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Forest loss and management in land reform settlements: Implications for REDD governance in the Brazilian Amazon

Driss Ezzine-de-Blas [a,*], *Jan Börner* [b], *Ana-Luiza Violato-Espada* [c], *Natalia Nascimento* [d], *Marie-Gabrielle Piketty* [a]

[a] *Center International en Recherche Agronomique pour le Développement (CIRAD), Campus International de Baillarguet, Montpellier, France*
[b] *Center for International Forestry Research (CIFOR), Rio de Janeiro, Brazil*
[c] *Tropical Forest Institute, Belém, Brazil*
[d] *Federal University of Pará, Belém, Brazil*

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ABSTRACT

Land reform settlements (LRS) in the Brazilian Amazon have been suggested to hold promise for the successful implementation of incipient efforts to reducing emissions from deforestation and degradation (REDD). However, differences in forest cover, deforestation behaviour and settler welfare plus the inevitable overlap of upcoming REDD efforts with existing conservation policies, mean that scope and impact of REDD in LRS will not be uniform across settlements. Based on evidence from a case study of four LRS and a Brazilian Amazon regional analysis of opportunity costs, this paper explores the actual scope for targeting initial Brazilian REDD efforts to LRS and discusses potential welfare and equity implications based on scenario analysis. While our findings confirm considerable economic scope for compensation-based schemes for avoided degradation and deforestation, the pre-existence of legal use right limitations in combination with the distribution of forest cover among LRS means that less than half of settlements – poorer – will be able to derive economic gains. Exploring a mix between incentives and disincentives seems to offer the most promising future regarding efficiency and equity successful results. The paper concludes with the implications of the results in the international debate on the constraints ahead to implement the REDD principles.

1. Introduction

Reducing emissions from deforestation and forest degradation (REDD) is an important aspect of a feasible global climate change mitigation strategy. This is not only because changes in forest cover represent a considerable proportion of global anthropogenic greenhouse gas emissions, but also because REDD is a comparatively low-cost mitigation option compared to current energy models (Kindermann et al., 2008; Clarke et al., 2007; Stern, 2007). International organizations, NGOs, and individual countries are pushing the REDD agenda, especially since REDD was officially discussed during the climate policy negotiations at the COP13 in Bali in 2007. Yet many key REDD design issues related to reference levels, monitoring and verification, benefit sharing, governance and funding remain open. In 2009 in Copenhagen, negotiators at the COP15 adopted the concept of "REDD+" i.e. REDD including sustainable forest management and forest carbon stock enhancement; which will most likely be an intergovernmental mechanism, contributing to forest policy implementation at national level (UNFCCC, 2009).

* *Corresponding author*. Tel.: +33 467593759.
E-mail addresses: Ezzine@cirad.fr (D. Ezzine-de-Blas), j.borner@cgiar.org (J. Börner).
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The Brazilian Amazon is considered to be one of the countries where a REDD mechanism could rapidly produce tangible mitigation benefits (Nepstad et al., 2009). Despite recent reductions, deforestation in the Amazon still represents over 10% of the world total (between 7 and 13 thousand km^2 in 2007–2009 according to the Brazilian National Space Research Institute, INPE). Since the COP13, unprecedented donor commitments to move forward with REDD support the belief that efforts to halt forest loss in the region are becoming ever more serious. At the COP 15, the Brazilian government presented its National Plan on Climate Change[1]. The plan commits to reducing the annual average deforestation rate for the period 1996–2005 by 80% by 2020. Apart from enhanced control and enforcement of the existing regulatory forest conservation policy (The Brazilian Forest Code), one of the plan's key components is to encourage conservation through a new national program of payments for environmental services (PES).

Several studies have analyzed the theoretical potential of PES as a way to avoid deforestation in the Brazilian Amazon (Börner et al., 2010; Börner and Wunder, 2008; Grieg-Gran, 2006; Nepstad et al., 2009). While its economic potential, i.e. comparatively low provider costs, was confirmed in practically all studies, Börner et al. (2010) identified serious short- to medium-term limitations for payments for avoided deforestation in the region. According to their findings and based on deforestation scenarios by Soares-Filho et al. (2006), (67)% of forests under deforestation pressure are subject to unclear tenure claims – a condition under which PES is bound to fail, because providers cannot legally guarantee service provision. Another 8% of threatened forests have already been declared strictly protected areas, thus raising legal additionality issues. The remaining 25% of threatened forests are divided among Land Reform settlements – hereafter referred to as LRS (7%), indigenous territories (9%), and extractive reserves (9%). However, their study showed that only in LRS, both observed past and simulated future forest loss can reasonably be considered tenant proper – an important pre-condition for PES-led REDD to function as an effective conservation mechanism (Cotula and Mayers, 2009). LRS thus appear as a critical starting point for appraising the viability of a national incentive-based REDD initiative, given the potential poverty alleviation benefits and that their relatively well-known tenure situation could allow for rather straightforward contract establishment and low cost compliance monitoring and enforcement.

Departing from these assumptions, the present paper assesses the tradeoffs that a hypothetical program of payments for avoided deforestation and degradation needs to face in terms of (1) the actual potential of Brazilian LRS to contribute to REDD-funded forest conservation, e.g. considering the potential overlap with the existing regulatory framework and (2) the likely implications of REDD for the welfare and equity of settlers. The paper is structured as follows: Section 2 briefly reviews the Brazilian Land Reform process that led to the creation of LRS. Section 3 documents data and case study material. Based on an analysis of logging arrangements in four LRS in the State of Para, Section 4 discusses the potential for and implications of reducing degradation - the second 'D' in REDD. Section 5 assesses the prospects for reducing deforestation in LRS–the first 'D' – at a regional scale. Section 6 discusses results and concludes with emerging policy issues.

2. Land reform settlements in the colonization history of the Brazilian Amazon: from deforestation incentives to forest conservation policies

The Brazilian Federal Land Reform program was launched in 1964 (Estatuto da Terra, 1964) to bring ''People without land to land without people''. This applied not only to poor and landless ''peasants'', but also to the expanding Southern Brazilian agribusiness. The main drivers of the land reform were the so-called ''*projetos fundiários*'', i.e. colonization projects of different size depending on settler background (IPEA, 2008). Among the most popular colonization projects were settlements for landless peasants, hence land reform settlements (PA). The land reform program has resulted in over 8,500 settlements covering more than 84 million hectares throughout the country[2]. Almost 90% of the total settlement area is in states that make up the Legal Amazon region.

