Ecological Economics 136 (2017) 53–61

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Brazil's National Environmental Registry of Rural Properties: Implications for Livelihoods

Suhyun Jung [a,*,1], Laura Vang Rasmussen [a,1], Cristy Watkins [a], Peter Newton [b], Arun Agrawal [a]

[a] International Forestry Resources and Institutions (IFRI) Research Network, School of Natural Resources & Environment, University of Michigan, USA
[b] Environmental Studies Program, Sustainability, Energy and Environment Complex, University of Colorado Boulder, UCB 397, 4001 Discovery Drive, Boulder, CO 80303, USA

ARTICLE INFO

Article history:
Received 22 July 2016
Received in revised form 1 December 2016
Accepted 1 February 2017
Available online 20 February 2017

Keywords:
Cadastro Ambiental Rural (CAR)
Impact
Livelihood
Forest Code
Assets

ABSTRACT

In Brazil, the Cadastro Ambiental Rural (CAR) is currently being implemented. This policy aims to geo-reference all properties and promote monitoring of, and compliance with, natural vegetation conservation requirements. Scholarly efforts and policy attention have so far concentrated on possible environmental impacts hereof, while the attention devoted to how the CAR might affect farmers' livelihoods has been limited. In this paper, we evaluate potential livelihood impacts of the CAR and programs that facilitate CAR registration. We do so by developing a conceptual framework and using evidence from semi-structured interviews with key stakeholders including farmers, governments, and funding agencies. We find that while the CAR and programs facilitating CAR do not have explicit livelihood impact goals, they nonetheless affect livelihoods, both positively and negatively, depending on the initial amount of natural vegetation on farmers' properties, farmers' access to credit and infrastructure, and changing market conditions. We argue that environmental interventions and policies need to consider potential livelihood impacts, especially if the policy intervention area has high poverty rates.

© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

1. Introduction

Brazil faces major challenges in the implementation of the 2012 Forest Code which relaxes the previous code from 1965 (Kröger, 2016). Deforestation in many areas, such as the Legal Brazilian Amazon, has been on the rise since 2013 and prospects for the future are not good as political appointments are sending anti-environmental signals (Fearnside, 2015, Fearnside, 2016a, Ferreira et al., 2014). However, one potentially promising mechanism of the new Forest Code is the Cadastro Ambiental Rural (the Rural Environmental Registry – CAR) (Soares-Filho et al., 2014). With the CAR, it is mandatory for all rural properties to be registered and caps have been set on the proportion of natural vegetation that can be legally cleared on any rural property (as low as 20% in the Amazon). The CAR also lays out guidelines for which areas should be permanently preserved. The implementation of the CAR requires geo-referencing and identification of property boundaries, Legal Reserves (LR), and Areas of Permanent Preservation (APP).

The CAR is primarily expected to enhance the ease of monitoring and enforcement of the Forest Code and other environmental legislations. This may in turn directly or indirectly affect what activities landowners can conduct on their land and subsequently impact landowners' livelihoods. For example, to achieve compliance with the Forest Code, reforestation may be required or landowners may need to pay taxes that they did not have to pay previously because their property was not registered in the state registry system (Kröger, 2016). Therefore, enforcement of the CAR is likely to affect not only the natural vegetation but also the livelihoods of private property owners through changes in land use, monitoring, and resulting changes in the provision of ecosystem services, such as water purification.

While many studies have evaluated the impacts of environmental conservation programs such as protected areas on local livelihoods (e.g., Andam et al., 2010; Clements et al., 2014; Ferraro and Hanauer, 2014; Miranda et al., 2016), and of large scale infrastructure as well (Fearnside, 2016b), few studies have systematically evaluated the impacts of the CAR on local livelihoods. Both scholarly and policy efforts have concentrated on environmental aspects (Azevedo and Saito, 2013; Gibbs et al., 2015; L'Roe et al., 2016) with little assessment of how livelihoods (the capabilities, assets, and activities required for a means of living (Scoones, 1998)) may be affected. Although livelihood impacts may not be an intentional objective of the CAR, some agencies, such as the Brazilian Development Bank that manages funds to facilitate CAR registration, do expect livelihood impacts to occur, albeit the specific nature of such impacts remain unknown (BNDES, 2015). Notably, the Brazilian Development Bank has been open to engage in additional or new activities that can specifically help farmers compensate for

* Corresponding author at: 2004 Dana building, 440 Church St., Ann Arbor, MI 48104, USA.
E-mail address: sjungx@umich.edu (S. Jung).
[1] Both the authors contributed equally to this work.

http://dx.doi.org/10.1016/j.ecolecon.2017.02.004
0921-8009/© 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

potential income losses (BNDES, 2015). This underscores an urgent need to devote attention to the multitude of ways in which farmers' livelihoods may be affected by the CAR.

