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A theoretical analysis of a hypothetical auction program to pay for biodiversity in Peruvian Amazon nuts (*Bertholletia excelsa*) ecosystems

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Abstract

Peru is a megadiverse country with the second extension of forests in the Amazon basin. The design of efficient public policies for these territories is challenging due the fragility of public institutions and lack of economic valuation of important ecosystem services provided from old-growth forests.

This paper develops preliminary a dynamic system model and a theoretical analysis from the ecological economics perspective for a key non-timber forest product of the Peruvian Amazon basin: the Amazon nut (*Bertholletia excelsa*). Specially, we analyse the bioeconomic dimensions of two ecosystem services: pollination and the forest cover to provide habitat for flora and fauna.

The contribution of this paper is to present evidence that support the argument that decision makers from development countries have an excellent investment opportunity for conservation of biodiversity in indigenous lands with Amazon nuts.

Keywords

biodiversity, non-timber forest product, auctions, pollination, ecosystem service, Peruvian Amazonia

Introduction

Loss of biodiversity is a significant global environmental problem, especially for extremely biological diverse countries, because of their importance for the entire world with such a large quantity and diversity of species and global ecosystem functions. Markets for biodiversity conservation generally do not exist, and this value is therefore not included in the national accounts. This lack of formal valuation has contributed to growing rates of degradation in forests around the world (Stoneham et al. 2012). In order to preserve biodiversity, new approaches are required. This is complicated by the fact that many developing countries face the challenge of balancing economic development against preserving biodiversity that is critically important for the rest of the world (United Nations Environment Program et al. 2008).

Over the last 30 years, there have been special efforts of governments from developing countries in Amazonia to develop policies and design strategies to improve the conservation of biodiversity (Flores, 2002; Dourojeanni et al. 2010) . The best known efforts have focused on the creation of reserves and protected natural areas on public land (Flores, 2011). However, less has been applied in privately held by indigenous forests or rural land. Some authors have criticised in the case of Amazon nuts landscapes, the economic opportunities that can provide this non-timber forest product to solve their poverty and degradation of the poverties (Escobal et al, 2002). Other authors have criticised the lack of planning of government in rural areas. When economic incentives have been developed for private agricultural land, they have been to support unsustainable practices by less efficient farmers (De Ferranti et al., 2005).

The provision of conservation of biodiversity in the territories of indigenous people using non-timber forest products as the main source of income offers an interesting context to analyse from ecological economics perspective. However, there are few initiatives to promote provision of conservation goods from public forests because of the lack of public funds and critical opportunity costs in an economically developing setting (Flores, 2002, 2011). Corruption has also affected results of forest concessions (Amacher et al., 2012), increasing transaction costs for stakeholders.

For developed countries, auctions for the conservation of biodiversity have been developed where private land managers are invited to formulate their payment requirement for a clearly defined conservation measure. Competition between landholders in the auction can reveal the 'real' lowest cost of delivering the desired conservation outcome. In our analysis we will include the possibility that the opportunity cost of land is much lower than in developed countries, however this does not mean that the economic value for conservation should be smaller, as some researchers have considered (Fleck et. al., 2010).

In this paper we consider mechanisms that have been developed and implemented in developed economies such as Australia which have the goal of conserving biodiversity. The purpose is to develop these mechanisms in ways that might successfully deliver conservation outcomes in developing economies. We identify as a critical problem that the implicit economic valuation of ecosystem services is zero. And, we assess in this paper, how some preferences for conservation of biodiversity could be made explicit to give proper signals to different stakeholders.

The Bush Tender scheme offers payment for conservation services in the state of Victoria, Australia. This innovative auction based approach has been able to deliver results that have been elusive with a range of previously applied mechanisms like command and control, subsidies or grants. The Bush Tender scheme applies only in the state of Victoria where 33,339 hectares have been incorporated into Bush Tender projects since 2001. These auctions have been designed to offer an economic incentive to landholders to provide the public goods of conservation of biodiversity through activities such as retention of native trees, grazing management or fencing and targeted weed control (Department of Sustainability and Environment, 2012). These economic incentives have been developed after an assessment that found other mechanisms have not demonstrated improvements in the conservation of biodiversity. An important aspect of this scheme is spillovers. The conservation of biodiversity on public land or reserves depends in an important way on the outcomes obtained in natural resource management on private land (Lindemayer and Burgman, 2005).

The Bush Tender scheme seeks to improve the protection and management of high significance biodiversity assets in an efficient way. A key aspect of this efficiency is that the tender scheme elicits the willingness of landholders to supply conservation services, thereby enabling a market for the conservation of biodiversity to form when combined with demand for these services. This approach is successful and empowering because it enables landholders to generate a regular and reliable income stream thereby providing landholders with the incentive to manage and protect native vegetation. This is an important dimension when considering such a scheme for developing countries that seek to preserve biodiversity.

