

# A critical appraisal of economic valuation methods in the context of halting deforestation in the Brazilian Amazon

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**Abstract:**

This paper critically discusses how different economic valuation methods can be used to measure the benefits of halting deforestation in the Brazilian Amazon. Four different valuation methods are discussed: the replacement cost to measure the value of carbon sequestration and biodiversity maintenance, the contingent valuation method to measure the value of better protection management, the travel cost method to determine the recreational value of community based ecotourism, and deliberate valuation as way to understand the larger socio-economic dynamics driving deforestation on agrarian settlements.

This paper concludes that the contingent valuation method should be preferred over the travel cost method and the replacement cost method for valuing the maintenance of crucial ecosystem services, like carbon sequestration and biodiversity in the Brazilian Amazon. In addition to contingent valuation, group-based methods, like deliberate valuation, can help elicit deeper held values that Brazilian smallholder farmers have for the environment and consequently make them engaged in more responsible trade-offs between agrarian development and maintenance of biodiversity.

**Introduction**

Increasing land deforestation rates in the Brazilian Amazon have become a major environmental concern. Deforestation in the Brazilian Amazon is responsible for an absolute loss of 39.900 km<sup>2</sup> of dense forest per year (Malhi et al. 2014). The

associated reduction in biodiversity and increases in fire and drought frequencies are destabilizing the ecosystem, potentially releasing 21+-4 Pg C by 2050 (Almeida et al. 2011). Because the Amazon plays an important role in the terrestrial system by hosting a range of important ecosystem services such as biodiversity and carbon sequestration (Malhi 2008), it becomes clear that the effects of deforestation in the Brazilian Amazon<sup>1</sup> have a local and global dimension. In order to limit further deforestation and associated disruptions in the Brazilian Amazon, it is necessary to identify the agents responsible for deforestation and understand their motivations;

#### *Clearing of forest on private land*

Roughly 25% of the Brazilian Amazon is private land (Börner & Wunder 2008). For many private land owners, cattle ranching is considered a very lucrative source of income thanks to government subsidies and prospective gains from rising global beef prices. Consequentially, a large part of deforested area in the Brazilian Amazon is used for livestock pasture (Margulis, 2003). It is therefore essential that alternative business models based on a more sustainable use of forest areas are promoted.

#### *Illicit Logging*

Another important driver of deforestation in the Brazilian Amazon is illicit timber extraction, which can be attributed to weak enforcement of protection laws on public and private land. Enforcing command and control regimes on an area equal to the size of the Amazon can be a daunting task, but it is necessary, since 40% of the Brazilian Amazon is weakly protected public land (Börner & Wunder 2008). It has therefore been suggested that a stronger enforcement of already existing legal frameworks, and a closer cooperation between government agencies and monitoring programs would greatly contribute to a reduction in illegal logging (Wellesley, 2014).

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<sup>1</sup> Due to the vast variation in ecosystem structure, climate and socio-economic context across the Amazon basin, this report is limited to the Brazilian Amazon because it has the highest rates of deforestation

*Role of economic valuation*

The sale of illegally logged timber wood and the excessive conversion of forested land to livestock pasture are an unsupportable income base for sustainable development. It has therefore been argued that more efforts should be put into the creation of new income generating streams provided by a healthy forest ecosystem (Fearnside 1997). One necessary condition for alternative income generating activities to be sustainable is that they need to keep the ecosystem structure and processes of the Brazilian Amazon intact. For the maintenance of ecosystem services to be an income generating opportunity, they need to create utility that can be valued in monetary terms.

Economic valuation plays a necessary role in the identification and estimation of alternative income streams for maintaining ecosystem services (Brown et al. 2007). Based on the framework by Verweij et al. (2009), several ecosystem services are provided by the Brazilian Amazon:

*Supporting services:*

The Brazilian Amazon provides living room for an uncountable number of species, making it the most floristically diverse ecosystem on the planet. There is a general consensus that loss of biodiversity negatively affects the capture of biologically essential resources (e.g. light, water, carbon) and the processes converting them into biomass (Cardinale et al. 2012). A distinction needs to be made between direct and indirect benefits accruing from biodiversity (Nunes & Van den Bergh 2001). Indirect benefits can be referred to as the value of biodiversity essential to maintaining a proper functioning ecosystem structure, whereas the direct benefits of biodiversity are the production and consumption of ecosystem services (Nunes & Van den Bergh 2001). Since the maintenance of biodiversity constitutes an environmental service for which there are beneficiaries who would be willing to pay for (Fearnside, 1997), determining the value of this maintenance becomes necessary.