In this paper, we investigate theories of change in livelihoods as a result of the CAR and CAR related programs. CAR related programs are defined as programs that either a) facilitate registration in the CAR by helping farmers to geo-reference their properties; and/or b) build capacity among farmers on how to be in compliance with the Forest Code, which includes knowledge on the CAR and how to restore degraded areas. Examples of such programs are the International Climate Fund (ICF), the Amazon Fund and the German Development Bank's state CAR programs (Amazon Fund, 2015; KfW, 2015) and the Responsible Soy Project by The Nature Conservancy and Cargill (TNC, 2015). We note that there is a difference between the outcomes of the CAR as such and the outcomes of CAR related programs. Wherever possible, we aim to tease out those differences but with the caveat that the CAR and CAR related programs are deeply entangled as the latter are a necessity for smallholder farmers to register - that is, farmers most often lack the knowledge and the means to register by themselves and the programs provide services which offset registration costs and teach farmers how to ensure that their property is in compliance with the Forest Code. Measuring actual, causal impacts of the CAR and CAR related programs is not yet possible because national implementation of CAR began only after the revision of the Forest Code in 2012 and is still underway, and because livelihood impacts may take a while to unfold and be detectable. Rather, we develop theories of change that may underpin potential livelihood impacts of the CAR and CAR related programs. Establishing theories of change is an essential, yet undervalued, first step to any program evaluation and as such we see this work as valuable for future assessments of the CAR and CAR related programs.

We first outline the multiple pathways through which the CAR and CAR related programs may affect livelihoods of rural households by modifying Ellis' framework for micro policy analysis of rural livelihoods[2] (Ellis, 2000) and adopting a Sustainable Livelihood Approach (SLA) (DFID, 1999). Second, we apply the framework to two biomes in Brazil to assess plausible livelihood impacts using information collected through semi-structured interviews with farmers and other stakeholders involved in the CAR and CAR related programs. Finally, we argue that future environmental interventions and policies need to more substantially consider potential livelihood impacts.

We use the Amazon and Cerrado biomes as case areas because these biomes provide a high value of ecosystem services and have higher poverty rates than the rest of Brazil - thus, the change processes are important from both an environmental and a livelihood perspective. The Amazon biome includes some of the states with the highest CAR participation. For example, in Pará, the first state to initiate CAR registration in 2007 before it became mandatory, 99% of the area that is subject to CAR registration was registered as of October 2016 (Brazilian Forest Service, 2016). The Cerrado biome has much less legal protection than the Amazon; it is one of Brazil's agricultural hotspots, with only 7% of the area preserved as protected areas and the potential for 40 ± 3 Mha to be legally converted for agricultural production (Soares-Filho et al., 2014). This makes the consideration of livelihood impacts of the CAR particularly critical because it is likely to directly impact how farmers manage their natural vegetation.

Through these cases, we provide an analysis of how the CAR and CAR related programs have affected and may affect livelihoods. In the following sections, we summarize the revision of the Forest Code in 2012, introduce our conceptual framework, describe our methods and data collection strategy, and then use the framework and data to illustrate theories of change in terms of livelihood impacts of the CAR and CAR related programs. Finally, we use the presented findings to refine existing theorizations of the linkages between the CAR and livelihood outcomes.