The Bush Tender scheme has required a commitment by Australian governments of AUS$ 18 million during last 10 years towards landholder payments for on-ground works and land use changes to improve the condition and security of their native vegetation over a five-year period and with permanent activities.

In the remaining three sections of this paper, we present: First, the methods and materials applied, identifying the study area. Then, we present the preliminary ecosystem model. And, we explore from the ecological economics perspective, its biological and economic dimensions. Finally, we present a hypothetical auction-based approach program to pay for two ecosystem services. We discuss if these auctions could be applicable to the Peruvian Amazon nuts case, specifically considering the case of indigenous people.

Methods and materials

The assessment of the potential application for auctions is analysed in this preliminary study that is applied to a case study of Amazon nuts that stands in old-growth forests of the Peruvian Amazon. This paper specifically focuses on economic incentives for the indigenous territories taking an ecological economics perspective.

An ecological-economic model is developed to analyse the complex dynamics of ecosystem services and identify key parameters and variables. The model explores the potential profits of non-timber production in an old-growth forest and its links with ecosystem functions and pollination input,

Second, to address the link between profits and pollination input, the model develop by Winfree et al. (2011) is considered and analysed for the case of Amazon nuts production function characteristics. And, third, a hypothetical conservation program is discussed from the adaptation of the model of Stonehan et al (2003) to the characteristics of Peruvian Amazon.

Study area

The region of Madre de Dios in the Peruvian Amazon is part of the hotspots of biodiversity of the world and the current Amazon nut collection areas cover more than 2.5 million hectares.

In the Peruvian non-timber concession areas created in 2001, approximately a 1000 Amazon nuts concession holders enter the 1 million hectares of forests and 5 native communities with 52, 963 hectares titled where interrelations among flora and fauna for pollination of Amazon nut trees has developed over thousands of years.

The exports of Amazon nuts are controlled by a small number of firms. The harvest is conducted manually on the forest floor after the extremely hard-covered fruit of the Amazon nut trees have fallen. Both the collection and the subsequent transportation are labour intensive and costly. Once harvested the nuts are transported to collection centres in 70 kilo bags, where they are dried.

Monetary income from the sale of Amazon nuts is the most important source of income for indigenous people, even though it is a seasonal activity. At the beginning of the harvest 2011 in January, the price by “barrica” was S/75, at the end of the harvest in March 2011, it was S/150, as seen in Table 1, and for which we have estimated economic benefits. It should be noted that this utility is achieved with an economic value of their work, which does not include health insurance costs, or formal contracts. This could be improved by moving towards an organic fair trade certification if the premium price received could be invested to improve labour conditions, but currently, the costs of certification are high for the size of business for the indigenous people. Also, it is important to highlight that the main interest of projects with natural resources of indigenous people of this study have been the focus of REDD+ (Reducing Emission from Deforestation and Forest Degradation) carbon sequestration projects (Ministerio del Ambiente del Peru, 2010).

As someone who has worked in the study area of this paper since year 2001 and he has witnessed the changes in the prices and the benefits for different stakeholders, including indigenous people. We have gathered some information in June 2011 from the organic producers of the indigenous communities with some characterization of the producers that it is shown in Table 1. It can be seen that the descriptive statistics of the 4 native indigenous communities in the area of study shown a total area of almost 50,000 hectares with 10,301 Amazon nut trees. This natural capital allows 120 harvesters and their families to obtain an estimated average profit of US$ 1163 per harvester per year or US$ 3.5 per hectare per year. These quantities are 50% less compared with other crops and estimates of the same Amazon nuts in Brazil or Bolivia, but is one of the few alternatives of income for them. It reflects in part, the minor density of these Amazon trees that happen in Peru. See Flores (2011).

Table 1: Descriptive statistics of harvesting Amazon nuts from 4 indigenous communities*, Madre de Dios – Peru, 2011

Variables/ 4 Native Communities	**Total**	**Mean**	**Min.**	**Max.**	**S.D.**
Area (ha)	48,363	12,090	3,857	31,423	11,317
Amazon nut trees	10,301	2,575	1,120	4,003	1,125
Amazon nut harvesters	120	30	18	52	13.49
Production in “barricas” (bb.)	4,064	1,016	343	2,018	640.63
Production per productive tree (bb.)	----	0.37	0.31	0.54	0.09
Production per harvester (bb.)	----	35.17	19.05	67.26	19.27
Estimated profit per harvester/ year ($)	----	1163.79	645.56	2278.84	657.94
Estimated profit per/ hectare/ year ($)	----	3.52	2.17	4.59	0.98

Source: Own computations, Flores (2011)

*Notes: Price: S/150 / bb. With an exchange rate of S/2,70 per USD.

