and uncontrolled expansion of this activity can encourage deforestation and consequently contribute to the loss of important ecosystem services that also contribute to the well being of society.

The unfeasibility of developing agricultural activities in the interior of Madre de Dios or beyond the surroundings of the IOH is shown by the estimated net present values obtained here. Our results suggest, therefore, that the best alternatives to increase agricultural rents should be related to intensification of the production process in existing established smallholdings, that is, by increasing farming productivity. This approach would avoid the expansion of the activity by means of opening new forest areas which, however, would not produce significant rents to farmers. We therefore state that deforesting new areas to develop agriculture and livestock farming in Madre de Dios, especially in areas further away from the IOH, does not make sense from an economic and environmental point of view, and thus, represent a sub-optimal and inefficient alternative to use the land.

The forests in Madre de Dios still cover 96% of its whole territory (~7.5 ha million). This is a significant forest area that should deserve great efforts to find better alternatives to guide its economic development and encourage its environmental conservation. Since preserving the natural patrimony is important for local and global sustainability, this study aims to contribute with local agents to develop strategies that would protect forests from impacts of future interventions in Madre de Dios. For the case of agricultural activities, we believe the best strategy is opposite to the current thought and policy, which encourages its expansion. Investments that pursue intensification of farming on currently unproductive farms appear to be the best alternative.

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Dinamica EGO software is a free public environmental modeling computing platform, developed by researchers at the Centre for Remote Sensing of the Federal University of Minas Gerais. This was used for the development of this model. Enter www.csr.ufmg.br/dinamica or contact us dinamica@csr.ufmg.br for more information on use, applications, and training.

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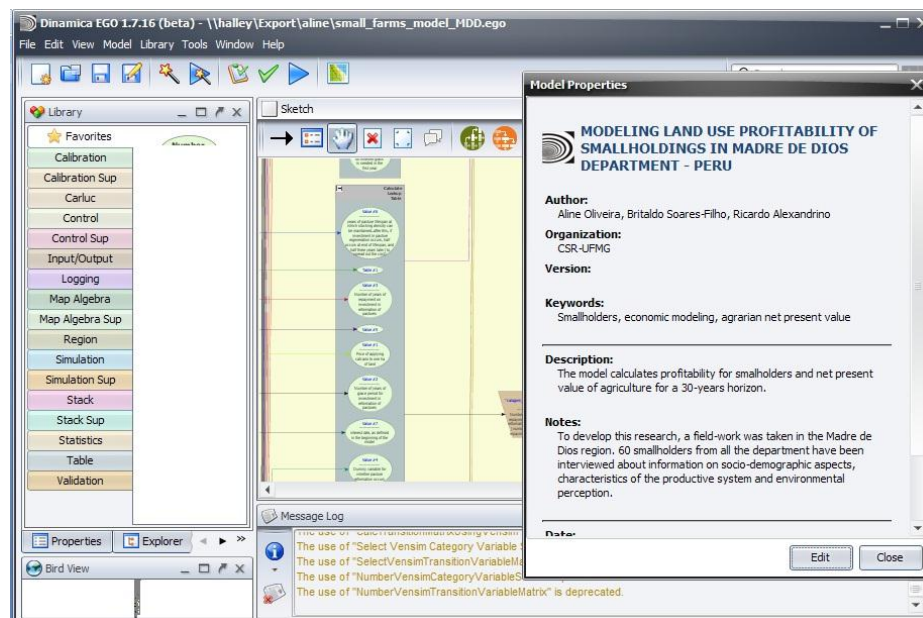
Promoting Forest Conservation and Sustainable Development Partnerships in the Amazon

Land use rents of agricultural smallholdings in Madre de Dios Department - Peru

In Madre de Dios, agricultural activities are mainly run by small landholder settlers. Farming is not a much promoted activity in the region, contributing to only 8.4% of the gross Departmental product. Lack of investments created a scenario of generalized developmental delay in the rural sector, reflected in low productivity and low profitability rates for local producers. Here we use a spatial explicit model to calculate 30-year net present values (NPV) of agricultural smallholdings rents in Madre de Dios. We found rents varying between US$20 ha^{-1} year^{-1} and US$60 ha^{-1} year^{-1} and a maximum NPV of US$120 ha^{-1}, which is mainly found near markets. With these results we aim to provide strategic data that could contribute to the formulation of agrarian public policies able to conciliate socioeconomic rural development and environmental conservation.

The Madre de Dios Department in Southeastern Peruvian Amazon is recognized for preserving one of the richest biological and cultural diversities in the world, and for its importance for the regional socioeconomic and environmental dynamics [1]. As part of the triple frontier MAP region, which includes the state of Acre in Brazil and the Department of Pando in Bolivia, Madre de Dios currently faces major interventions promoted by the IIRSA (Initiative for the Integration of Regional South-American Infrastructure), through the development of mega-infrastructure projects such as the Southern Interoceanic Highway (IOH).