2. Material and Methods

2.1. Background

Farmers, many agricultural corporations, and their representative political parties have criticized the Forest Code (originally enacted in 1934 and first revised in 1965) for limiting economic growth through expansion of agricultural production because of the law's high level of restrictions. Efforts by agribusinesses to weaken the regulations of the Forest Code, along with a fall in deforestation rates since 2004, led to a revision of the Forest Code (law 12615/2012) in 2012 (Soares-Filho et al., 2014). The revised Forest Code has weakened some regulations while strengthened and added others and it remains to be seen just how transparent the CAR is for evaluating compliance with the Forest Code through linking landowners to land use on a particular property (Gibbs et al., 2015). However, enforcement of the Forest Code has been hindered by insecure land tenure, large remote areas, and lack of monitoring and enforcement capacity. Overall, the CAR is foremost a governance instrument that aims to achieve improved environmental outcomes.

There are two main regulations in the Forest Code that apply to farmers and that are specifically related to the CAR and CAR related programs. First, farmers and ranchers must preserve Areas of Permanent Preservation (APP) that include environmentally sensitive lands. APPs are set aside because of their value for protection of freshwater and conservation of areas for freshwater recharge (Sparovek et al., 2010). APPs include areas adjacent to rivers, natural or artificial reservoirs, river sources or headwater, lakes, land above 1800 m^2, mangroves, dune vegetation and forests, the border of plateaus and mesas, wetlands, hilltops, and hillsides with a slope steeper than 45°. Second, farmers and ranchers must maintain a certain percentage of their land as protected forest preserves, called Legal Reserves (LR). The percentage of LR varies depending on the type of vegetation and geographic location of the property. The LR percentage is lowest (20%) for lands in the Atlantic Forest, the Cerrado outside of the Amazon region, and the Caatinga (tropical dry forest in the northeastern region of Brazil), while it is higher in the Amazonian Grasslands (35%) and the highest (80%) in the Amazon. Finally, the 2012 Forest Code includes a number of specific changes in regulations related to the CAR as follows:

- Land owners are required to participate in the rural environmental registration (CAR) system, which was voluntary before 2012.
- Illegal deforestation carried out before July 22, 2008 might be pardoned if the land owner registers in the environmental registry system (CAR) and in the state's Program for Environmental Regularization (Programa de Regularização Ambiental - PRA).[3] Land owners that have cleared areas for construction, plantations, pastures, and fallow land to increase soil fertility in violation of the Forest Code before July 22, 2008 do not have to reforest as long as they meet the new standards for protection.
- Land owners are allowed to count all APPs, such as forests along rivers and hillsides, as part of their LR under certain conditions. Before the amendment APP restrictions were in addition to the LR requirement.
- LR in forest regions of the Amazon can be reduced to 50% in states

[2] A rich literature posits a dynamic relation between different types of assets and livelihood opportunities (Bebbington, 1999; Ellis, 2000; Scoones, 1998). While these approaches share many similarities in relation to the capitals required for a means of living, Ellis (2000) places particular emphasis on the mediating character of institutions and social relations both in regard to livelihood strategies adoption and access to capital assets.

[3] Each state is supposed to have PRA that includes technical details on recovery of APPs and LRs as well as criteria for compensating LRs from properties that have more LRs than those required by the Forest Code (Environmental Reserve Quota - Cotas de Reserva Ambiental (CRA)) (Duchrow and Alencar, 2015).

with more than 65% of its area occupied by protected areas or indigenous territories, and that have ZEE (Economic Ecological Zoning). In this case, the state can decide the size of the LR.
- The amount of required forest along rivers must range between 5 and 100 m - a decrease from the previous range between 30 and 500 m.

All rural properties across Brazil were required to register in the CAR by May 2016, but the Brazilian Ministry of Environment recently extended the deadline by one more year. As of October 2016, 99% of the possible registration area was registered, equaling an area of 393 million ha (Brazilian Forest Service, 2016). The extensive process of geo-referencing the boundaries of all properties involves visits to rural areas by teams of trained consultants, who work with property owners to register their properties in the CAR. Since registration in the CAR is not equivalent to a land title, and indeed does not indicate anything about legal ownership, overlapping claims are allowed in the CAR. Many states have their own CAR system that needs to be merged with the federal CAR system (SICAR, 2016). Some states have relatively low CAR participation to date. For example, in the state of Bahia, in the Cerrado, only 40% of the possible registration area was registered as of October 2016 (Brazilian Forest Service, 2016). Thus, the approaching deadline for CAR registration imposes pressure on state governments to facilitate rapid implementation. Furthermore, state governments are compelled by law to assist smallholders (definition varies by state) to become registered.