The Ecosystem Model

Biological dimension

The biology of the Amazon nuts trees include the fruit that are non-timber forest products and have the characteristic of being renewable. Every year, from January to March, these fruits fall to the ground of these gigantic trees (more than 50 meters), that can produce fruits during 500 years and live more than 1000 years, are collected to obtain its edible seeds that are dried and shelled to be exported. On the other hand, the renewal characteristic of fruits production is the result of numerous interrelations in the fragile ecosystem where Amazon nuts trees stands. Among those interrelations, we consider special attention to the disperser role of the agoutis (*Dasyprocta spp.*) and the success of the cross pollination of the Amazon nut tree flower, by the hymenopterans bees of the *Bombus, Centris*, and *Xylocopa* genders (Corvera-Gomringer, R., et al., 2010).Every year, the agoutis hide and store 3 to 8 seeds per each seed they consume; therefore, it has allowed that the agoutis' descendants find food in the same ecosystems, while some of the seeds that dispersed turned into productive trees (Cornejo, 2001).

The productivity of Amazon nuts trees depends critically of the successful cross pollination of its flowers by bees, the previous year. To fulfil their ecosystem functions, these bees need a forest cover that they can use as habitat. It is critically affected by increase of forest fire smokes due changes of land use. (Corvera-Gomringer, R., et al., 2010). In this paper, we have simplified the complex interrelation between biodiversity and the production of Amazon nuts with the following two relations:

$$NTFP_t = f(ab_t, q_{t-1}) \quad (1)$$

$$Q_t = g[ab_t, sd_{\mathrm{t-15,t-16,...,t-500}}] \quad (2)$$

NTFP stands for the natural production of nuts in year t, that depends on abiotic factors (e.g.:temperature, rain, wind among others) and cross pollination of Amazon nut trees in year t-1. In this model, we consider "ab" as an exogenous variable *ceteris paribus* and focus our analysis in the change of cross pollination variable.

Q_t is the quantity of productive Amazon nuts trees in year t. It depends also on abiotic factors and the quantity of seed dispersal "sd" produced by agoutis from 15 to 500 years ago, that also depends on the quality of the forest. This overlapping of functions is summarized in the following graph (Figure 1).

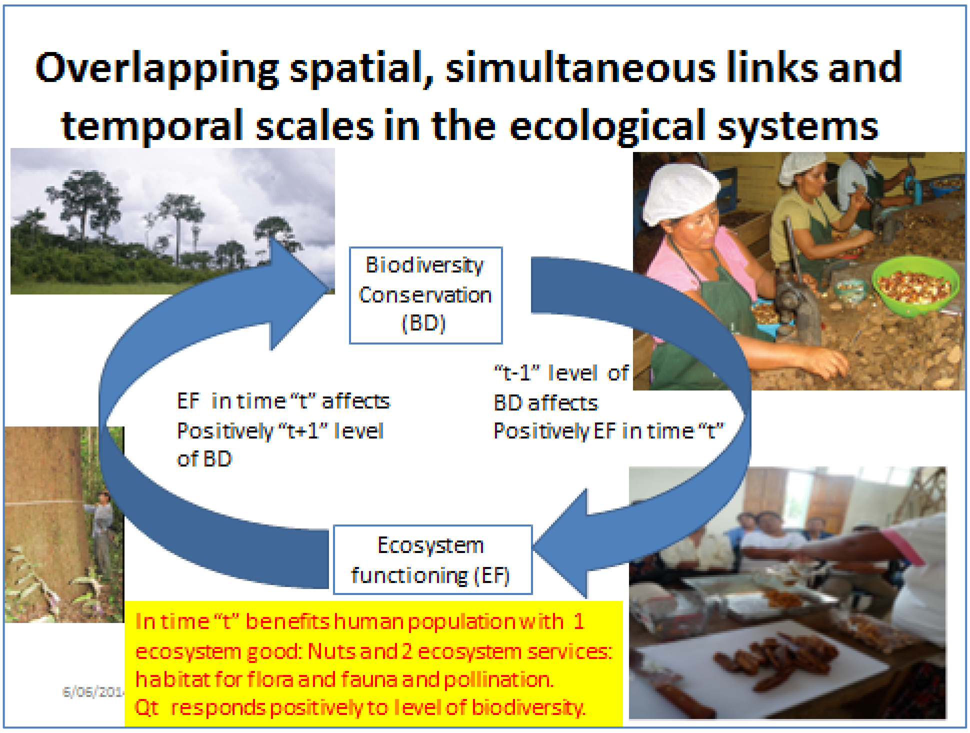

Figure 1. Overlapping in Biodiversity Conservation in Amazon nuts forests and ecosystem functioning