*Regulation services:*

Refers to the benefits that are obtained from the regulation of ecosystem processes. Climate regulation and carbon sequestration are arguably the most valuable regulation services of the Brazilian Amazon. Other relevant regulation functions are water regulation, soil retention, as well as the prevention of soil erosion (Fearnside 1997), but this paper will focus on climate regulation and carbon sequestration as environmental services to be valued.

*Cultural services:*

Services providing non-material benefits such as '*opportunities for spiritual enrichment, mental development and leisure*' (De Groot et al. 2002). Ecotourism, specifically community-based tourism can link biodiversity conservation with providing sustainable revenues for local communities (Kiss 2004). While ecotourism might not be a panacea for halting large scale deforestation in the Brazilian Amazon (Kiss 2004), it is nevertheless important to discuss how economic valuation can help determine the potential value of this industry as a sustainable income base for local communities.

Economic valuation also plays an important role in estimating the value of improved protection management programs on public forested land. If Brazilian authorities are serious about fighting illegal logging on the currently weakly protected public lands in the Brazilian Amazon, then it is essential for decision makers to be informed about the value of improved forest protection management to reduce illegal deforestation.

*Purpose of this paper*

This paper discusses the use of valuation methods as an information vehicle for decision makers to assess value of improved conservation management of public forested land, and to elicit the value of alternative income streams incentivizing farmers not to engage in clearance and subsequent cultivation of farmland. The common thread is providing an economic rationale for biodiversity conservation and halting deforestation in the Amazon. Four different valuation methods will

be analyzed: the replacement cost to measure the value of carbon sequestration and biodiversity maintenance, the contingent valuation method to measure the value of better protection management, the travel cost method to determine the recreational value of community based ecotourism, and deliberate valuation as way to understand the larger socio-economic dynamics driving deforestation on agrarian settlements. Each method will be analyzed for its strengths and weaknesses, and the extent to which they are relevant in the context of halting deforestation in the Brazilian Amazon.

### **Replacement Cost Method**

The replacement cost method can be defined as measuring the “*cost of replacing a lost environmental good or service, or conversely the replacement cost avoided if the environmental good or service is provided.*” (Brown, 2007). It is not a method for measuring the benefit accrued from the environmental good or service per se. Instead, it is a useful way to approximate the value of one option, whose direct benefits cannot be measured, through the costs of replacing it with another substitute capable of providing the same goods and services (Brown, 2007). While the replacement cost method provides proxy measures for the direct use-value of an ecosystem service, it does not measure the total economic value of an ecosystem service (Christie et al. 2012). One caveat of the replacement cost method is that it requires the benefits to be fairly equal to those ascribed to the missing ecosystem service i.e. perfect substitutability of the missing ecosystem service.

While the replacement cost method has been used in number of case studies in developing countries to value the cost of soil erosion, valuing wetlands and sustainable forest management (Christie et al. 2008), it is not clear how the same approach can be applied to valuing the maintenance of biodiversity in the Brazilian Amazon for two reasons. First, while the negative impacts of biodiversity loss through deforestation on ecological processes and the provision

of good and services in the Brazilian Amazon are widely acknowledged among ecologists (Cardinale et al. 2012), little can be said about the costs of replacing them through a substitute. Second, it is inconceivable what alternative man-made good can replace the function of biodiversity to maintain ecosystem structure and provision of various environmental goods and services. Therefore, the replacement cost method is of little help to value the maintenance of biodiversity, and cannot provide an answer to how local people should receive funds derived from the environmental service of maintaining biodiversity.