In several biomes, third-party donor agencies are assisting state governments with the costs of registering smallholders. Such agencies include the International Climate Fund (ICF) (helping in the states of Maranhão, Tocantins, Bahia, Piauí) and the German Development Bank (KfW) (helping in Acre, Amazonas, Rondônia, Pará, Mato Grosso, Bahia, Paraná, Rio de Janeiro, São Paulo states). Interventions such as the Brazil Cerrado Climate Change Mitigation Program (UK Government, 2012), funded by the UK through the ICF, the Amazon Fund, and KfW aim to speed up the rate at which smallholders become registered in the CAR. For example, the ICF has funded activities that send technicians to municipalities to directly help farmers geo-reference their property boundaries and prepare documents for the registration.

Overall, Brazilian forest conservation and agricultural land use are affected by a wide array of governance interventions, implemented by governments (federal, state, and local), non-profit organizations, private sector groups, and communities (Amanor and Chichava, 2016, Caviglia-Harris, 2016). Such interventions include the designation of protected areas and indigenous lands, payments for environmental services programs, agricultural certification programs, and supply-chain sustainability initiatives. The CAR is therefore one of many approaches being implemented in a complex institutional landscape. Some of these interventions are complementary; others are antagonistic; yet others are substitutable. The relative importance of these different governance approaches in achieving different sustainability outcomes is unclear. Within this context, the CAR remains a fascinating and potentially important component, since it leverages the availability of remotely-sensed satellite imagery to facilitate monitoring and enforcement of Brazil's central piece of environmental legislation, the Forest Code.

2.2. A Conceptual Framework of the Linkage Between CAR and Livelihoods

The first step for examining possible livelihood impacts of the CAR and programs facilitating CAR is to define what we mean by livelihood. We start with the premise that assessments of rural livelihoods need to go beyond quantitative measures of cash income because rural livelihoods are constituted by both tangible and intangible assets and institutions (Scoones, 2009). In line with Ellis (2000, p. 10), we define livelihood as that which comprises: "… the assets (natural, human, financial, social, and physical capital), the activities, and the access to these (mediated by institutional and social relations) that together determine the living gained by the individual or household." This definition allows us to focus on both the means and outcomes which is necessary to develop a more sophisticated conceptualization of impacts of the CAR and CAR related programs.

We modify Ellis' framework for micro policy analysis of rural livelihoods (Ellis, 2000) to adopt a dynamic and holistic view from the Sustainable Livelihood Approach (SLA) (DFID, 1999). Both frameworks have been widely used in rural livelihood analyses (Fernandes and Woodhouse, 2008) and originate from the same literature concerned with sustainability, livelihood strategies, and poverty (e.g., Chambers and Conway, 1992; Carney, 1998; Scoones, 1998). Ellis' framework provides a livelihood "platform of assets" as the starting point to discuss how access to assets are modified by social relations, institutions, and organizations in the context of various trends and shocks. This is appropriate for our purpose of studying plausible livelihood impacts because the CAR and CAR related programs involve federal, state, and municipal governments, NGOs, private companies, and funding agencies. However, the framework does not explicitly address the linkages and feedback loops among institutions and social relations, assets, and livelihood impacts. For example, it does not illuminate the process through which global economic trends have specific impacts on organizations and assets. Hence, in line with the SLA, we emphasize the dynamic nature of livelihoods and we focus on the modifiers and components influencing livelihoods. By doing so, we address not only the livelihood impacts of changed access to assets but also how local and global trends and shocks directly and indirectly impact livelihoods, and how environmental changes can influence assets.

Through this framework, we attempt to address the linkages and dynamics among the CAR and CAR related programs and farmers' assets and livelihoods. By doing so, we combine the strengths of Ellis' framework and the SLA and contribute to the literature in need of place and context specific studies that address linkages across components and scales (Scoones, 2009).