From the ecological perspective, an indicator of the sustainability of the production of this non-timber forest product is that the successful cross pollination of the previous year is associated with a non-degraded forest where the Amazon nuts will be extracted in this year, *ceteris paribus* abiotic factors. For the sustainability of the biological production of this NTFP, the resilience of the ecosystem is more important than the number of Amazon trees (Q_t). As it was clearly identify by the International Union for Conservation of Nature (IUCN) when put this specie in its Red list in Brazil. (Flores et al., 2011)

There is a threshold of impact in the forest cover where Q_t could be positive, but $NTFP_t$ zero. The positive relation between $NTFP_t$ and biodiversity is more evident when two additional equations are included:

$$FC_t = FC_{t-1} + G_t \tag{3}$$

$$G_t = r_{max} FC_t \left(1 - \frac{FC_t}{k}\right) + e_t \tag{4}$$

Where FC_t is the forest cover measured in percentage, proxy value of the non-degradation of the forest. And, r_{max} is the intrinsic maximum growth rate of the forest cover specific to the ecosystem where Amazon nuts stands and K is the carrying capacity of the forest cover abundance that allows a habitat for the pollinating fauna. Following Hein (2010) in equation 4), we consider that G_t represents the growth of the forest cover, and it is measured as a percentage. For an estimation of the model, a baseline of 100% is assumed. And then compared for the year of data to determine how much the forest cover has been reduced. If the error term "e_t" has an expected value of zero, then it is an indicator of the resilience of the ecosystem.

The relationship between reductions of FC_{t-1} is linked to the reduction of q_{t-1}, and we argue that reductions can be addressed with precautionary activities in the forest as well as through permanent activities similar to the Bush Tender program.

Economic dimension

The economic dimension of the NTFP gathering from the perspective of indigenous people in Peru, with five percent of total area is analysed here. The Gatherers-Hunters have a dynamic of use and conservation of natural resources that goes against the reduction approaches that have been made with a traditional economic approach, looking them only in the dimension of poverty. Some Policy makers in Peru look at them as backwards sector, considering in their analysis only monetary variables and traditional indicators such as gross domestic product growth or unsatisfied basic needs (De Soto, 2010)

The economic dimension of the decision making process of the indigenous people must be considered following a Georgescoau-Roegan tradition and not only including ecosystem service values as if they would be solved by the market (Gowdy, 1998). We understand the sustainability of the non-timber forest production and conservation of biodiversity associated is achieved if these people continue living valuing the life that they have chosen as valuable to live (Sen et. al, 1993). This expected quality of life includes to have the right to maintain their tradition to gather, fish and hunt, without being pressured by public officers to do agriculture or renting their lands to undertake other activities more "profitable".

To model the economic perspective, we can relate the harvest (H_t) of the Amazon nuts with the natural production ($NTFP_t$), and also with the price paid by the exporting company (P_t) as the following:

$$H_t = h(NTFP_t\ , P_{t-1,} P_t) \tag{5}$$

It is assumed that Indigenous people harvest almost everything they can, but we have seen how also they see the price of last harvest season as reference to preparing themselves and invest in the current harvest campaign, and also they expect a price for this season. The representative elected by them tries to negotiate all the production in a certified way.

In Table 2, we see a market with growing prices for Peruvian Amazon nuts, as it happens from the last decade to the current one due to various factors: more demand due to a growing human population; it is considered a luxury good, also even crisis has affected some regions; other destinies have continued with the demand.

Amazon nuts are the main source of income for indigenous people. Before the period presented in Table 2, it has been years as 2001 when the Price offered their product was as low as 10% of the price offered in October 2012[1]. At this time, the economic value of the non-timber forest product was so low that doesn't give any incentive to put too much effort in organising to manage the natural production. Now, even that there was an international crisis in Europe and USA that reduced the consumption of Brazil nuts, other countries as Australia, Russia or Canada have replaced the former importing countries as is seen in Table 2.

Indigenous communities sit better in the global market economy, moving from a barter economy, that they did 15 years ago. In the past, the firms charged the indigenous people for transporting their nuts harvested. Today, some indigenous people have their own boats to transport it by themselves. Therefore, they have reduced their transaction costs, and since prices have grown significantly, they can work more days, work more hours per day, afford basic capital costs of machetes and gathering tools and payment for food for the days that are worked in the field. It

[1] Observation registered by the researcher in the native community of Palma Real in year 2001.

also, improved relations with exporting firm and thanks in part, to support of some local Non- Government Organizations, trying to work together, they have improved their negotiation power in the face of the monopsony of the exporting companies.