The land reform program was embedded in a fluctuant policy and economic environment characterized by attractive rural credits, agrarian production subsidies, and expansion of transport infrastructure that contributed to shaping agricultural development at Amazonian forest margins (Binswanger, 1994; Gillis and Repetto, 1988; Smith et al., 1996; Walker and Homma, 1996). The expansion of staple and commercial crops as well as extensive cattle production, were the main drivers of the loss of forest cover (Sayago and Machado, 2004). Many LRS failed - in some cases, nutrient-poor soils were a serious limitation to low-input agriculture. All too often, however, precarious infrastructure and missing market links prevented settlers from establishing financially sustainable land use systems (Alston et al., 1999; Schneider, 1995).

Differentiated categories of LRS emerged as the National Institute for Agrarian Reform (INCRA) attempted to adapt resource use and access rights in settlements to the characteristics of land and settlers. Popular alternatives to traditional settlement projects are Sustainable Development Projects (PDS) and Agro-extractive Settlement Projects (PAE) (Coca, 2008). While traditional LRS allow property rights to be transferred from the State to the settlers, PDS and PAE are essentially use right concessions. Besides, the Brazilian Forest Code requires landholdings, including LRS, to preserve 80% of land as a 'forest reserve' (*Reserva Legal, Medida Provisória* 1.956-48 2001). The management rights of the forest reserve are collective for PDS and PAE, and individual for PA. These characteristics are summarized in Table 1 in section 3 below.

Although most municipalities and states where settlements are located perform comparatively well in terms of the

[1] The Brazilian REDD strategy: How the country has achieved major deforestation reduction in the Amazon. Copenhagen, December 2009. Ministry of Environment.

[2] National Institute for Agrarian Reform (INCRA): www.incra.gov.br.

Table 1 – Basic descriptors of LRS studied.

LRS	PA Mojú I		PDS Virola-Jatobá	PA Altamira	PA Bom Jardim
LRS area (ha)	147,472		30,000	3915	94,735
No.of families in LRS	1635		187	1060	687
Assoc./Coop.	Acoprasa	Aprocosma	Virola-Jatobá	CANOR[A]	COOPCAO[B]
Assoc./Coop. area (ha)	3400	4500	30,000	600	1000
No. of families in assoc./coop.	60	52	187	6	25
Travel time to market	5[a]	6[a]	7[b]	3[c]	3.5[d]
Creation date	1996	1996	2004	1972	1997
% deforested	6	6	3	53	38
FR tenure	Individual	Individual	Collective	Individual	Individual
Agricultural techniques	Manual	Manual	Manual	Some mecanisation[C]	Some mecanisation
No. sampled	7	6	6	4	8

Assoc: Association; Coop.: Cooperative.
FR: Forest reserve.
[a] to Santarém.
[b] to Altamira.
[c] to Uruará.
[d] to Pacajá.
[A] Cooperativa Agroextrativista Novos Rumos.
[B] Cooperativa de Cacau Orgânico.
[C] Lawnmower, cutter roll.

Human Development Index (CEPAL, 2008), conditions in LRS are often precarious. Many families lack electricity, clean drinking water, health and education services, and transport to urban and market centers. Many settlers depend on growing staple crops or external rents for subsistence (Barbero, 2006). Few settlers have the means to invest in improving productivity and reducing the environmental impact of their land use systems. Slash-and-burn is the main extensive production technology and requires new forests to be cleared on a regular basis (Ferreira, 2001; Veiga et al., 2004). Deforestation in LRS remains high; during the 2002–2006 period, 18% of the deforestation detected by INPE occurred inside settlement boundaries[3], usually illegally within the forest reserve. Since the implementation of the Forestry Law 4.771 in 1965, logging and extraction of non-timber forest products are the only activities permitted in the forest reserve. Yet, settlers can only extract timber from the forest reserve if bolstered by a sustainable forest management plan. Because engagement in the formal timber market requires qualified knowledge and comes with high initial transaction costs, there are few successful examples of self-managed forest reserves in LRS (Drigo et al., 2010; Medina et al., 2008; Wiersum, 2008),

3. Data and methods

The analyses in this paper are based on a subset of five case study LRS complemented by a spatial analysis of LRS at the regional level. Case study LRS were selected to include different types of settlements that actively participate in legal logging activities and along a gradient of accumulated deforestation (closely correlated with age) (Table 1).

The five case study LRS are located close to the BR-163 and BR-230 Amazonian highways (Fig. 1). Along the BR-163 and BR-230 (or Trans-Amazonian) highways, numerous settlement projects and other development interventions have had a major impact on both the economy and the landscape. The region is much better linked to regional and national markets than many other forest margins in the Brazilian Amazon: there are a number of commercial airports, and the Xingú and Tapajós rivers are navigable all year round. The city of Santarém, located at the confluence of the Tapajós and the Amazon rivers, hosts one of the biggest silo and cargo facilities in the state of Pará. Nevertheless, poor road infrastructure results in high transport costs, especially in the rainy season.

Settlers within LRS are organized in associations or cooperatives – the same LRS usually contains a number of associations or cooperatives. While cooperatives often serve marketing purposes, associations are legal entities that enable access to other type of services, e.g. subsidies, credits, or external support from projects. Both are eligible to submit forest management plans. The LRS Mojú was established in 1996 by INCRA, when the members of its two associations (ACOPRASA, APROCOSMA) were already living on the spot. Members of both associations primarily grow staple crops. The LRS Virola-Jatobá, in the district Anapú, was created in 2003 in response to social pressure. In the area of Pacajá, the LRS Bom Jardim was settled during the 1970s, driven by the land reform at its early stages. So was the case for migrants of the LRS Altamira, which settled close to the city of Uruará. Both are situated in the Transamazon region. Settlers in the LRS Altamira created the CANOR cooperative, under the support of international technical cooperation and research organizations, to develop a forest management plan. Of our sample, CANOR is also the only LRS engaged in self-management logging: the three associations in the other case study LRS have sub-contracted logging to outside companies who pay stumpage fees (Drigo et al., 2010). Besides, the LRS Bom Jardim is the only sample LRS without an approved forest management plan. It was included in order to compare the investment intentions of settlers not yet engaged in logging operations with the use of money coming from logging by settlers that got engaged in logging activities.

[3] Calculated based on the data documented in Section 3.