The prospects of replacement cost methods are little more promising in the context of carbon sequestration lost through deforestation. While research is being done on carbon engineering technologies capable of extracting carbon dioxide from the atmosphere, it is still an infantile field (Jamieson, 2013) and little can be said about the cost of replacing one hectare of carbon sequestering Brazilian rainforest by some carbon extracting infrastructure.

Instead of the replacement cost method, measuring the social cost of emitting carbon through deforestation has better prospects of measuring the benefits of maintaining the carbon sequestering capability of forested land. The social costs of climate change can be measured through cost-benefit analysis or a marginal cost method, the latter capturing better the marginal change caused by one additional hectare of deforested land (Clarkson & Deyes 2002). Only a few studies have attempted to estimate the costs of climate change. A study by the Climate Vulnerability Monitor (2012) estimates that by 2030 the costs of climate change can reach 3.2% of global GDP, with the world's least developed countries being most affected, facing costs of up to 11% of GDP. These costs are likely to be underestimated though, as they do not take into account the consequences of positive feedback loops caused for instance by the release of Arctic methane deposits or large-scale climatic disruptions such as the collapse of ocean circulation mechanisms (ibid). Additional uncertainty occurs when estimating social costs on a *per* tonne of carbon basis. While according to the 1996 Intergovernmental Panel on Climate Change's published report 'Economic and

Social Dimensions of Climate Change' estimates an additional tonne of carbon dioxide to cost 37\$ (2015 levels), a recent paper by Diaz et al. (2015) estimate the social cost of carbon at 220\$ per tonne by incorporating the reduced growth of economic output as a permanent effect of climate change into the cost function. In addition to the uncertainty of estimating the social costs of climate change, the choice of discount rate is crucial as the related costs of climate change will occur over a period of more than 100 years (Clarkson, 2002). Choosing a too high discount rate can underestimate the damage climate change can cause to future generations. Assuming that reliable estimates of the social costs of climate change exist, measuring the benefits of protecting one additional hectare of forested land in the Brazilian Amazon remains a relatively straightforward task, since the current rate of deforestation and annual uptake in the region are fairly well estimated at 39.900 km<sup>2</sup> year<sup>-1</sup> and 0.42-0.65 Pg C year<sup>-1</sup> respectively. In a later stage, this estimated social cost of carbon of the region could be translated into benefits of avoiding deforestation and afforestation, which in turn can provide economic reasons for compensating farmers for not converting their land to cattle tenure or farmland, and a better justification for funding programs aiming a better protection of public lands from illegal logging.

### **Contingent Valuation**

Stated preference methods have become popular for the valuation of non-market environmental goods, particularly for the economic valuation of environmental changes that are not reflected in changes in purchasing power, recreational demand or any other observable behavior (Adamowicz et al. 1998). One type of stated preference method is the contingent valuation method (CVM) where respondents are asked to state their willingness to pay for the improvement of an environmental good, or willingness to accept compensation for the degradation of it. CVM is a survey based method and takes into account socio-economic, economic and behavioral characteristics of the respondents, and how these explain respondent's choices (Adamowicz et al. 1998). A strength of the contingent valuation method is that it can be used for estimating both use and

non-use values - the latter having no market value, and the value of simply knowing of the existence of the good, which plays an important role when surveys are held with respondents who are not directly affected by changes in a distant environmental good (Christie et al. 2008). In contrast to market-based and revealed preference methods, CVM values possible future scenarios, and not the value of the current state of a good (Christie et al. 2008) .

Several CVM studies have been made to elicit WTP for better protection management of tropical rainforest. Kramer et al. (1997) estimate US residents to have an average willingness to pay of ~ \$31-45 (2015 adjusted) per household to make a one-time donation into a fund to protect an additional 5% of tropical rainforest. A similar study by Horton et al. (2003) in the regional context of the Brazilian Amazon finds that UK and Italian residents are willing to pay US\$63 per household to fund the implementation of a protection programme covering 5% of the Brazilian Amazon, yielding an aggregate of US\$ 1.28 billion across all Italian and UK households<sup>2</sup>. A positive element of this study is that aggregated funds collected are outweighing the estimated costs of successfully improving protection programs in the Brazilian Amazon (Horton et al. 2003).