One of the declared objectives of the IOH project, as well as one of its motivations, is the development of extensive cattle ranching [2], which is considered one of the main drivers of deforestation in the MAP region. Thus, although the expansion of cattle ranching is meant to contribute with rural development and life quality for the small settlers, we understand that the agrarian public policies should also meet environmental governance criteria, such as land-use-zoning to develop some areas and preserve others.

Aiming to provide the Regional Government of Madre de Dios (GOREMAD) with strategic data to sustainably manage agricultural activities, here we estimate the net present value (NPV) per hectare of farming in Madre de Dios for a 30-year period. NPV were calculated for landholdings along the IOH (Fig.1), and indicate where farming is profitable by incorporating the local effects of biophysical and demographic characteristics, infrastructure, production system, and economic parameters.
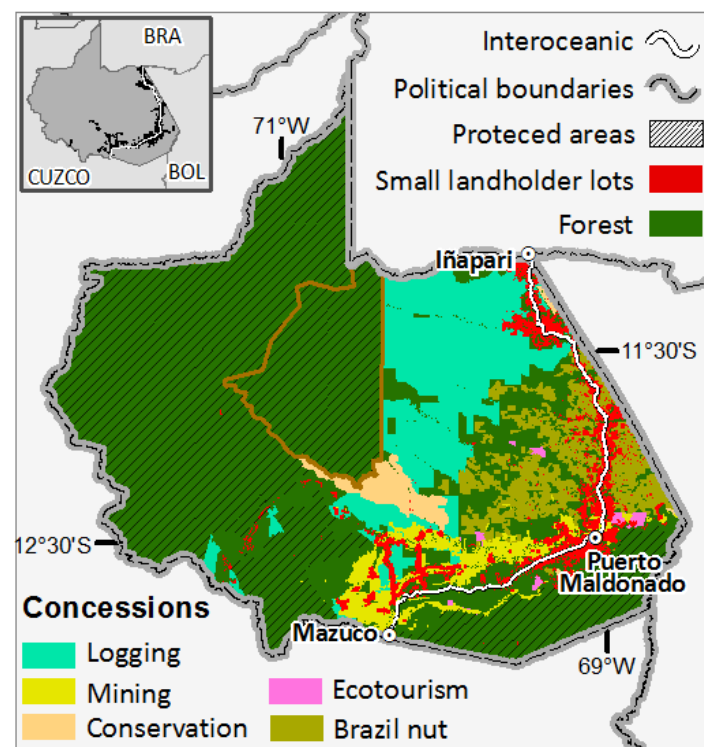
Figure 1. Main land uses in Madre de Dios.

Modeling Profitability

We first estimate rents for 60 small landholders (areas ≤ 100 ha) that we interviewed (2010), whose properties are located on both sides of the IOH. They provided information about costs, prices and revenues from selling a whole range of agricultural products (Table 1). Next, using hierarchical cluster and discriminant analyses, we estimate profitabilities for all small landholders near the IOH (around 3,400). The products selected for the calculation of profitability (Table 1) are the most commonly produced in the region for both subsistence consumption and market sales.

Type of products	
Agriculture:	Rice, Corn, Banana, Tangerine, Cassava, Copuazú, Avocado, Orange, Pineapple, Papaya, Beans, Cucumber
Livestock:	Poultry, Cattle, Pigs, Sheeps

This second step was conducted in order to initially classify the 60 landholdings surveyed, according to their profitability and other economic and biophysical variables (Table 2). For this purpose, we used the hierarchical cluster analysis, a statistical procedure of classification and grouping [3]. Groups created by this method were then used as input to a discriminant function, used to classify new survey elements (in this case, the rest of land owners who were not interviewed) into the former groups. This allows the estimation of profitability for all the land owners in the vicinity of the IOH. Discriminant analysis is a technique used for classifying elements of a sample, however the classification made with a discriminant function is based on probability theory, going beyond mathematic distances that are usually used in grouping methods, resulting in higher efficiency and reliability [4].

Table 2. Selected variables for *Hierarchical Clustering*

Economic	Production System	Demographic	Biophysical
Costs of manpower	Total land area	Resident Population	Land cover
Costs with input products	Total Production (kg)	Male Population	Climate
Costs of taxes	Distance to market (km)	Female population	Physiognomy
Costs of transportation	Agricultural suitability		Geology
Total Costs	Forest Area		Geomorphology
Total Revenue	Area for annual crops		Soil
Annual return	Area for perennial crops		Vegetation
Spatial Revenue	Area for ranching		Land use
Rates of transportation costs	Transport used		Physiography

Profitability data were used to calculate net present value of the agricultural activity for a period of 30 years, at a rate of 7.35% [1].