2.3. Methods

To identify theories of change in farmers' livelihoods as a result of the CAR and CAR related programs, we draw on data collected from three rounds of interviews, conducted in 2011, 2015, and 2016. These three rounds of interviews were carried out with stakeholders directly involved in the CAR and CAR related programs. In 2011, we interviewed farmers and project employees from the Responsible Soy Project as well as municipality and state government officials. The interviews were part of a study aiming to evaluate impacts of the Responsible Soy Project[4] by The Nature Conservancy (TNC) and Cargill. TNC and Cargill have geo-referenced farmers' property boundaries in the Santarém area[5] since 2005, which they later registered for the Pará state CAR system established in 2008. Also, they have helped farmers restore APPs since 2006 (Cleary, 2007). The project initially registered 315 properties with an average area of 390 ha. Interviewees included eight farmers, three municipal and state governmental officials, a senior officer at the International Finance Corporation (IFC), four employees from TNC, and four employees from Cargill. While these interviewees were not

[4] The Nature Conservancy and Cargill started to collaborate on the project since 2005 after Cargill opened a soybean export facility in Santarém. Greenpeace launched a high-profile protest against Cargill and the facility in 2006, claiming that Cargill is "Eating up the Amazon." Cargill used the Responsible Soy Project to show that they are making farmers in compliance with the Forest Code. To the authors' knowledge, this is the first of its kind project to facilitate geo-referencing of farmers' properties, which later was transferred to the state's CAR system.

[5] The project area was only implemented in this area near the port facility. Cargill and TNC required farmers within this area to be registered for the CAR and be free of deforestation in order to sell their soybeans to Cargill.

representative of all agencies working with CAR, they were selected to represent a set of central stakeholders involved in the CAR and CAR related programs. TNC and Cargill employees were facilitators of CAR registration whereas municipal governmental official and state environmental government's officials were responsible for monitoring deforestation. Interviews with farmers were conducted in the state of Pará, where CAR registration had already been facilitated; as such, these data provided us with insights about how the national implementation of CAR and CAR related programs have affected farmers' livelihoods. Rather than providing quantitative estimates of impacts, these interviews served to inform our development of hypotheses of livelihoods impacts.

A second set of interviews was done in late 2015 with key personnel from KfW, the Amazon Fund, and ICF - the three major funding agencies supporting CAR related programs in the Cerrado biome. The activities supported by the Responsible Soy Project and by the major funding agencies were very similar: capacity building and training to facilitate registration in the CAR and restoration of APPs and LRs. The funding agencies were selected to represent key agencies supporting programs to facilitate the CAR for small-scale farmers in the Cerrado and Amazon biomes. A third set of interviews was done in May and June 2016 with 42 small-scale farmers who had registered for CAR in the states of Bahia and Piauí within the Cerrado biome. These farmers registered their properties with the help of the *ProCerrado* program, funded by the ICF.

The details of the three sets of interviews are described in Appendix 1.

3. Plausible Livelihood Impacts of the CAR and CAR Related Programs

Fig. 1 shows the multiple pathways in which the CAR and CAR related programs may impact livelihoods of rural households. In the following, we primarily focus on institutions and organizations as plausible modifiers of livelihood impacts. We do so by firstly describing (A) the global and national context in which the CAR and CAR related programs are situated and how they might directly and indirectly affect livelihoods. We then describe (B) the role of institutions and organizations as "access modifiers" in CAR implementation. We focus on (C) the subsequent modified access to assets ("livelihood platform") that rural households may have, as well as (D) the possible impacts on livelihood security as a result of changes in assets and livelihood strategies after CAR. Further, we exemplify feedback loops between different components.