CVM analysis could be used in the context of this paper to elicit respondents' WTP for better protection management aimed at tackling illegal logging on public land in the Brazilian Amazon. Improving protection management could include employing more enforcement officers in public park areas, better training of enforcement officials and investing in monitoring systems tracking revenue flows from illegal timber sales (Wellesley 2014). In line with Whitehead (2006), the next step would be devising a questionnaire design from similar CVM studies valuing better protection management in the Brazilian Amazon. A CVM closely related to improved protection management has already been done by (Horton et al. 2003). Their study included two hypothetical scenarios of protecting an

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<sup>2</sup> WTP estimates from Kramer were adjusted to 2015 levels using the inflation calculator of the US bureau of Labor Statistics, WTP estimates from Horton (2003) were adjusted to 2014 levels using inflation calculator of the Bank of England.

additional 5% or 20% of Brazilian Amazonia, with the purpose of taking into account the possibility of 'embedding effects' (Horton et al. 2003). This could be simulated in the context of tackling illegal logging by offering one small-scale and one large-scale improvement of protection management on public land. It is necessary that In order to take into account the uncertainty of eliciting people's WTP for hypothetical changes in a distant environmental good (Horton et al. 2003; Christie et al. 2012) a dichotomous question format requiring simple yes/or no answers for given bids, and a payment ladder approach to accommodate for uncertainty in bid levels should be included in the questionnaire design. The next step would be to choose an appropriate payment vehicle. While tax payments may provoke respondents' averseness towards tax raises (Kramer & Mercer 1997; Zander et al. 2014) causing them to understate their true willingness to pay for environmental protection, it has nevertheless been argued that these payments are more realistic than a voluntary contribution to a hypothetical conservation fund (Horton et al. 2003)

A major concern with applying CVM studies to elicit people's willingness to pay for improved rainforest protection in the Amazon lies in the difficulty of making informed choices about the value of a distant ecosystem. For instance, in the study by Horton et al. (2003), Italian and UK respondents faced large uncertainties in the formulation of their WTP. A related problem occurs in the CVM study by Kramer et al. (1997) where US respondents said they would be aware of rainforests and the importance of conserving them, but that it is a too complex cognitive task to allocate compensation funds regionally and among different types of forest. The same task complexity is likely to appear when conducting a CVM study for better protection management in the Brazilian Amazon. Usually, CVM studies assume that respondents properly understand concepts like *maximum willingness to pay* and have a clear understanding of the change scenarios proposed. However, this might not always be the case when conducted in developing countries where local communities due to different ontological views and belief systems might have different interpretations of WTP and change scenarios

(Christie et al. 2008). However, this should not be a concern if the CVM method is conducted with respondents in a developed country.

### **Travel Cost Method**

Based on the principle that ecosystem services must pay for themselves by generating economic benefits, community eco-tourism has been promoted as a sustainable income stream for local people and improving local attitudes towards conservation (Kiss 2004). Since the Brazilian Amazon is blessed with a rare ecosystem rich in biodiversity and aesthetic appeal, ecotourism could provide significant regional economic opportunities. Selected areas of the Brazilian Amazon, if promoted well, could be used extensively for the recreational purpose of ecotourism.

The travel cost method is a non-market valuation method specifically used for measuring the recreational (i.e. direct) use value of travel sites. The travel cost method is a demand based model, relating demand for a site (in terms of number of visits) to the cost of a visit that an individual is willing to take to that particular site (Parsons 2003). In theory, it can be said that the relationship between the number of visits made and travel costs is a downward sloping demand function. A core assumption of the model is the further a person lives away from the travel site, everything else the same, the higher are the travel costs. Since the travel cost method is demand-based, one can derive estimations of the consumer surplus of a site for a given number of times at a given price (Parsons 2003). Two types of travel cost models exist: zonal travel cost, and the individual travel cost model. The zonal cost model derives a demand curve by averaging travel costs for different concentric areas around the travel zone. On the other hand, individual travel cost modes count the number of trips per year by individual users of a travel site. Individual travel cost models are more appropriate for travel sites that attract infrequent travelers from afar, while zonal travel cost models are the preferred type for local, frequently visited travel sites (Fleming & Cook 2008). In

the case of ecotourism spots in the Brazilian Amazon, which are unlikely to attract a large share of frequent travelers, it is the best option to employ the individual travel cost model.