Table 2. Peruvian exports of Amazon Nuts in US$ FOB

Countries	Mean 2004-12	S.D. 2004-12	Growth 2004-12
USA	11,794,666	3,607,385	119.75%
Russia	526,202	707,193	242.52%
Australia	525,163	396,935	166.21%
UK	936,556	680,696	55.84%
Canada	554,311	401,352	136.55%
New Zealand	90,102	201,559	3375.41%
Netherlands	256,807	194,617	-6.05%
Germany	440,688	367,056	-41.32%
Japan	105,427	82,897	189.01%
Italy	145,986	109,275	103.71%
Spain	92,184	115,325	-68.57%

Source: Comision de Promocion del Peru para la Exportacion y el Turismo - PROMPERU[2]

The organic certification has bring some more commitment for the exporting company to show their clients paying a fair price, however the indigenous people has to relies in the projects of the NGO to pay for a certification, that it should not be the main source of dealing with paying for biodiversity.

Now the prices are not so different with the offered by other non-indigenous harvesters. Organic certification has been useful to search for a "fair" price, but it is far away to be the main strategy to pay for conservation of biodiversity. We consider that certification is not an end itself, but a mean. As in the case of Peruvian Amazon nuts almost everything is exported, we consider that the importing consumers as well as the government should provide the firms with the right signals to increase their participation in the payment for conservation of biodiversity. One validate way is with a hypothetical auction conservation program. This will be significant for the firms, because they have an interest in maintaining the sustainability of their natural resource inputs. As presented in Figure 1, the question about the resilience of the Amazon nut ecosystem is something that should not interest only to some

[2] Original data retrieved from http://www.promperu.gob.pe/ September 2014.

consumers and the indigenous people but also to the exporting firms which obtain profits due the renewable capabilities of the healthy habitat for wild pollinators.

In Figure 1, the H^{max} is the maximum harvest from natural production every year. The economic question about sustainability is if the exporting firm considers only the marginal costs of harvesting, given the price P^E, when threats such as increasing the forest fire reduce the capacity of pollinators to provide ecosystem services. i.e. negative externalities happen. Furthermore, the difference of US$ (P^F-P^E)= P* would be the price for the conservation of biodiversity in H^{max} hectares needed to avoid that loss of resilience of the ecosystem.

Also, it is important to observe the minimum supply price where the two lines intercept, P_{min} is the minimum price that the harvesters require to cover the fix costs to enter to the forest to collect nuts. Figure 2 presents a basic analysis of harvesting Amazon nuts using linear marginal costs with a threshold. It implicitly assumes that the marginal cost of harvesting more Amazon nuts is increasing steadily at a fix until the carrying capacity threshold.

