ECONOMIC ASSESSMENT OF ENVIRONMENTAL HYDROLOGICAL SERVICES OF NATIVE FOREST IN THE SCHWARZENBERG BROOK WATERSHED, ELDORADO, MISIONES

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ABSTRACT

The problem of this research is to determine the economic value that the people from Eldorado assign to hydrological services of the native forests. The general objective of this project is to evaluate the hydrological environmental services that native forests provide to the Schwarzenberg watershed, for a forest restore project. The following activities have already been developed: a compilation of antecedents; characterization of the present watershed´s condition; the determination of protection services provided by the native forests; and the economic valuation of environmental service, using the contingent valuation method.

The results indicate that the eldoradenses have assigned a monetary value of 2,025 pesos per hectare per year to the environmental service, and the conclusion was that without the surrounding protective forest, the maximum flow and the torrential condition of the basin increase. Families are willing to pay for the hydrological environmental services that native forests provide to the basin; and it is recommended to do more studies to outline a payments system for environmental services, considering that the Schwarzenbergs watershed drains into the Piray Mini stream, a short distance upstream from the outlet of the public water supply system of Eldorado.

KEY WORDS: Valuation, Environmental Services, Protection, Watersheds; Native Forests.

INTRODUCTION

The low value of the economic importance of forest environmental services, is due in large part to that it is not reflected in market prices, to the difficulty of determining the monetary value of these services and the lack of a system payment for environmental services.

> "The systems of payments for environmental services (PES) are a novel solution that allows you to reverse a situation of environmental degradation through the market logic, and transform areas of high environmental value and risk due to demographic pressures in areas that achieve sustainable development "[Martínez de Anguita, P. et al, 2006, p. 53](1).

Regarding the legal framework, it should be noted that Article 41 of the Constitution of 1994, refers to the right of all people to develop in a healthy environment. The General Environmental Law No. 25,675 of 2002, defines the minimum requirements of environmental protection establishes the need for sustainable management of natural resources. Also, the minimum budget law Environmental Management Water System No. 25,668 of 2003, defines the watershed as a unit of natural resource management. National Law No. 26.331 of 2007 on minimum environmental protection of native forests in Article 1 establishes the minimum standards for environmental protection: the enhancement, restoration, conservation, development and sustainable management of native forests conservation and environmental services that these forests provide to society.

In relation to the Misiones province, on 10/29/09 was sanctioned by the Legislature of the Province of Misiones Law No. 4248 which proposes Regular payments for environmental services that generate native forests or forest plantations established. Waters provincial Law No. 1,838, as amended by Law No. 3.391/83, Article 137 which states: The enforcement authority may establish watershed protection areas, fountains, water courses or reservoirs where grazing will not be permitted to animals, deforestation or alteration of vegetation.

As local methodological background, we can mention the research: "Methodology for economic development and environmental assessment of plans for watershed management in the province of Misiones" [Martinez Duarte, 2006, p. 101](2) "evaluation of alternative courses of action in Schwelm creek watershed, Eldorado, Misiones, Argentina" [Martínez Duarte, 2003, p. 108](3).

The welfare of the population of the town of Eldorado, about 80,000 inhabitants, is affected because the stream Piray Mini, approximately 147,925 hectares, which supplies water to the municipality has a flow with sudden and violent flood, whose waters have high turbidity values. One of the factors influencing the situation is native forest logging sheds protector.

The Schwarzenberg creek watershed of approximately 955 acres, which drains into the Piray

Miní creek at a distance of approximately 5,000 meters upstream from the outlet that supplies the city of Eldorado, is a priority watershed for forest hydrological restoration considering not so much the amount of its flow, but mainly the overall environmental degradation.

This research work addresses the environmental economic valuation of the protective function of the water system that provided by native forests in order to provide knowledge for the design of a system of payments for environmental services to producers owners of these forests. The overall objective of the research project is to assess monetarily hydrological environmental services provided by forests native to Schwarzenberg creek watershed.