Several travel-cost based studies have been done to measure the recreational value of ecotourism sites (Tobias & Mendelsohn 1991; Kumari 1995). However, to the knowledge of the author, no studies exist using the travel cost method to estimate the recreational value of ecotourism sites in Brazilian Amazon, but that does not imply that it cannot be done. A first step would be defining and measuring the travel costs to get to the site. Several ecotourism sites already exist in Brazil. Researchers would need to go to the sites and ideally find a random sample of individuals asked about travel-related expenditures such as equipment, accommodation and food. Distance costs usually include fuel costs, assuming that travel is being done by car or motorcycle. Travel time costs would be the opportunity cost of travelling to the site, usually estimated as a fraction of the hourly work wage (Fleming & Cook 2008). From this, a single site model using the individual travel cost method could be developed to assess the recreational benefits lost if the quality of the ecosystem site were reduced through regional deforestation or biodiversity loss.

However, this approach faces many methodological challenges. One-time visitors from foreign countries would have to report extensive and discretionary travel costs including plane ticket, transfer cost, lodging. Uncertainty would also arise when asking international visitors about the exact number of travel hours spent to the site. One convenient way is to exclude these observations from the sample and simply assume that foreign tourists place the same recreational value as local visitors do (Tobias & Mendelsohn 1991). However, this is likely to underestimate the true recreational value of a travel site, especially when attracting a high proportion of foreign travelers who are likely to value the site more than locals due to a lack of nearby substitutes (*ibid*). Finally, the travel cost method assumes that the travel costs accrued by the travelers are exclusively for one single recreational site. However, this is likely to not be the case for international travelers who may visit several sites in the Brazilian Amazon. Several methods

have been proposed in the literature to account for joint consumption benefits from several sites, but they generally render the travel cost models less predictive (Clough & Meister 1991).

### **Deliberative Monetary Valuation**

One major driving force of land use changes on private land in the Brazilian Amazon has been the Brazilian agrarian reform program, a government sponsored, rural settlement scheme designed to redistribute large landholdings and allocate unclaimed public lands as rural properties to smallholder families (Peres & Schneider 2012). Between 1995 and 2011, over 1 million families have been allocated to 8865 settlement plots encompassing an area of ~15% of the Brazilian Amazon (Schneider & Peres 2015). Smallholder rural development schemes have been praised by international agencies as an effective tool to escape rural poverty (IFAD, 2013). However, a recent study by Schneider & Peres (2015) links agrarian settlements in the Brazilian Amazon to increased rates of deforestation through timber extraction, charcoal production and overhunting by smallholders, as well as conflicts over land claims. Besides the significant start up costs, rural credit flows and subsidies associated with relocating and supporting settlement families within the Brazilian agrarian reform program, a major concern is the placement of these settlement plots inside legally protected areas, causing the inevitable downsizing and degradation by settlers (de Marques & Peres 2014), and short-lived unsustainable revenue streams followed by rapidly used up natural capital and selling of land to large commercial landowners (Schneider & Peres 2015). It can be said that large-scale agrarian settlement schemes in the Brazilian Amazon are a failure from an efficiency and sustainability perspective, but also a governance problem arising from the conflicting interaction between state and non-state actors, such as small holder syndicates and large commercial landowners. The relevance of social groups rather than just individuals needs to be emphasized in this context. As (Otsuki 2011) points out, institutional arrangements enabling settlers to conduct sustainable agriculture need to “*consider settlers’ social organizations as elements of the social forces that shape settlement landscapes*” and that they shape

agricultural outcomes through “*different sorts of social relations and norms*”. This emphasis on power structures, different ontological and ethical perspectives resonate in the deliberative valuation method.