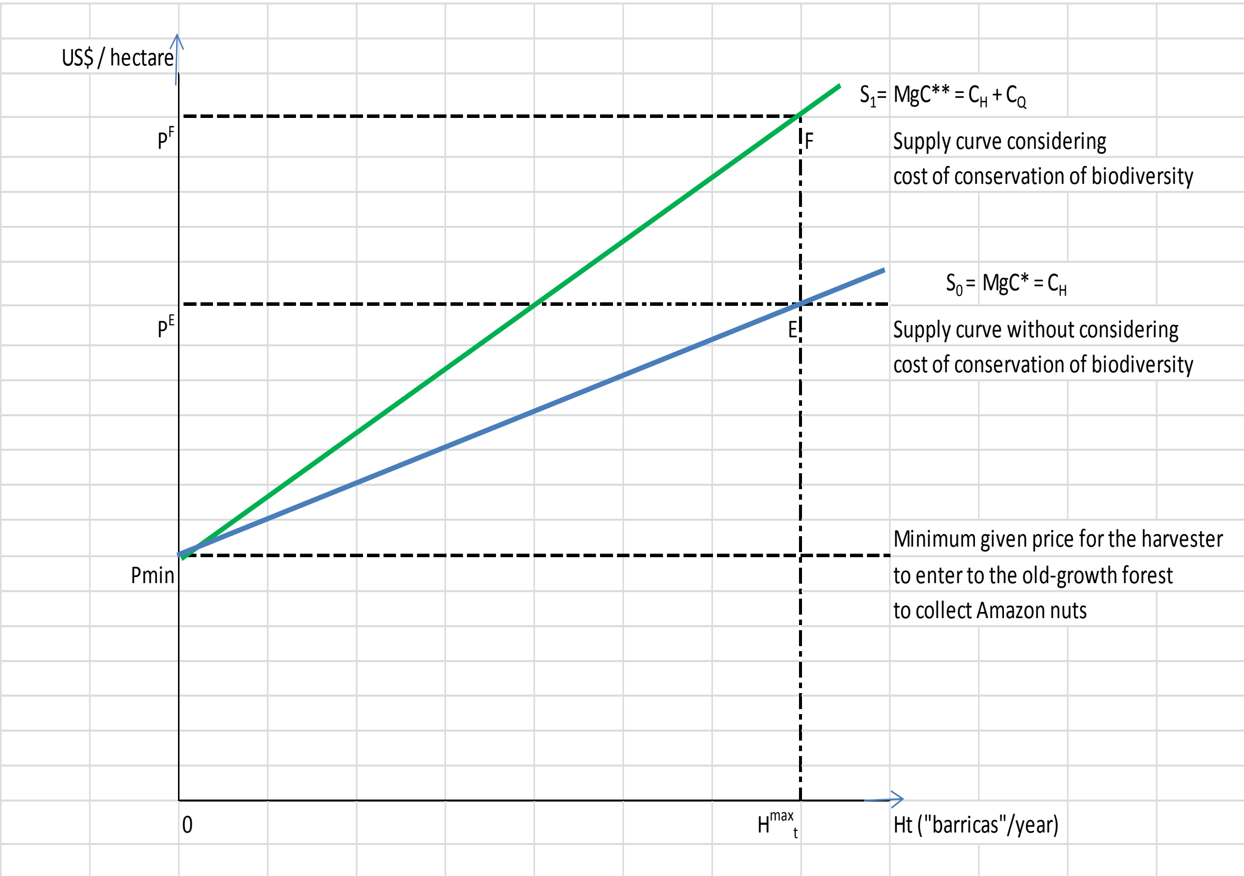

Figure 2. The threshold for Amazon nuts' ecosystem collapse

Winfree (2011) has modelled the pollination has an input for farming companies. We adapt this, for the exporting firm. Since the reduction of the pollination affects the exporting firms.

$$\Pi_t = P_t H_t(q_{t-1}) - C_t[H_t(q_{t-1}), q_{t-1}] \quad (6)$$

Then, the annual benefit changes this year, when pollination change in the previous year would be obtained differentiating respect to q_{t-1}:

$$\Delta\Pi_t = [P_t \left(\frac{\Delta H_t}{\Delta q_{t-1}} - \frac{\partial C_t}{\partial H_t}\right)\left(\frac{\Delta H_t}{\Delta q_{t-1}} - \frac{\partial C_t}{\partial q_{t-1}}\right)]\Delta q_{t-1} \quad (7a)$$

But, as changes in pollination are not considered in the costs, then the last derivate term of 7a is zero, and we would have:

$$\Delta\Pi_t = [(P_t - \frac{\partial C_t}{\partial H_t})\frac{\Delta H_t}{\Delta q_{t-1}}]\Delta q_{t-1} \quad (7b)$$

And, the 500 period benefit accumulated changes would be:

$$\Delta\Pi_{500} = \sum_{t=1}^{t=500}[(P_t - \frac{\partial C_t}{\partial H_t})\frac{\Delta H_t}{\Delta q_{t-1}}]\,\Delta q_{t-1} \quad (8)$$

In equation (8), if q_{t-1} is reduced and nuts prices are taken, then

$$\Delta\Pi_{500}<0 \text{ due to } \Delta Q_t <0 \text{ and/or } (\frac{\partial^2 C_t}{\partial H_t^2}) >0 \quad (9)$$

Equation 9 is the negative externality caused by other activities different to the nut extraction. For example, an increase in forest fires by practices in surrounding lands that affects cross pollination.

The effect of pollination can be reversed with government refunding exporting firms that invest in conservation of biodiversity, paying for natural growth of their input. Through the money they invest for supporting auctions of specific indigenous communities that show clear results and verifiable indicators such as achieving organic certification in all the process of Amazon nuts from collecting to transport.

Auctions are cost-efficient to avoid the reduction of ecosystem services. With these payments, indigenous people can apply forest management practices that maintain the old-growth forest functions. Paying for conservation through auctions is a cost-efficient investment. For example, in Figure 2 in Time 0: C hectares would be made available for conservation. In Time 1, without providing any incentive to conserve, E has. would be made available for conservation.

From the Figure 1, we have that according to the carrying capacity of the ecosystem, $P^F H^{max}$ is the maximum optimal quantity that would be expected to be auctioned for paying for conservation. From the Figure 2, we can see if the society values the Amazon nuts enough to get those funds, then the loss of ecosystem functions will be less as this payment program starts sooner. C is bigger than E, in the example. One important advantage of this payment program is that not only would allow to protect an specie, but an entire habitat. In the case of Amazon nuts, already the trees with valuable species have been extracted, the ecosystem functions continue working.

Other advantage of this payment program is that it is cost-efficient than alternative models for funders. For example, in Figure 3 if a government or donor provides a fixed rate scheme (P*) of payment, it would only allowed D hectares for conservation.