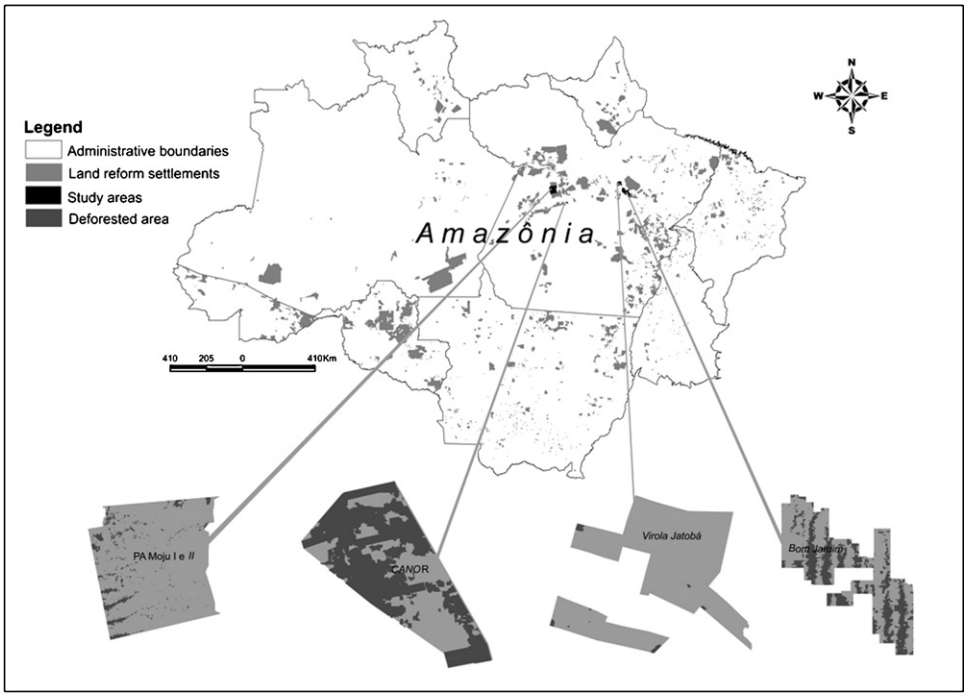

Fig. 1 – Land reform settlements in the Brazilian Amazon and sampled sites.

We administered a semi-structured questionnaire to a total of 31 farmers divided amon the four settlements (see also Table 1). The questionnaire covered general information on land use, on settlers' geographical origin and on socio-economic conditions. Open questions were used to record reasons for logging, the type of commercial agreement and how the returns to logging were invested. In the cases where logging benefits had been invested in productive or other durable assets, the answers were verified in the field.

For the regional scale analysis, we used spatial data provided by the Brazilian Institute for land reform (INCRA) comprising LRS in the Legal Amazon region (Table 2). The spatial data covers only roughly half of the area included in the agricultural land reform since its beginning, but is fairly complete considering that a considerable amount of former LRS have become private property over time.

LRS polygon data was overlaid with historical deforestation maps as well as conservation opportunity costs (see appendix for calculation steps), land use/cover information from the latest agricultural census, and estimated travel costs. Shortest possible travel time by road and waterways was estimated from 524 municipal centers in the Amazon region to the central points of 1,1181,400 km^2 sized grid cells using the Accessibility Analyst software package developed by the International Center for Tropical Agriculture (CIAT). Travel speed for waterways, unpaved and paved roads was set at 10, 25 and 60 km/h, respectively.

4. Results and analysis

4.1. *Forest management in LRS: implications for payments for avoided degradation*

LRS mainly equip settlers with land and forest use rights that are compatible with the Forestry Law and are even more restrictive for some of the new types of settlements (see Section 2). In our sample, apart from the PDS Anapú, all case study LRS are conventional settlements (PA) composed of 100 ha individual plots. All three case study PA were created

Table 2 – Data sources used in the regional level analysis.

Input data	Source
1. Location and size of land-reform settlements	INCRA (2007)
2. Annual deforestation (vector data set 2002–2008)	INPE-PRODES[a]
3. Conservation opportunity cost estimates	Börner et al. (2010)
4. Land cover estimates	ESA/ESA GlobeCover Project, Médias-France/Postel © 2006
5. Travel cost	Estimated using the Accessibility Analyst software
6. Land use and fixed asset value household data	IBGE Agricultural Census 2006

[a]The Brazilian Space Research Center's (INPE) Program for the Calculation of Deforestation in the Amazon.

Table 3 – Characteristics of logging contracts and value of stumpage fees payments.

LRS	PA Mojú I		PDS Virola-Jatobá	PA Altamira	PA Bom Jardim
FR tenure	Individual	Individual	Collective	Individual	Individual
Logging regime	Agreement	Agreement	Agreement	Self-management	Agreement
Benefits capture	Individual	Individual	Shared	Individual	Individual
Payment type	Stumpage fee	Stumpage fee	Stumpage fee	Market	Stumpage fee
Rotation cycle [yrs]	25	25	25	15	25
Total net benefits (st.dev.) [R$]	27,900 (14,807)	19,798 (7684)	1136	No benefits[a]	–
Total benefits (st.dev.) [R$/ha/yrs]	16.7 (8.5)	11.3 (4.1)	17.0		–

Source: Field data.
[a] Data from Drigo et al. 2010. Until 2008, the community only managed to sell 50% of the timber they had explored.

before 2001, but only CANOR declared its forest reserve before 2001, the year when the Forest Law on the forest reserve was adjusted from 50% to 80%.

Since no such reserve was declared for the Mojú LRS before 2001, the 80% rule now also applies to this settlement. The PDS Anapú was created after 2001, and is subject to additional restrictions on use rights, e.g. an annual deforestation limit of 3 ha per family and the collective property status of the forest reserve. In all cases the forest reserve is subject to forest management according to an approved management plan with a legal limit of $30m^3$/ha for timber extraction. The majority of settlers, 70% in our LRS sample, depend on agriculture as their main source of livelihood. The other 30% depend on alternative incomes, such as non-agrarian professional activities – e.g. teaching- or governmental pensions. Conversion of some forest into agricultural land is thus often inevitable. Agricultural land use systems in our LRS sample are almost all characterized by low external inputs. Only in Altamira, where agriculture and cattle raising are more common than in the other case study LRS, mechanical equipment is occasionally used for pasture management. Most settlers grow annual staple crops in land intensive slash-and-burn systems and only occasionally input-intensive perennial cash crops, like fruit trees in agro-forest systems and black-pepper. Extracting timber from the forest reserve therefore represents one of the few economic alternatives to farming.

With the exception of the Altamira LRS where spatial analysis data shows that slightly more than 50% of the landholding has been used for agricultural purposes, *de facto* (i.e. actual) use apparently corresponds to *de jure* (i.e. legal entitlement) rights in all LRS in our sample. Hence, if the Brazilian government decided to implement REDD according to the proposed strategy of improved law enforcement and payments for environmental services, what options and potential implications would apply to the LRS concerned?