DEVELOPMENT

Materials and methods

It raised the hypothetical scenario of implementing a conservation and restoration of native forests and water protective soil, to compare with the current baseline situation of the watershed.

During the development of the research work were conducted the following activities:

1. Collection and processing of background. Information and secondary and primary data. The methodology was also in conducting fieldwork to enter the socio-environmental context and the entire watershed productive, developing a view from the ground for better understanding of the problem. In the field, the tool used was the qualitative semi-structured interview, recorded on forms, recorded or filmed, and the sample survey, asking people selected key informants and representatives of institutions involved in this area, with the aim to know the views of the interviewees and see reality from their perspectives.

Firstly, a pilot survey was conducted with 30 sampling units of the 15,000 families who make up the total users of the public water supply, which has determined that processed statistically adequate sample size is 96 units minimum sampling for a confidence level of 95%. Finally, we surveyed 130 heads of families.

2. Characterization of the current situation of the watershed (Analysis background, using Geographic Information System (GIS), direct observation: fieldwork, semi-structured interviews, surveys, and developing a plan of conservation and restoration of protective forests. Once collected and systematized the secondary and primary history, the team conducted an analysis of the information obtained and developed a diagnosis on the subject. Terrestrial inspections were conducted in the watershed in order to verify the physical, biological and socioeconomic analysis forest production problems requiring compensation for environmental services as a basis for assessing the hydrological benefits contingent, population served, in a real or potential hydrological environmental services of forests, and recorded on maps relevant data observed during runs and

geo-referenced using Global Positioning System (GPS).

3. Determination of protective services that forests provide and implement existing in the basin, according to the restoration plan formulated by:

a) The calculation of the maximum instantaneous potential watercourse, using the method of García Nájera (López Cadena de Llano, F.1978). This author proposes the following formula to determine the flow:

Qmax (m3/sec) = (a*p* (42+0,525*F)*F^2) / ((1+F)*(1+0.025*F) * (0.5+√ F)); Where:

a = 1 - ((3*Fc) / (4*F)) F = area of the basin in km^2; Fc = km^2 vegetation in good condition, and p= average slope of the basin.

b) The qualitative determination torrential state, according to the method described by Lopez Cadena de Llano, F 1978. This author states that the state's current torrential basin responds to the following equation: ET = (C*R) / (V*G), where C is the climatic factor expressed by the rate of erosion (d), R = relief expressed by the average slope (p), V = index of vegetation water protection; G is equal to the factor geological (lithology (L) and edaphic (α and β erodible soil erosion resistant soil).

4. Economic valuation of the protective function of forests through the contingent valuation method (Azqueta, 1996): To enhance the protective function of forests, expressed in monetary values, we used the direct method or hypothetical called Contingent Valuation Method, through information provided by key informant persons, representatives of institutions related to the topic, landowners and native forests, Eldorado city water users selected by the statistical method of simple random sampling, when asked about the analyzed monetary valuation based on welfare that generate native forests that provide environmental benefit of watershed protection.

The field work was divided into three blocks: The first block contains the relevant information about the project, with the two hypothetical alternatives mentioned actions. Another section describes the object of study. Described stage, questions are now directed to try to find out the willingness of people to preserve and restore the native forest and conservation valuation on forest cover in the watershed. The amounts involved in the arrangement to assess monthly totals were during the period of the planning horizon of 20 years. Finally, a third section explores some of the most relevant socioeconomic characteristics.

The population is 15,000 families members of the public water supply, the sampling unit being the family. First, we developed a pilot survey on 30 random samples, which processed statistically determined that the sample size should be 96 families and for a confidence level of 95%, and finally it was decided to conduct the survey sample to 130 units.

The cabinet work consisted mainly in the study of cartographic material performed by Argentina Surveys Topographic and Photogrammetric Company (CHART) 1962-1963 (1:10,000

scale plant-altimétric leaves, soil map of the province of Misiones 1:50,000 maps Cadastral), aerial photographs and current satellite images. Based on existing maps, and the study of satellite images and aerial photographs, were made, aided by the Geographic Information System (GIS), marking an appropriate scale maps important details that are observed in the field.