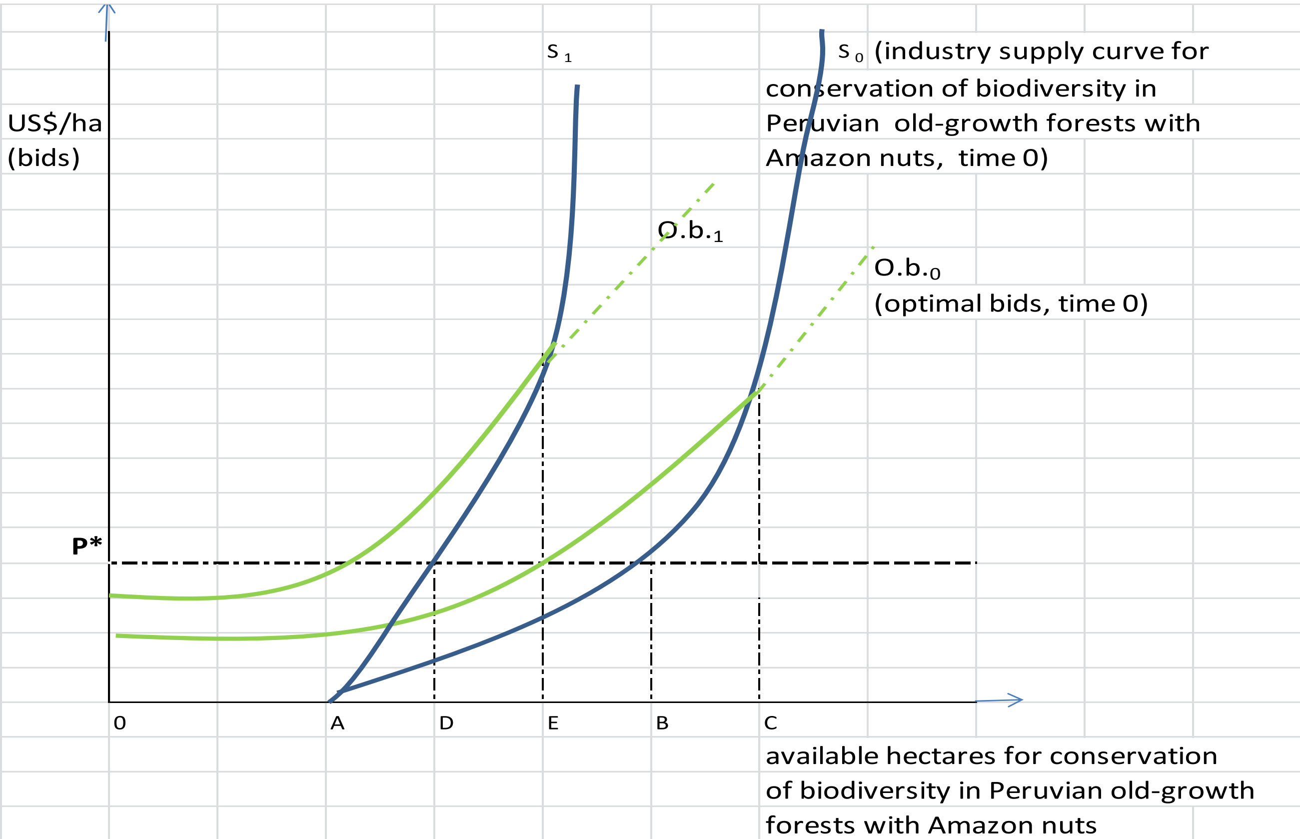

Figure 3. How much degradation of old-growth forest can society afford? Source: Adapted from Stoneham et al. (2003)

Discussion

The analysis made in this paper provides enough support to think in investment for conservation of biodiversity in habitats than in species. And, in the case of the Amazon nuts' ecosystem in Peruvian Amazonia, the opportunities of investment and multiple benefits for maintaining ecosystem provision are clear. In this section, we explore the relevance of this conservation, the reliability and validity of the analysis made and the future research needs in this topic.

Relevance of Amazon nuts' ecosystem conservation

This study has addressed the sustainable biological and economic path of the gathering of Amazon nuts by the indigenous people from Madre de Dios. It has been identified from the bioeconomic perspective that a relation between more production of a non-timber forest product and more biodiversity exists, and this relation does not happen in the majority of forest products. This is due the explained relation of the stand Amazon nuts trees that maintain or increase their productivity in a natural cycle linked with a healthy habitat for the cross pollination in the previous year. Cross pollination is not affected where it is a healthy environment for the flora and fauna that contributes for the pollination of flowers and dispersal of seeds.

The main threats for the provision of these ecosystem services are the increase of forest fires, the change of land use in surrounding territories and the expected large negative impacts on the Amazon basin as it has been identified by the last Intergovernmental Panel of Climate Change assessment (IPCC, 2014).

