quetzales per cuerda. If the farmers’ opportunity costs of secondary forest exceed the offered amount of payment, the farm organization will not change, i.e., the farm does not supply more land for secondary forest. The opportunity costs are implicitly calculated by the LP as it seeks to maximize the income of the farm household by looking for the optimal combination of production
and other activities, including the acceptance of the offered payment for environmental services.

Figure 1 and 2 show the simulated land-use changes and increase in land units under PES for the maintenance of secondary forest and support of natural reforestation for the farming system “vegetable farmers” and “livestock and maize farmers”, respectively. The figures illustrate the fact that, depending on the farming system characteristics, the opportunity costs for the environmental measure “secondary forest” varies. Figures 2 and 3 show on the Y-axis the shadow cost\(^{27}\) of land under secondary forest for the two farming systems “vegetable farmers” and “livestock and maize farmers”, respectively.

The main constraints for farming system “vegetable farmers” are: an area is necessary for satisfying the subsistence demand (maize and beans), the cultivation of vegetables, animal tenure, off-farm activities, family labour, hiring labour, capital and total area.

The main constraints for farming system “livestock and maize farmers” are: the necessity to have a subsistence-saving area (maize and beans), animal tenure, non off-farm activities, hiring labour, capital and total area.

Figure 1. Scenario under PES

Whereas “vegetable farmers” would provide additional cuerdas of land for secondary forest already at a payment higher than 216 quetzals per hectare (i.e., implying lower opportunity costs of secondary forest), “livestock and maize farmers” would only supply some of its farming land for secondary forest if payments were to exceed 407.6 quetzales per year and cuerda. The farming systems will not react until payments amounting to more than the shadow cost are offered. “vegetable farmers”, being a more “flexible” farming system, reacts more sensibly to the payments and “offers” us additional land units for every single payment, whilst response to the payments of “livestock and maize farmers” is more rigid.

\(^{27}\) Shadow cost: „increase in objective value required for an activity to enter the optimal solution. Cost of forcing selection of an activity” (PANELL, D., 1997)
The above findings concerning the minimum level of payments for secondary forests are location-specific and would likely differ with varying biophysical, social and economic conditions found across different watersheds of Guatemala. With the LP, we can produce such figures for each environmental measure of every farming system.

FINDINGS AND CONCLUSIONS

The LPM provides a tool for simulating the possible impacts of various payment levels for different environmental services. The LPM gives us estimation about the farmers’ reactions to the policy instrument and could help to find a satisfactory mixture of options.

The calculation enables us to provide a more substantiated estimation of the required level of payments so that a specific environmental measure will be increasingly adopted in the farmers’ production systems.

We discussed different scenarios with urban water consumers, local stakeholders and farmers. The groups are aware of the fact that economic scarcity in the area will drive farmers to continue using more land covered by forest for staple food cultivation, mainly maize and beans, to reduce the fallow periods and to abandon conservation techniques such as re-vegetation measures. They also agree and react positively to the “possible” introduction of this policy instrument. Strengthening that financial compensation would significantly enhance the likelihood of more environmentally friendly production systems.

On these grounds, the creation of such an incentive mechanism for conservation is a first step that can transform the environmental measures into an attractive production
factor and in that way slow down the loss of vegetation cover and forest in the area as well as provide farmers an alternative income source. A second step could be a cost-efficiency calculation for the total amount of money that we “could have” yearly from the water payments made by the citizens of Cobán for environmental measures in Mestelá. However questions about the implementation of cost-efficient measures are difficult to analyse and answer because in order to do so, we have to generate a specific order of preferences. These preferences change depending on the goal, i.e., either water catchments protection, or biodiversity protection and conservation, or landscape conservation. In the case of watershed protection, the creation of such a preferences-list is linked to the in-depth study of the hydrological function of re-vegetation measures and that would go beyond the scope of this study.
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