Improved law enforcement can yield additional forest conservation, vis-à-vis the status quo in LRS that do not comply with the forest reserve either in terms of total forest cover or in terms of logging practices (e.g. Altamira). Settlers in LRS with high forest cover, however, easily comply with conservation standards and may thus continue ''business as usual'' unless encouraged otherwise by conservation incentives, such as those planned in the national PES program. Theoretically, such payments could involve compensation for (1) reduced agricultural expansion (first D of REDD), or (2) reduced timber extraction (second D of REDD)[4]. A detailed discussion of the first option is provided in the following section. Here we focus on the implications of past forest reserve use in our sample LRS for the prospects of reducing emissions from forest degradation.

Without exception, settlers' engagement in legal forest management has been plagued with obstacles. It took the associations in our sample an average of three years and considerable external support to see their management plans through the approval process. Since commercial logging requires considerable upfront investments, three of the case study LRS negotiated a stumpage fee with commercial logging firms (see Table 3). Contracts must adhere to the association's management plan and typically involve a fixed price per unit of wood that varies with the tree species. The Altamira settlement's cooperative (CANOR) is the only example of a self-managed logging operation. At the time of our study, the CANOR cooperative reported an overall net loss from logging operations due to unexpected costs and failed negotiations (Drigo et al., 2010). In parallel, the associations that chose stumpage fees reported net gains, which were delivered in the form of a unique pay-off for a full 25-year rotation cycle for PA Anapu and in the form of a yearly pay-off in the case of PDS Virola-Jatobá. Except for the PDS Virola-Jatobá, benefits from forest reserve management accrue individually to the user of each landholding. In the PDS Virola-Jatobá, where the forest reserve is subject to a collective use right, benefits accrue to the association and an annual payment equivalent to timber yield was negotiated with the logging operator. The highest annual per hectare return was obtained by the association of PDS Virola-Jatobá with 17 R$/ha/yr, while the lowest stumpage fee was obtained by the Aprocosma association in the PA Moju with 11.3 R$/ha/yr. Often, logging contracts involved additional community benefits, such as wells and improvement of access roads. These were estimated at 13.6 R$/ha/yr (Sablayrolles et al., 2008). Hence, total return to forest management ranged between R$ 24.9 and 30.6 per year and per hectare.

Conceptually, the logging agreements chosen by most of the case study LRS transform settlers into recipients of regular or one-off transfers in exchange for access to their forest reserve. Implicitly, however, the arrangements also keep settlers from illegally converting the forest reserve to non-forest uses. This business model reflects PES type agreements in practically all aspects. The agreement is (1) voluntary, (2) a buyer and a seller exist, and (3) the agreement is conditional to the provision of an environmental service (see Wunder (2005)

[4] The now official ''+'' added to REDD implies reforestation as a third option, which is not considered in our analysis.

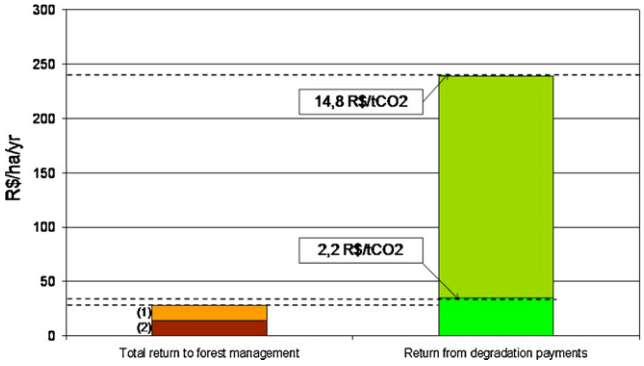

Fig. 2 – Logging stumpage fee and carbon credit payments per cubic meter and per hectare. (1) Return from stumpage fee; (2) road access improvements and other indirect benefits.

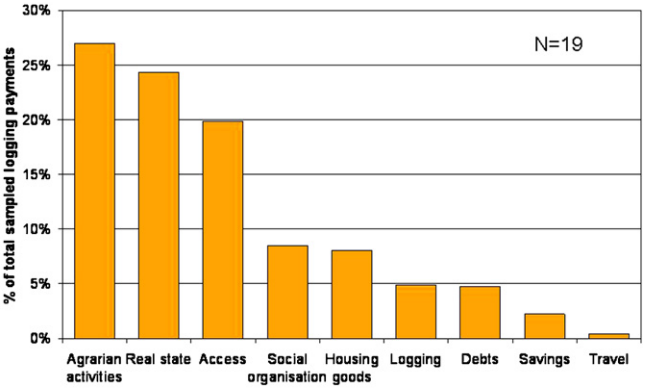

Fig. 3 – Types of investment as a percentage of total logging payments analyzed.

for a widely used definition of PES). Provided that the impact of logging on forest carbon content can be established with reasonable accuracy, the forth element of the PES definition, a well-defined environmental service, is also fulfilled.

Fig. 2 shows the stumpage fees obtained by the associations in our LRS sample expressed in terms of *reais* per ha and compares these to the actual carbon value from degradation based on current carbon emission offset prices. Following Mazzei et al. (2010), we assume that timber extraction causes emissions equivalent to a 22.5% loss of aboveground biomass. Higher – 16.4R$/tCO2[5] for offset prices of project-based voluntary transactions – and lower – 2.2R$/tCO2 for offset prices at the Chicago Climate Exchange (CCX) market – average 2009 offset prices on voluntary carbon offset markets are used to illustrate the potential range of carbon values (World Bank, 2010). Even assuming the most conservative carbon offset price, returns to carbon market participation would be higher than local timber rents. The comparison shows that, despite significant differences in offset prices between the existing marketplaces, switching from timber to carbon markets would be a viable and comparatively more attractive business option for settlers. Especially if, like for the logging contracts, the initial transaction costs of market participation were partially covered by support organizations.

A common criticism of direct conservation payments is that they can transform economically productive agents into passive recipients of benefits and thus increase their dependency on permanent financial transfers (Martin et al., 2008; Pollini, 2009). This allegation would of course equally apply to the type of logging arrangement chosen by the settlements in our sample. However, our data on how transfers were spent by settlers provides location-specific but nevertheless strong evidence against the dependency hypothesis.

Fig. 3 depicts the expenditure category and its respective share of the total returns from forest management. A detailed description of the investment and expenditure categories is provided in Table 4.

Contrary to the dependency hypothesis, settlers invested 75% of total logging payments in productive activities and assets, such as improving agricultural production systems, estate, transport equipment, and social capital. Less than 10% of total rents were spent on pure consumer goods, such as domestic appliances and leisure activities. The investment of forest management rents has therefore primarily targeted non-forest land uses with the aim of increasing living standards and economic returns from agriculture. Only a few real estate investments were made outside the settlement area, such as acquisition of land or houses close to the urban center of Santarém. Clear differences exist among investment choices in the LRS in our sample. While both associations in PA Mojú spent almost 80% of the stumpage fee on agrarian activities and real estate, settlers in PDS Virola-Jatobá invested in collective benefits, e.g. access, social organization and forest management. In fact, PDS Virola-Jatobá settlers plan to adopt self-management of their forest reserve when the stumpage fee agreement expires.