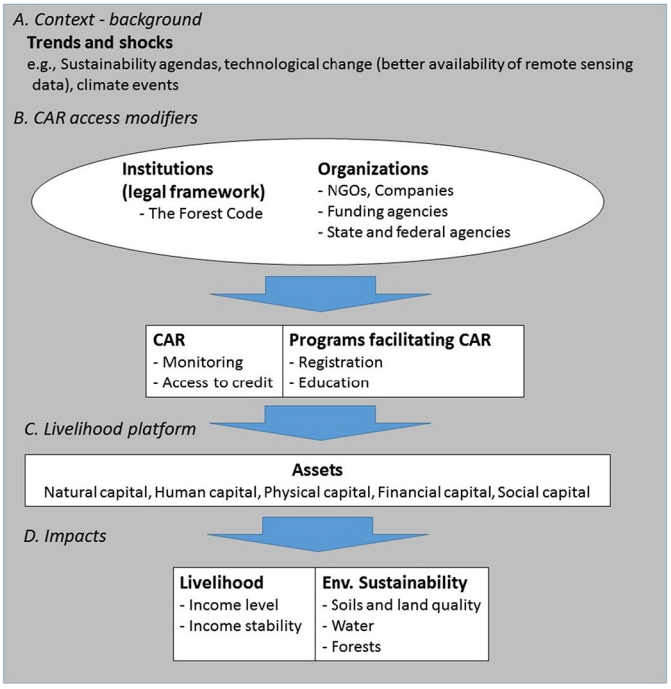

Fig. 1. A framework to describe livelihood impacts of CAR and CAR related programs. Adjusted from Ellis (2000) and DFID (1999).

3.1. Context (A) – Trends and Shocks

The recent increase in deforestation rates in the Amazonian biome has caused concern in relation to a range of sustainability issues, such as global climate change and biodiversity loss, and the CAR was born in the context of policies aiming to promote sustainability through private forest conservation (Gregorio et al., 2016, Nunes et al., 2015). Moreover, the implementation of the CAR became feasible because of improvements in remote sensing technologies. Technological advancements that enabled satellite imagery-based monitoring systems equipped governments with better tools to enforce environmental regulations and thus more effectively address large scale sustainability concerns. During the past 10 years, Brazil has increased the enforcement of the Forest Code in the Amazon biome by using remote sensing data and conducting field visits. National deforestation and land use and land cover databases such as PRODES and Detection of Deforestation in Real Time (DETER) in the Amazon and the TerraClass Cerrado in the Cerrado biome have provided the means for detailed monitoring exercises and they are used by state and municipality governments to monitor deforestation, forest fire, land use, and restoration.

3.2. Impacts on Livelihoods

Our interviews revealed that the contextual changes described above have direct and indirect impacts on farmers' livelihoods through changes in market conditions and enforcement of environmental regulations. For example, a senior program officer at IFC stated that the business environment in Brazil had changed significantly in the past five years as the government had become more willing to involve the private sector and NGOs in enforcement of environmental laws and decision making processes assumed to promote a broad range of sustainability issues such as climate change and biodiversity protection. These issues have also been driving market conditions that may promote lower deforestation rates, for example, through certification schemes, moratoria, and sustainability standards (Gibbs et al., 2016; Macedo et al., 2012). Increased interest in sustainably-sourced agricultural products was also manifested in the Round Table on Responsible Soy (RTRS) to certify sustainable soybean production, which should, in theory, entail legal compliance with the Forest Code and responsible business practices regarding labor conditions and community relations. The emergence of sustainability standards supported by enhanced monitoring capabilities has thereby fueled an interest among many companies in only sourcing agricultural products from lands that are in compliance with the Forest Code, and environmental concerns have become more important with increasing consumer demand for sustainable products (e.g. Reinecke et al., 2012; Schouten and Bitzer, 2015). These trends are likely to change farmers' production decisions for compliance with the Forest Code and for certification of their products, which will directly change their livelihood strategies, livelihood security (e.g., income), and environmental outcomes.

Also, greater availability and use of satellite imagery has enabled more successful monitoring efforts. These efforts have been directly influenced by political leaders such as former President Luis Inácio Lula da Silva, former Minister of the Environment Marina Silva, and several independent public prosecutors. Such attention and efforts have directly affected farmers' production decisions. Fines have been given to properties with unlawful deforestation and the properties have accordingly been placed on a public record of embargoed properties. The number

of fines imposed annually by the Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) has increased in the Amazon since 2002 (Assunção et al., 2013). Since federal law prohibits producing, buying, and selling products from embargoed areas (Decree 6514/2008), it is no doubt problematic for farmers to have properties placed on this record (IBAMA, 2015; Rajão and Vurdubakis, 2013). This monitoring and enforcement strategy appeared to have constrained farmers not only on their production decisions but also on their access to forest resources (Sunderlin et al., 2005).