Results

The background to characterize the current state of the art, there are references to partial theoretical and methodological aspects on the subject, so they are not directly applicable to the subject matter.

The Schwarzenberg creek watershed, is a priority watershed for restoration considering overall degradation that occurs primarily in the irregular variation of the flow and the pollution of water turbidity.

Socioeconomic background indicate that the first settlers arrived in Eldorado in 1919, they found an unknown environment, very different to the one described by the propaganda of the colonizing company. This situation led to all kinds of conflicts in the relationship between environment and socio-cultural process, the pioneers tried to solve according to their original culture, transforming the natural environment to another environment similar to that of their home countries. The highly endangered, and the very limited resources available for education, health and safety, were real obstacles to achieve the desired minimally welfare of these pioneers and their families associated with the customs welfare and quality of life that they had reached in the European countries from which they originated. The strategy chosen to address the problem was the systematic elimination of native forest by slashing and burning of vegetation (grazed), activity facilitated by the availability of loggers and support of the Paraguayan government.

Currently, the access roads to the lots are in fair to poor condition. The average distance from the paved road is 3 miles and the maximum distance from the same route to the Piray Miní stream is 4.5 kilometers. On roads roofs occurs predominant erosion, and there cultivated land sheet has erosion, sediment deposits in streams near the farms. Courses temporary and permanent water are plentiful, not having protective forests in the most cultivated.

The main crop is Pine, complemented with other forest species implanted and Yerba Mate. Other annual crops are destined only for consumption. Regarding the management of the plots, implementing conservation techniques is observed, such as contour planting or terraces, and in many cases planting guide lines in the direction of maximum slope. They use Glifozato (Roundup) to control weeds that compete with crops. It was noted in applying insecticides in people without mask, gloves and safety gaiters. However, farmers say they take the precautions, do not wash the containers of products, such as herbicides and fertilizers, sources and streams, and also show that

no symptoms of poisoning recorded. They say they do not use these containers to carry water or food and chemicals stored in special tanks. In relation to livestock are cattle, swine and poultry for home consumption. To prepare the site for their crops using the slash and burn method. In some cases the water for consumption is drawn from wells and is used without prior disinfection. It is sanitized, they wash their clothes and draw water to irrigate vegetable nurseries and streams near the farms. They believe that the water from these springs and streams are polluted, but they have no alternatives, and show that unless the drought that hit the region last summer, no water deficit and that even in these dry periods, with some decline, there was water in springs and wells.

In relation to the physical aspect of the basin, we can mention that the terrain is undulating with hills well defined dominant element, and to a lesser percentage or sloped areas with short steep slopes to watercourses. The geology and geomorphology presented in Brasilia massif basement acting as basic substrate, such training was covered in the Triassic period by successive layers of igneous rocks, the basic type called basalt. As most significant morphological parameters we note the following: The higher altitude 260 m.a.s.l. (meters above sea level); lowest point: 130 m.a.s.l. (meters above sea level); basin area: 955 acres; perimeter; basin: 13,984.9 meters; basin axis: 4,572.6 meters, main stream length: 5,018.5 meters.

The soil mapping unit are 9 (CHART), deep red, highly evolved. This unit contains the so-called red earth soils derived from basalt, highly erodible once destroyed the upper horizon A.

> "According to the Köppen classification (1936), the climate identified with the formula Cfa which corresponds to a humid subtropical climate with no dry season and very hot summer (LEE, 1968: 32a). Sharing Capitanelli climate criterion (1992:99), corresponds to Eldorado located at 160 meters above sea level the climate unit 'winter without heat and with maximum rainfall in spring and autumn', and is characterized by high temperatures (annual average: 21℃, maximum total: 43ºC, absolute minimu m: -4.5℃). The average annual rainfall is 1590.1 mm., Series 1941-1950, and 1,715 mm., Series 1926-1977)" [Arenhardt, 2009, p. 33][(4)].