Our analysis did not quantitatively capture the possibility of agricultural investments resulting in increased expansion of agricultural activities. While some of the agricultural investments indeed went into cattle production and might have contributed to forest conversion, the majority of investments were used for land use intensifying activities. Under a carbon market agreement such phenomena would certainly have leakage effects that need to be controlled for. Provided that carbon market incentives are conditional on compliance with contract rules and appropriate sanction mechanisms are in place, incentives to expand low profit extensive cattle production should be minimized. Our results permit cautious optimism that most of the LRS in our sample would benefit from selling carbon emission reductions from degradation instead of timber, without having to change their current land use plan.

4.2. *A regional perspective: scope for avoided deforestation in Amazonian LRS*

Evaluating whether targeting initial REDD efforts to LRS would generally be a viable and attractive strategy requires broadening our perspective to the regional scale. Key questions relate to (1) how much deforestation can we expect to be reduced through REDD in LRS? (2) Can this reduction be achieved at reasonable costs? And (3) what effects could such

[5] USD exchange rate to Brazilian *reais* was estimated at 2.0 R$/USD as the average of 2009 exchange rates.

Table 4 – Types of investments made from logging stumpage fees in Acoprasa, Aprocosma and Association PDS Virola Jatobá. Investment previsions of COOPCAO settlers are in cursive.

Type of expenditure/investment	Description
Agrarian activities	Black pepper seeds; chain-saw; spade; drill; disc saw; corn, beans and rice seeds; rice peeler; pasture; cattle; wire for fences; motor for cutting cassava; acapu plants; *milk cow; water well; fish culture; cattle; reforestation; commercial trees (açaí, cocoa, mango)*
Logging	Forest engineer
Real state	House reform; water well; land in santarém; house in santarém; tiles; *house reform; buying house in the city; buying another land-holding*
Access	Driving licence; car; second hand truck; motorbike; bycicle; truck
Housing goods	Electrical appliance; satellite dish; generator; solar panel; television; freezer; chairs; clothes; medicaments
Social organisation	Association funds; syndicate of workers fees
Savings	Savings for cattle ranching
Debts payment	Debts
Travel	Leisure time

Table 5 – Size and deforestation in LRS according to accumulated deforestation classes.

Remaining forest (%)	Total LRS area (ha)	Number of LRS	Average area (ha)	Number of new LRS types (PDS, PAE)	Annual deforestation rate[a] (%)	Annual forest loss[a] (ha)
<20	2,694,985	308	8750	3	6.9	14,636
≥20 and <50	6,833,162	443	15,425	3	6.7	136,651
≥50 and <80	7,031,186	395	17,800	18	4.0	125,997
≥80	11,620,771	799	14,544	186	0.4	53,829

[a] Calculated for the period 2004–2008.

a strategy have on wellbeing and development in Amazonian LRS?

Table 5 provides an overview of forest stocks and deforestation dynamics in our region-wide spatial sample of LRS polygons. LRS have been classified according to categories of accumulated deforestation. Only in the first group with remaining forests below 20%, is average settlement size significantly lower than in the other three groups. Fig. 4 shows that LRS are primarily concentrated in the states of Pará, Mato Grosso, and Rondônia, which historically have had

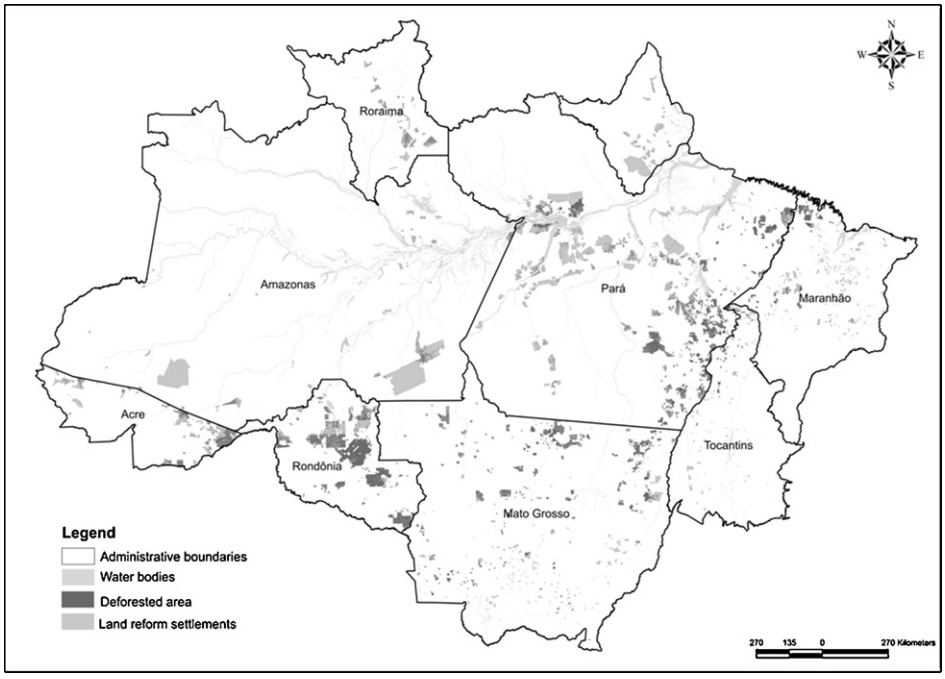

Fig. 4 – Location and accumulated deforestation in LRS in the Brazilian Amazon.

Table 6 – Average opportunity costs and per hectare emission reduction potential for LRS.

Remaining forest (%)	Opportunity cost (NPV[b] R$/ha)	Avoided emissions (tCO_2/ha)	Cost-effectiveness[a] (NPV R$/$tCO_2$)	Remoteness (h travel time)
<20	1627.869	159	24.3	1.7
≥20 and <50	1648.799	217	16.4	2.6
≥50 and <80	1843.453	316	9.7*	4.2
≥80	1360.528	265	10.2*	4.0

[a] Calculation based on original data, not average values shown in the previous columns. Difference of means statistically tested.
[b] Net present value calculated over a 10 year horizon using a 10% discount rate.
* Insignificant difference (TukeyHSD, $p = 0.05$).

the highest annual deforestation rates. Most of the relatively well conserved LRS are located in the central and north-western Brazilian Amazon.