Results

Agricultural production in Madre de Dios is based on a non-mechanized process, manually cultivating and harvesting crops basically for the subsistence consumption of the farmers. Besides being a consequence of biophysical characteristics, such as low soil fertility and long periods of drought, the low productivity of farming could be explain by the scarce subsidies and technology available to producers. In this context, the use of machinery, fertilizers or improved seeds is virtually non-existent.

Therefore farming in Madre de Dios provides very low profits to producers. Estimated rents to surveyed properties are shown in figure 2.

As said, rents are generally low. Moreover, we observe negative values for some small landholders, which may reflect the infeasibility of farming as a land-use in these areas. The sample data did not show a spatial pattern regarding the distance to markets, access to highways and other biophysical characteristics that may influence farming productivity and profitability.
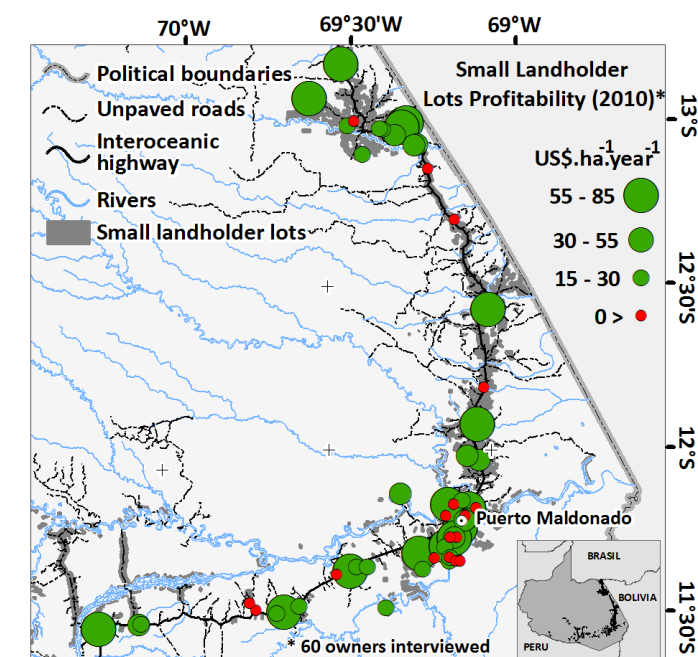

Figure 2. Annual profitability per hectare, for the 60 small land-owners interviewed.

Nonetheless, the estimated profitability for the entire set of small landholders (Fig.3) demonstrates a different behavior, with higher profitabilities corresponding to farmers whose properties lay around the most developed towns and trading centers, such as Puerto Maldonado. This result might be a response to the proximity of the market centers, which reduces total transportation costs and increases profits. Similarly, the NPV (Fig.4) shows the same pattern, suggesting that in the long run, investments in agriculture should be directed to these high-rents areas.
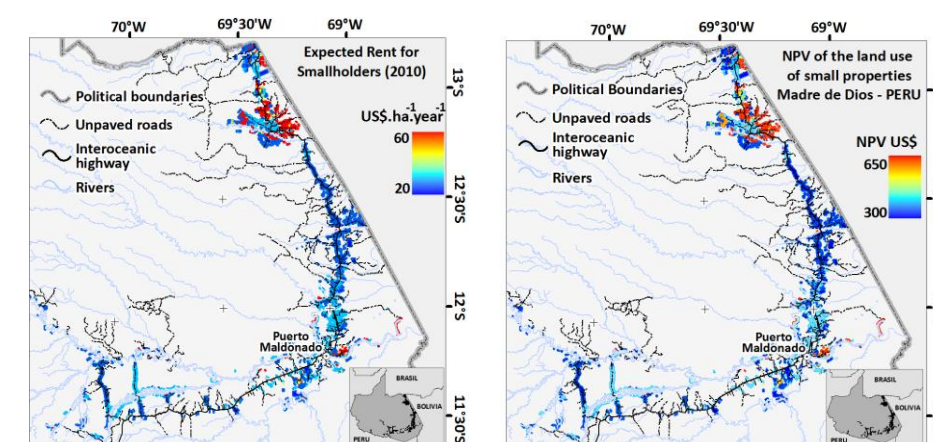
Figures 3 and 4. Annual rents (left) and NPV (right) of farming in Madre de Dios.

As expected, the low rents found for profitability reflect the lack of investments directed to the agricultural sector in Madre de Dios. However, despite undervalued, farming in Madre de Dios occupies about 40% of the economically active population of the Department [5], and supplies a significant amount of food products required by local markets.

Improvements in farming and in the life quality of the rural population are a necessity that can be partially satisfied with the construction of the IOH because it will reduce transport and transaction costs for commerce in Madre de Dios, thus increasing profits of local producers. However, an unplanned