The urban and suburban areas is in the upper basin, registering the presence of housing complexes with very high population density. The excreta disposal is done primarily through cesspools and septic tanks, as the city of Eldorado does not have sewer or treatment plant sewage effluents. While housing complexes of Kilometre 10 have sewage treatment plants, the performance is poor. In urban areas, water for daily household consumption comes from drinking water network managed by the Eldorado Electricity Limited Cooperative, and the majority of the population is connected to the power grid of the same cooperative. In the lower basin there is recorded low population and land cover is largely composed of pine reforestation.

Indicators were determined protective services provided by native forests if the proposed project is implemented by calculating the instantaneous potential maximum flow using the formula of García Nájera, according to the following calculation (López Cadena de Llano, F.1978):

Qmax = (a*p*(42+0,525*F)*F^2)/((1+F) * (1+0.025*F)*(0.5+√ F)) = 57 m3/sec;

Where a = 1 - ((3*Fc) / (4*F)) F = basin area in km^2 = 9.55;

Fc = km^2 basin with native vegetation in good condition = 2.14

P = 0.75 for being mean slope basin somewhat uneven.

The qualitative determination torrential current state of the watershed according to the method described by Lopez Cadena de Llano, 1978, reports that the state pouring basin is expressed as follows: ET = (d2*p3)/(L21*β*V4); or erosion is weak (d2); the slope is medium (p3); the litho logical factor is composed of hard rocks (Basalt) (L21); are easily eroded soils (β) and the rate of hydrologic protection the forest is low (V4) due to the small surface of protective forests.

There was formulated a conservation plan remnant native vegetation, and restoration through reforestation solid edges waterways currently no forest cover, and the enrichment of degraded forests. The restoration aims to cover the edges with native species of water courses, complying with the remaining forest protection forest systems, to regulate stormwater runoff, improve the water regime, water quality and biodiversity. The restoration plan is through massive reforestation of 17 hectares of land located on edges of water courses currently with no native forest cover; and the enrichment of 197 acres of existing degraded forests.

Table 1: Balance Land Used Surfaces

Land Use	**Hectares**	**% in total**
Restore massive reforestation	17	2
Suburbs	77	8
Aeroparque	20	2
Commercial Reforestation	239,8	25
Pastures	22	2
Yerba plantations	8,4	1
Native vegetation to preserve and enrich	197	21
Chacras	65,5	7
Urban Area	283	30
Roads and others	25	3
Total	955	100

Source: Own Elaboration

Surfaces and percentage share of the total area of different land uses, are listed in Table 1.

Description of protective forest restoration project: With the restoration of protective forests of the hydrographic network of Schwarzenberg Creek watershed through massive reforestation and forest enrichment native, using native species. Through reforestation of 17 hectares of land without forest cover currently next to streams, and the enrichment of 197 acres of highly degraded forests remaining have solved part of the problem given in the watershed, consisting of the widespread ecological imbalance.

Diagnosis of the social and environmental situation: Generally the whole basin ecological gaps recorded. The degree of environmental impact is mitigated only by the still low productive development, but there is no proper planning or rational use of resources, so it is considered the right time to propose and start implementing this restoration project of protective forests soil and water mains.

Justification and Description of Project: The project will restore the protected forest of the hydrographic network and the company will comply with the legal requirement set out by the provincial Act No. XVI-53 (Before Law No. 3.426/97) of protective forests and green belts. Both for reforestation and enrichment will use seedlings of native species that have shown good development on this site and high value for the quality of its wood, its energy, ornamental or food for wildlife of the place and the people of the watershed, ie proposes a multiple-use approach to comprehensive environmental benefits.

It is considered that recovery of protective forests of the hydrographic network is a priority, as it will act regulating runoff and erosion, slow water pollution, improve flow distribution and generally provide hydrological, ecological and socio-economic benefits.