While deforestation has indeed been high (4–7% per year) in the majority of LRS, over 40% of LRS (both in number and area) boast relatively low deforestation rates and, on average, 95% of their extension under forest. Almost a fifth of the latter group consists of new conservation oriented LRS categories, such as PDS and PAE, which indicates that the LRS in this group are rather young. Due to our classification of LRS in low to high forest cover categories, high rates of deforestation do not necessarily coincide with absolute forest loss. In fact, if we look at absolute deforestation, we find the highest annual forest loss in the two categories with medium remaining forest cover.

If only *de jure* additional emission reductions from deforestation outside the forest reserve were eligible under REDD, scope for internationally funded intervention in LRS would be limited to roughly 0.5 $GtCO_2$. In practice, however, trying to avoid these emissions would be futile without securing carbon stocks in the legally protected share of forests. Based on average annual deforestation rates between 2002 and 2008, avoided deforestation in high forest cover LRS could *de facto* result in 2.9 $GtCO_2$ of avoided emissions – or in almost 5 $GtCO_2$ if all LRS in our sample and their remaining forest lands were included. These figures may appear small compared to estimates of the Amazon's region-wide mitigation potential – e.g. 115 $GtCO_2$ (Soares-Filho et al., 2006). But still, the mitigation potential in Amazonian LRS comfortably compares to the traded volume (4.8 $GtCO_2$) on global carbon markets in 2008 (World Bank, 2010).

The total costs of implementing a REDD mechanism are traditionally divided into transaction costs, i.e. the costs of organizing the exchange of money for emission reduction and the costs of actually reducing emissions that result from the need to reduce economically profitable agricultural and forestry activities, i.e. opportunity costs. These costs are typically borne by land users if forest conservation is induced by control and enforcement measures. However, many REDD proponents (Pagiola, 2008; Wunder et al., 2008) favor compensation-based conservation policy instruments, such as payments for environmental services (PES). Under a PES-dominated REDD strategy, the opportunity costs would thus effectively accrue to REDD buyer countries. Using the methods and data documented by Börner et al. (2010) (see Annex), opportunity cost estimates were obtained for the LRS data set (Table 6).

While differences in opportunity costs per hectare among our four LRS classes are neither strikingly large nor statistically significant, estimates per ton of CO_2 for avoided deforestation reveal substantial and significant differences between low and high forest cover LRS. This is partly due to higher aboveground biomass of the forests in younger and less

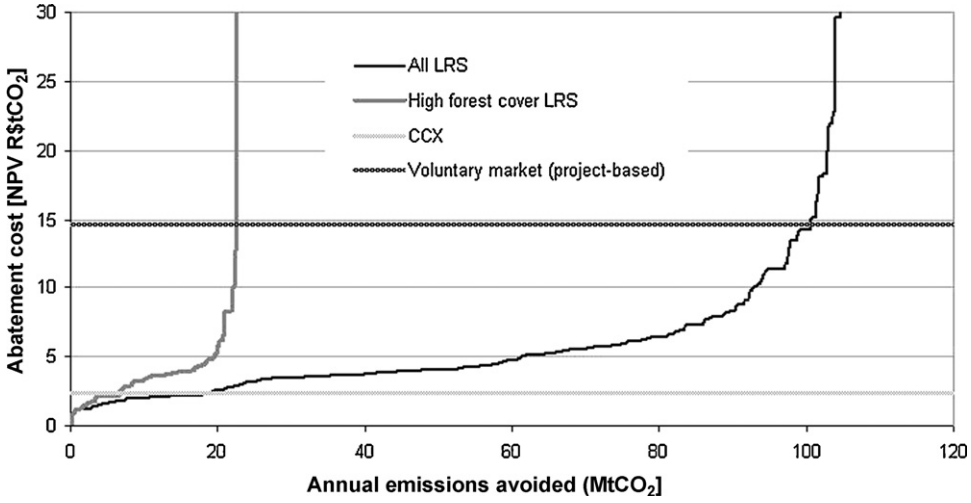

Fig. 5 – Emission abatement cost curve for LRS in the Brazilian Amazon with 2009 reference prices for carbon offsets at the Chicago Climate Exchange market (CCX) and project-based voluntary transactions (World Bank 2010).

degraded LRS and partially due to their remote location, i.e. returns to agricultural and forest activities vary according to transport costs.

Fig. 5 shows the potential annual carbon supply from LRS in terms of an emission abatement cost curve from a business as usual deforestation scenario. If only annual emission reductions are considered, high forest cover LRS could provide a mere 20% of the total reduction potential in LRS. Whether this potential can be realized, however, depends on actual demand for carbon offsets. As a result of the global financial crisis, prices on many carbon markets plummeted in 2009 (World Bank, 2010). Hence, if we use the average 2009 offset price at the Chicago Climate Exchange (CCX) market, the most conservative price estimate, only roughly a fifth of farm-level provision costs would be covered in both the full sample of LRS and the high forest cover subset. Nonetheless, offset prices of project-based voluntary transactions in 2009 compare comfortably with LRS provision costs: even if transaction costs amounted to one third of the transaction value, over 90% of deforestation in LRS could be bought out. Total payment costs would then amount to R$ 1.5 billion per year, if a fixed per ton offset price was paid to all providers or to minimum R$ 0.5 billion if prices were differentiated according to providers' opportunity costs. Provider rents would be inversely proportional.

However, direct participation in carbon offset markets is a rather unlikely scenario for most Amazonian LRS. Not only because few carbon markets would consider *de facto* emission reductions in LRS entirely additional, but also because REDD is expected to be implemented by national governments. The Brazilian REDD strategy outlined at the COP15 in 2009 points to the combined use of incentive and disincentive-based policies to reduce emissions from deforestation in the Amazon region. An answer to the question of how REDD is likely to play out in terms of settler welfare and equity thus depends almost entirely on how the government ultimately integrates incentives, i.e. compensatory mechanisms, in its existing regulatory conservation policy framework.

Let us therefore analyze the *status quo* in terms of wealth and equity in Amazonian LRS. Fig. 6 shows settlers' asset wealth in terms of accumulated deforestation classes.