Deliberative valuation has been appraised as more participatory and inclusive than conventional valuation methods, as it emphasizes the multi-dimensionality of stakeholders’ values in resource management (Kenter et al. 2015). In the context of environmental valuation, it postulates that information about the value of environmental resources cannot be collected through the aggregation of individual values alone, it also needs to take into account the community structures in which they interact, and hence, the underlying social and shared values guiding group behavior (Kenter et al. 2015). Social values can have a multitude of meanings. While in conventional welfare economics, social value is determined through the aggregated WTP of individuals, sociological approaches like deliberate valuation aim to identify not only economic, but also cultural, aesthetic or ecological factors as drivers guiding human behavior. Shared social values differ from social values in that they do not exist a priori, but need to be elicited through social learning processes, which are the outcome of effective dialogues between different stakeholders (Stagl 2004).

A detailed discussion of how deliberative valuation should be implemented in the context of deforestation on smallholder land goes beyond the scope of this essay, but it suffices to say that deliberative valuation is a necessary complement to traditional monetary valuation techniques to assess the costs and benefits of agrarian settlements in Brazilian Amazonia. For sustainable agrarian development models to be created in these areas, government agencies responsible for the implementation of those settlement schemes like the Brazilian Federal Agrarian Agency (INRCA) could send representatives to have a critical dialogue with settler community members and leaders in order to understand the hopes and motivations that drive them to become smallholder farmers, as well as the circumstances causing them to degrade their land using unsustainable agrarian practices, and subsequently abandon it. The costs and benefits of current settlement programs could be valued with deliberative choice

experiments aiming at eliciting smallholder families' preferences for reduced unemployment, better formations, increased community cohesion or conversation of biodiversity. An effective deliberation would use these group meetings to familiarize settlers - who rarely have sufficient knowledge about coexisting with standing forests on their settlement plots and living from non-timber products (Schneider & Peres 2015) - with the complex trade-off between agrarian development and maintaining biodiversity. One could then assess how much these ecological-economic considerations are in line with the elicited shared social values of the settlers. In a later step, policy makers might need to reassess the development goals that they took for granted as representing the interests of the smallholder communities, and potentially adjust their settlement policies to upcoming candidate families. Hopefully, more efficient allocation of tax payer money into agrarian settlement schemes and more sustainable agrarian practices used by smallholders could curb down deforestation rates associated with the agrarian reform program.

### **Conclusion**

This essay discussed how economic valuation methods can be used in the context halting deforestation in the Brazilian Amazon.

The replacement cost method generally has little practical use for measuring the value of biodiversity maintenance and improved protection management against illegal deforestation. This is due to the non-substitutable character of ecosystem services like biodiversity and carbon sequestration that cannot be replaced through manmade technologies. Instead of the replacement cost method, other cost-based approaches like the social cost of carbon method better reflect the cost of foregone carbon sequestration, and in that respect, provide more insights into the benefits of avoiding deforestation through improved forest protection management.

Still within the realm of valuing better protection management of public lands against illegal logging, the contingent valuation method can also be considered an appropriate method. Several CVM studies have been done eliciting both local and international respondents' values for different improvement scenarios of forest protection management. However, important challenges remain related to the significant task complexity when making informed choices about the value of a distant and complex ecosystem like the Brazilian Amazon.

The travel cost method can be applied in the specific context of informing decision makers about the recreational value ecotourism spots in the Brazilian Amazon put at risk by local deforestation. However, unresolved methodological issues remain when accounting for the high share of foreign travelers visiting ecotourism sites. It should also be noted that the travel cost only reflects recreational services provided, and therefore overlooks the tremendous benefits of carbon sequestration and biodiversity services provided by the Brazilian Amazon.

Finally, deliberate valuation in combination with stated preference techniques like choice experiments or contingent valuation could provide learning outcomes that have important implications for how smallholder farmers relate with their environment. This could be used to promote more sustainable management practices resulting in less degradation of forested land.

Overall, it can be said that the contingent valuation method should be preferred over the travel cost method and the replacement cost method for valuing the maintenance of crucial ecosystem services like carbon sequestration and biodiversity in the Brazilian Amazon. In addition to contingent valuation, group based methods like deliberate valuation can help elicit deeper held values that smallholder farmers have for the environment and consequently make them engaged in more responsible trade-offs between agrarian development and maintenance of biodiversity.

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