3.3. Access Modifiers (B) – Institutions and Organizations

That key institutions and organizations have a central bearing on farmers' livelihood became also evident during interviews. In the Responsible Soy Project, TNC helped farmers register in the CAR system and be compliant with the Forest Code. TNC facilitated the process of property registration by hiring technicians to geo-reference farmers' property boundaries and preparing the necessary documents (e.g. environmental diagnosis and recovery planning for degraded areas). Also, TNC held seminars and meetings to provide technical assistance to farmers on how to restore APP in their properties and comply with the Forest Code. Further, they chose 12 pilot farms to act as demonstrative and monitoring areas. One of the officials at the state environmental agency (SEMA) expressed that the help from TNC during the process of CAR registration made the report from farmers more trustable. Without them, many farmers would not have the capacity to prepare the documents necessary for registration. CAR related programs, like the one provided by TNC, thereby provide farmers with means to comply with the Forest Code.

The three major funding agencies interviewed established contracts with NGOs and/or state and municipal governments to implement their activities on the ground. They provided a legal basis for the registration process and help with landscape management. Thus far they have focused their efforts on capacity building for development of a CAR state system compatible with the federal system. Because of an apparent disconnect between state and federal CAR systems, such initiatives are timely.

3.4. Changes in Livelihood Platform (C) and Impacts on Livelihoods (D)

In this section, we provide theories of how farmers' asset base may change as a result of the CAR and CAR related programs.

3.4.1. Natural Capital

The impact of CAR registration on natural capital is likely to depend on a) the amount of native vegetation already cleared, b) when the clearing took place, and c) the extent to which clearing activities can be detected and deterred. On the one hand, the CAR may reduce the amount of land available for agricultural production if farmers are more closely constrained by the legal reserve rules in the Forest Code. On the other hand, the Forest Code provides amnesty for historically-illegal deforestation because it differentiates between conservation and restoration requirements and forgives legal reserve debts (Soares-Filho et al., 2014). For example, the average deforestation rate[6] of 315 farmers who were participating in the Responsible Soy Project was 2% and 1% between 2005 and 2008 and between 2009 and 2012, respectively, with the average area of properties being between 320 and 390 ha. The new Forest Code only limits the use of the area corresponding to the 1% of area deforested between 2009 and 2012.

Farmers that have more LR area than what is required by the new Forest Code may deforest their land if their marginal revenue from deforestation is higher than the marginal cost of deforestation. However, if farmers have less LR area than what is required by the new Forest Code, they will be mandated to restore forests on their land. If they comply, they may either a) reduce total production, by reducing the productive area; b) maintain total production, by intensifying production on a smaller productive area, or c) maintain total production, by expanding their agricultural activities into new areas. According to a staff from TNC, some farmers had deforested their property to expand the total land area for farming while others had cleared small forest patches in the middle of their agricultural plots to increase the efficiency of farming practices, an action minimizing the amount of scattered patches and creating a better connected farm area. Therefore, a decrease in the amount of arable or pasture land could reduce production and decrease income. Many farmers both in the Amazon and Cerrado biomes indicated that they had necessarily reduced their use of land as a result of registering their properties in the CAR and delineating boundaries for LR and APP. One of farmers in the Amazon biome specifically mentioned the high cost of maintaining LR since he had to reforest (with native vegetation, not tree plantations) his property after being fined due to illegal deforestation.

In sum, an increase or decrease in the amount of land available for agricultural production will directly change the land use and land cover. This may lead to changes in the provision of ecosystem services (Tallis and Polasky, 2009; Nelson et al., 2010; Goldstein et al., 2012) which can happen in at least two opposing ways. On the one hand, if farmers apply greater inputs (e.g. fertilizers) by production intensification or expansion of agricultural activities, then water sources may be polluted, which may reduce the quality of drinking water – an outcome directly connected to livelihoods. Farmers can also introduce cattle ranching with crop rotation, which may increase the meat production and the overall profit from farming – assuming a constant meat price. Such mixed crop and livestock production methods may improve or degrade the ecosystem, and in turn positively or negatively affect livelihoods. On the other hand, production reduction by increased preservation of LR and APP by enforcement of the Forest Code enabled through the CAR system may enhance the provision of ecosystem services, like water quality, in the long term by preserving forest corridors along rivers. Some farmers specifically mentioned the benefit of leaving natural vegetation along the river to preserve the water quality, which can benefit their livelihoods in the long run.