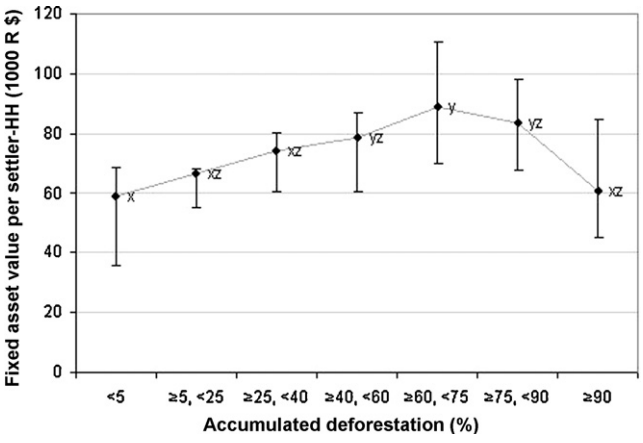

Fig. 6 – Fixed asset wealth for accumulated deforestation classes in Amazonian LRS. *Error bars represent 1st and 3rd quartiles. Dots with no letter in common are significantly different means values (Tukey HSD, $p = 0.05$)

It appears that average asset wealth is highest for LRS in middle stages of accumulated deforestation, whereas both well-conserved and highly deforested LRS feature the lowest asset wealth per household. This pattern must not necessarily be the result of a classical boom & bust cycle, in which cumulated deforestation has been argued to culminate in impoverished settlers (Rodrigues et al., 2009). In fact, some of today's LRS were already partially deforested before their inclusion in the land reform program. Nevertheless, since the wealthiest LRS are also those with the highest rates of forest loss (see Table 6 above), the pattern suggests that the wealthiest settlers are also the ones that could *de facto* have most to offer in terms of avoided deforestation, at least in the short run.

Again, whether high potential additionality turns out to be an advantage for settlers hinges on the REDD policy mix that the Brazilian government adopts. According to our estimates, the total abatement costs of reducing deforestation to zero in Amazonian LRS amount to a minimum net present value (NPV) of R$ 585 million[6] annually. This implies assuming that farmers will stop deforesting and degrading if they receive conditional compensation at their opportunity cost level. But this may not last long if compensations are not supported by contextual enabling conditions. If these costs were to be fully compensated through conditional cash transfers, 70% of transfers would go to the wealthier half of our LRS sample. Conversely, these wealthier LRS would be hit hardest by a command-and-control dominated Brazilian REDD strategy.

Mixing incentives and disincentives, as the Brazilian REDD strategy proposes, will have different implications for LRS depending on their share of remaining forests (see scenario calculation in Fig. 7). In LRS that are non-compliant with the National Forest Code, i.e. with less than 80% of forest cover or less than 50% if the forest reserve was titled before 2001, the decision of whether to deforest or not will depend on the size of the disincentive provided by forest law enforcement plus the size of the incentive provided by the conditional cash – or equivalent in-kind – transfer component of the REDD policy. For the sake of argument, let us assume a scenario in which conditional cash transfers cover only 50% of the opportunity costs in non-compliant LRS, i.e. equivalent to a 50% compliance subsidy. Hence, unless enforcement does not represent an at least equally high disincentive, e.g. by adjusting the size of fines and the frequency and coverage of enforcement missions accordingly, non-compliant settlers would be more favored by a "business as usual" scenario (Robinson et al., 2010).

However, settlers in compliant LRS do not face the threat of being fined for illegal deforestation; at least until the 80% or 50% forest cover threshold is reached. Participation of compliant LRS in the conditional cash transfer component of the national REDD policy would thus require payments that are at least equivalent to opportunity costs. Fig. 2 in Section 4.1 shows that such condition is verified for degradation payments in compliant case study LRS. For deforestation payments, Fig. 7 suggests how such a scenario would play out in terms of benefit distribution among LRS in the Brazilian Amazon. In order to assess the distributional impact of the scenario, the LRS sample

[6] Net present value calculated using a 10% discount rate for a ten-year land use trajectory that follows deforestation.

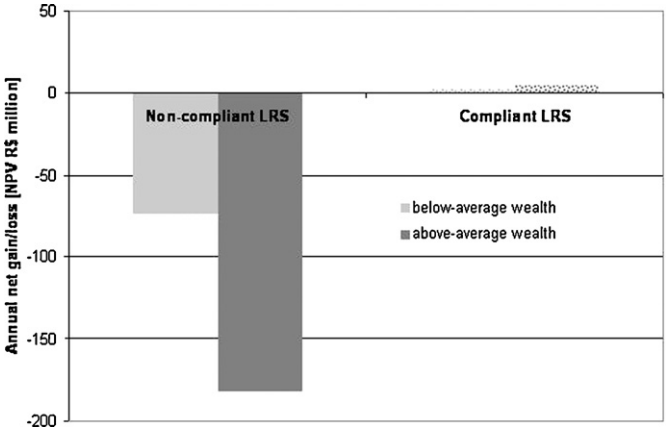

Fig. 7 – Distribution of costs and benefits among above and below-average wealth LRS in a REDD scenario with a 50% compliance subsidy for non-compliant and compensation of opportunity costs for compliant LRS.

was split into above and below average wealth groups according to fixed asset wealth per settler household.

At least for currently non-compliant LRS it turns out that an effective implementation of REDD is likely to come with significant economic losses, in the range of NPV R$ 70–180 million annually. Unless these losses are fully compensated for – a rather unlikely scenario given the current policy setting – only a minority of settlers stand to gain from REDD. It may thus be of little comfort that the observed deforestation dynamics render losses to below average wealthy settlers up to 60% lower than for their above average wealthy counterparts. Voluntary participation of currently compliant LRS in the conditional cash transfer conditioned to avoided deforestation is likely to result in moderate net benefits to settlers, benefits to below average wealthy settlers being 35% lower than for the wealthier group of LRS.

Of course, this scenario analysis is not without caveats. First, settlers may indeed be able to partially offset abatement costs by intensifying production activities on already deforested land. Scope for agricultural intensification will depend to a great extent on the pre-existing activity mix and on settlers' access to knowledge and improved technologies. Data from the 2006 Brazilian agricultural census suggests that over 75% of the production value in LRS originates from annual staple crop production, predominantly in slash-and-burn systems. Extensive cattle production comes second at roughly 14%, while profitable forestry and perennial crop production accounts for the remainder. Both annual staple crops and cattle production have been shown to provide comparatively low returns per hectare (Nepstad et al., 2007). Most of emission reductions will thus come from reducing the expansion of these two activities.

Second, reducing the expansion of agricultural activities may result in local economic multiplier effects, i.e. indirect abatement costs (or benefits) that result from partially suspending (or intensifying) productive activities. According to census data, for example, settlers employ on average 0.06 workers per hectare under productive uses. Completely suspending agricultural expansion in LRS could thus result in loss of employment for over 28,000 rural workers, unless new employment opportunities are generated by agricultural intensification on open lands. The same scenario would apply in the logging sector.