The indigenous people, exporting companies, government and international community can act with synergy and develop a strategy that addresses the conservation problem. Launching auctions with permanent activities, as in Bush Tender, would provide an adequate incentive for conservation of biodiversity to the stakeholders linked to the Amazon nuts market. This link is efficient to increase the supply of conservation of biodiversity and to give the right signals from consumers for exporting firms, to try to solve market failure and also, to encourage indigenous people to be more active in the provision of biodiversity conservation. Fulfilling the requirements for auctions, they will obtain more resources to protect and achieve fulfilment of their land rights.

After the approval of the Convention on Biological Diversity (UN, 1992), some authors criticised that payment for conservation of biodiversity from developed countries should not be discussed first (Perrings, 1994). Here, we have shown that Amazon nuts' ecosystem for indigenous people provides an excellent opportunity for international funding for conservation of biodiversity in the Amazon.

We have highlight in this paper that the economic motivation of the indigenous communities in front of Amazon nuts relies more on an ecological economic perspective. Indigenous communities gather more nuts not for profits, but to continue having the life they consider valuable to live. We criticise the strategies and policies that only work in the view of indigenous people as less efficient or less informed than other Amazon dwellers that practice agriculture, livestock or give more added value, because they are chrematistic and not holistically economic.

Amazon nuts exported from indigenous territories are five percent of all Peruvian exports of Amazon nuts. The quantity of trees maintaining their productivity gives an indicator of the associated biodiversity. So, we can link positively NTFP with biodiversity. Payment for conservation of biodiversity would provide the indigenous people with benefits to conserve their knowledge about the conservation of biodiversity and activities to maintain the provision of ecosystem services. Their work for conservation will be rewarded with the objective of fulfilled and resilient land territories.

A hypothetical conservation program developed in these territories would be cost-efficient for international agencies to address the problem of implicit zero economic valuation and to pay for biodiversity conservation in indigenous peoples' territories. It will allow a change from the barter of Amazon nuts to participate in the building of a market for ecosystem services. Also, it is a better option than certification, because with the latter, the upfront payments for organic certification of Amazon nuts creates more transaction costs and affects the indigenous' way of life, creating the need to invest time in transaction registrations as if they were farmers.

The current organic process does not take into account that the main reason the indigenous people sell their product is not to create profits, but to maintain the live they consider valuable to live, and their land rights.

The analysis made in this paper supports maintaining the capacity of the system to provide ecosystem services for non-timber production from the study area as an excellent investment opportunity for development countries. They would be for the maintaining of multiple ecosystem services. The achieved resilience of the Amazon ecosystems is more important than the reduction of species itself.

The need for getting funds from developed countries for these conservation programs raises questions about the feasibility of such schemes for developing countries such as Peru. However, the key to the provision of these conservation services without government payments is the marketing of these services to provide credible commitments that they will be provided. Furthermore, Amazon nuts (*B. excelsa*), can be marketed as being grown in a manner that preserves biodiversity, thereby eliciting higher prices and delivering returns to conservation activities. Finally, the reduction of more external debt can be negotiated in the framework of debt by nature swaps (Flores et al., 2011).

Reliability and validity

Information to the market about the sustainability of the harvest of a non-timber forest product that involves indigenous people could be more reliable addressed with geographical information about the source of the product. For example Amazon nut from Peru is by default organic. From our field research, the main change was between before and after certification, it was paper work, income that goes to the certifier, but not change at all in the process productive. Even the indigenous communities have to look for NGO help to support them with the organisation for the paper work. And, we find that the majority of consumers do not differentiate with the organic label in the majority of nuts retail shops in developed countries. They only see the generic label "Brazil nuts", and do not count with enough information as it was presented in this paper, to take a better decision in their choices comparing with other nuts. As this is a preliminary study, the exploration of those trade-offs between different kinds of nuts with more information of the consumers should be developed.

Limitations of this study include that generalizations cannot be made to other non-timber forests products in Amazon basin, due the relation between more nut production and more biodiversity conservation does not exist in all ecosystems. Furthermore, we know that currently the Peruvian government does not count with enough technical staff and equipment monitor implementation of the conservation policies. But, we have highlight that for the studied non timber forest product, the indicator to measure and validate the policy of auction is the number of stand trees. It provides an affordable indicator to measure and evaluate this strategy.

Future research

As this paper is a preliminary theoretical approach from ecological economics to improve our understanding of incentives for conservation of biodiversity in Amazon ecosystems with non-timber forest products. Then, empirical testing of the model with updated data should be collected in Peru and in developed countries to provide more evidence to validate the preliminary conclusions.

Finally, it would be interesting to explore how the strategies should be differentiated when we have different non-timber forest products, less linked to international markets and with other non-use values unlinked with indigenous people's lands and with non-direct relationships between more production and more biodiversity. Also, more research more should be targeted at investigating the link between REDD projects and conservation projects, payment for ecosystem services and trade-off in megadiverse countries.

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