The plantation itself is done using open courses in the undergrowth or vegetation residual colonizing areas where the forest was removed. The spacing between courses must be five meters and planting distance in the direction will be 7.5 meters in reforesting in solid, and in the case of enrichment ten meters to ten meters respectively.

Planting lines are oriented perpendicular to the slope of the land and all the tasks will be carried out taking care to minimize the environmental impact. The opening width of the courses will be the minimum necessary to establish the plantation and then manage the undergrowth to allow in adequate lighting and built seedlings free of excessive competition.

While farmers mentioned that the seedlings of native species are less attacked by leaf-cutter ants, corresponding control will be to ensure the establishment of plants.

For maintenance of the plantation, with the participation of the community in the basin, which was involved from the development of the project. Identified members of this society, properly advised, will be responsible for performing maintenance to ensure the establishment of trees by controlling ants, replacements, canopy cover and pruning. The active participation of the residents and students of Forestry, will train and raise awareness to direct actors, who perform in the future as leaders of the restoration of their own environment the area of this project and the entire watershed. This is one of the important indirect benefits of the project.

The remnant native forest restoration will be done through the management of Re-growth of native timber species of high value, showing good response to this type of management, and enrichment under cover of native species that have shown good development experimentally in

this type of environment. It is proposed to use existing natural species with good development in the area as Canafistola (Peltophorum dubium), Timbo (Enterolobium contortisiliqum) white parrot (Bastardiopsis densiflora), Guatambú (Balfourodendron riedelianum) Guayubira (Patagonula americana), black Lapacho (Tabebuia heptaphylla) and Araucaria angustifolia.

To enhance the protective function of forests, expressed in monetary values, we used the direct method or hypothetical called Contingent Valuation Method. The willingness to pay in pesos per month, expressed by the heads of families surveyed, for the case that the project is carried out, ranging from 1-5 dollars per month. The result obtained from calculating the average monthly values revealed is 2.4 pesos per family is the average price that each family would be willing to pay for the environmental benefits of native forest hydrology in the hypothetical case of implementing the project. Or, if you did not have to pay for the good, this amount is indicative of the economic value of the environmental benefit obtained average each household.

CONCLUSION

At present there is a lot of pressure from the people on remaining natural resources for fuel wood extraction and removal of native vegetation to prepare land for: reforestation, pasture, annual and perennial crops.

Of the 955 hectares of the basin, it is intended to preserve and restore 214 acres of protected forest land and waterways that make up the river system of the basin.

Given the multifunctional role of forests to restore, but that the protector is essential, the density must be 266 plants per hectare, massive reforestation and 100 plants per hectare enrichment.

Indicators protection service provided by native forests, indicate the influence of the native forest in good condition as proposed restoration plan, as without forest (Fc = 0) the maximum flow rate rises to 68.5 m3/sec (cubic per second) feet, that is an increase of 20% was recorded. The qualitative determination torrential current state of the basin reports that torrential state It is inversely proportional to the area of protective forests, reduction involves reducing forest protection index and therefore increases the pouring state of the basin.

It was possible to determine the economic value assigned to the Eldorado native forest hydrological services Each family would pay 28.9 dollars per year during the period of 20 years of the project, which multiplied by the 15,000 families who supply system public water supply of the town of Eldorado, totaling 433,385 pesos per year environmental economic valuation of environmental services hydrological protection would provide the implementation of the proposed project, with an average of 2,025 pesos per hectare of native /s (cubic meters per second), or

whether there is an increase of forest cover by year, totaling 40,503 pesos per hectare planned 20-year cycle, considering the 214 acres planned in the proposal.

It is recommended that a more detailed study, to develop a comprehensive management plan watershed and design a system of payments for environmental services, considering that this watershed drains into the Piray Mini creek, a short distance upstream from the outlet of public system of water supply of the city of Eldorado.

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BIOGRAPHICAL ABSTRACT

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