Nonetheless, analysis shows that significant emission reductions can be obtained by targeting initial REDD efforts to Amazonian LRS. A more realistic scenario of combining improved enforcement of existing regulatory policies with compensatory conditional cash transfers adapted to the amount of forest left will result in overall net losses for wealthy settlers and be competitive for the poor. In both cases, REDD payments will need to take the form of compliance subsidies and create enabling conditions for economic innovation.

5. Discussion and conclusions

This paper scrutinizes the hypothesis that Brazilian land reform settlements (LRS), although covering a relatively small area of threatened forest lands, represent a feasible starting point for an incipient national REDD initiative. This hypothesis is grounded in research that identified poor delimitation and regulation of land tenure in the Amazon as the primary limitation to implementing compensation-based REDD mechanisms in the region (Börner et al. 2010). LRS were identified as being among the few rather well delimited tenure categories in which internal deforestation pressure justifies prioritization of initial REDD investments.

A key observation from our LRS case study is that, apart from socio-economic conditions, accumulated deforestation in LRS is determined by settlement size, number of settlers, and settlement history. Especially in conventional LRS that do not dispose of large collective forest reserves, livelihood needs eventually force settlers to exceed their use rights, as in the case of the LRS Altamira. Our regional data set confirmed that this holds true for at least 38% of Amazonian LRS, in which there is practically no scope to induce forest conservation on top of what the Brazilian Forest Code already declares protected. In two of our case study LRS, forest reserves comfortably exceed legal requirements; a situation we confirmed for 41% of LRS, which together hold more than half the total *de facto* mitigation potential in Amazonian LRS.

Findings in both case study and regional assessments suggest that payments in the range of prices on voluntary emission offset markets could compensate for the opportunity costs of at least a quarter (low end estimate) to almost 90% (high end estimate) of avoided deforestation and forest degradation in settlements. Even if only emission reductions from avoided logging degradation were considered, carbon rents compared rather favorably to timber rents and average LRS opportunity costs of agricultural activities in our sample. High transaction costs may, nonetheless, change the picture if REDD prices were at the lower end of the observed range (Fig. 2).

At the regional level, our analysis suggests that only LRS with excess forest reserves would gain under a realistic national Brazilian REDD scenario. As a result of deforestation dynamics and forest distribution among LRS, poorer settlers would be hurt less than their better off counterparts. This outcome is due to the fact that wealthier LRS are also those with higher accumulated and annual deforestation rates. At the case study level this was reflected in the advanced production technologies used by LRS with high capitalization levels.

Our findings provide insight into the wider socio-economic implications of compensation-based REDD settlements. Especially in the public debate in Brazil, opponents of direct conservation payments often argue that such payments could encourage passive dependency (*assistencialismo*) of recipients on transfer payments. Our case study suggests otherwise. Settlers in three out of the four settlements under study have already engaged or are planning to engage in logging agreements that reflect PES type contracts covering the legally required forest reserve. The vast majority of logging rents was invested in productive activities and thus intended to actively contribute to improving settler welfare in the long-run rather than satisfying short-term subsistence needs.

But, as the regional-level assessment shows, many settlers will not be in the comfortable position of voluntarily negotiating the right to convert forest land, because deforestation in their LRS has already gone beyond the legal forest reserve. Even if *de facto* deforestation opportunity costs were subsidized through a national PES program at a rate of 50%, currently non-compliant LRS would generally lose. Losses to non-compliant LRS could be significant, in the range of NPV R$ 70–180 million annually–depending on asset wealth – or an average of R$ 500 per year for each settler family[7]. While such a loss may not fundamentally threaten settlers' living conditions in the short-term, it certainly does not contribute to creating an enabling environment for the adoption of improved agricultural technologies – a widely recognized necessary – albeit not sufficient – precondition for long-term sustainable agricultural development in the Amazon (Serrão et al., 1996; Vosti et al., 2001; Futemma and Brondízio, 2003; Börner et al., 2007). Yet, without a major improvement in public and/or private service provision to settlers (e.g. transport, credit, extension, technology innovation), it is possible that the initial success of a LRS focused REDD initiative – due to voluntary participation of high forest cover LRS – will be partially offset in the long run by illegal deforestation or welfare losses in non-compliant LRS.

The analyses presented in this paper have four potentially relevant implications for REDD governance in the Brazilian Amazon. First, settlements do indeed have to offer a significant and economically accessible potential for emission reduction. While the mitigation potential in LRS is certainly limited compared to estimates at the regional scale, over a ten year horizon it comfortably exceeds existing international commitments for REDD funding in Brazil (Nepstad et al., 2009).

Second, existing logging agreements between settlers and commercial loggers represent feasible business models for cash transfers that are conditional on forest conservation. At least in our small sample of settlers, respondents generally approved of ongoing logging contracts. Both settlers and logging firms have been willing to undergo substantial transaction costs to formalize logging agreements, but external support from research institutions and NGOs plus the participation of settlers in the design of agreements have been necessary preconditions. Provided the technicalities of carbon monitoring and verification can be solved, payments for avoided forest degradation could thus represent a means to harness *de jure* degradation emission reductions in medium and high-forested LRS.

Third, however decision makers design the Brazilian REDD policy, a cost-effective incentive mix will alter income distribution even if targeted only to LRS. A predominantly compensation-based REDD policy – unlikely because it would undermine the credibility of past conservation policies – would result in disproportionately high transfers to LRS with the highest deforestation pressure and welfare levels. Likewise, these LRS would suffer most from a primarily command-and-control oriented REDD approach. A middle course, i.e. the combination of improved enforcement and compliance subsidies for currently non-compliant LRS, coupled with payments or subsidies for avoided degradation in compliant LRS, appears to be a promising option for pilot experiences in Brazil. Our results suggest that such a scenario would affect income distribution among LRS in a much more equitable way than either one of the ''single-instrument'' options.

Fourth, combining incentives and disincentives to reduce emissions from land use change in LRS will nonetheless result in overall economic losses for settlers if applied at a regional scale. At the stage of agricultural development and capitalization level that prevails in the majority of LRS in the Amazon, it cannot be expected that financial incentive-induced local innovation will allow all settlers to leapfrog on a long-term sustainable development path. While technologies to intensify the associated production systems certainly exist, many intensification options require advanced management skills, up-front investments, and improved market access, i.e. keys to overcome major adoption barriers. Several REDD commentators have thus suggested that efforts geared toward considering full range of economic social and political costs must accompany REDD incentives in order to ensure emission reductions are permanent (Ghazoul et al., 2010; Campbell, 2009; Karsenty, 2008; Peskett et al., 2008). What rises in turn the question of the real availability of enough funding (UN, 2010).

[7] Given the lack of accurate population information for the settlement polygon data set, average per settlement population was used for this rough estimate.

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