3.4.2. Human Capital

The CAR related programs contributed to farmers' human capital in the form of providing education on the Forest Code and how to comply with it. This was especially valuable for small-scale farmers living in remote areas because they tended to be less knowledgeable on the Forest Code. Many small-scale farmers interviewed in the Cerrado area did not know the requirements of the Forest Code and the reasons for the CAR registration until this was directly explained by staff from the CAR related programs. Although these educational benefits tend to be overlooked by funding and implementing agencies, they should be accounted for as they may accumulate and contribute to improved livelihoods in the long run. For example, research from other areas has indicated that simply the ability to comply, vis-à-vis awareness of the law, is a stronger motivation for compliance than are normative or social motivations (Winter and May, 2001).

While the Responsible Soy Project and the ICF *ProCerrado* program both communicated the purpose of the CAR, the Responsible Soy Project also educated farmers about changing consumer demand for sustainably sourced products, the value of standing forests, provision of different ecosystem services, carbon sequestration etc. Accordingly, the interviewed farmers in the Responsible Soy Project expected decreasing demand for illegally-sourced agricultural products from unregistered farms. Also, the interviewed farmers suggested that they would eventually only buy land when that land was registered in the CAR and legally maintained. Indeed, an issue raised by many farmers was that the CAR might lead to changes in market demand in the long term and the interviewed farmers were clearly aware of the possible market changes

[6] Measured as deforested area over remaining forest cover.

caused by the CAR. Many were interested in changing their production strategies to account for the changing demands - they just needed the capacity to do so.

3.4.3. Financial Capital

One of the main negative financial impacts farmers may experience through CAR is the cost of registration, including geo-referencing of property boundaries by hiring technicians. Yet, many CAR related programs have helped avoid upfront costs associated with the actual registration of properties. Without assistance from CAR related programs farmers would need to hire technicians to geo-reference their properties, requiring both time and money. All interviewed farmers explained that this process would be a substantial challenge and the resources to register properties provided by the Responsible Soy Project and the *ProCerrado* program were therefore greatly appreciated as it saved farmers from a financial burden.

Further, enrollment in the CAR may soon become a requirement for farmers to maintain or gain new access to rural credit lines because banks will require CAR registration for financial loans (OECD, 2015). Therefore, the Brazilian government has promoted continued or improved access to credit as one of the main incentives for farmers to register. In the past, getting financial assistance has typically been a difficult process for many farmers - mainly because of the required documents such as land title. This process is thus expected to become less cumbersome since CAR registration will fulfill a requirement to access credit. Ultimately, improved access to credit can have a bearing on the capacity of farmers to make investments which in turn may affect productivity and profits. Many small-scale farmers in the Cerrado biome mentioned the lack of funds to invest in agricultural production in order to increase profits. In fact, key personnel from the interviewed funding agencies argued that the main direct livelihood benefit of getting enrolled in the CAR would be farmers' increased accessibility to credit.

In addition to getting access to rural credit lines by the government, farmers will most likely also experience greater access to credit offered by private companies if they have entered the CAR. Many firms making investments in Brazil are very attentive to any potential risks that are associated with land title issues and they may at minimum require farmers to be enrolled in the CAR or in compliance with the Forest Code as a condition for providing credit, as asserted by a senior officer at IFC.

3.4.4. Social Capital

The CAR and CAR related programs will also likely affect social capital such as networks of families, friends, and associations sharing common interests and relationships with firms and governments. The training programs and registration assistance offered by CAR related programs may promote extended information sharing and also form new networks that did not exist before – for example, information or new networks related to how to be in compliance with the Forest Code, and how to develop/strengthen farm and off-farm activities. In the case of the Responsible Soy Project, TNC employees stated that farmers share their knowledge on how to be compliant with the Forest Code, gained through APP restoration demonstration pilot sites, at various meetings among farmers. This shared knowledge through networks facilitated by CAR related programs may indirectly help improve livelihoods of the farmers directly participating in the CAR related programs.

Increased social capital assets acquired from firms and governments may have indirect impacts leading to better access to agricultural inputs such as fertilizers and seeds (physical capital). As evidenced by interviews with governmental officials and ICF, subsequent governmental policies will require CAR registration as a condition for providing access to inputs. For example, improved access to inputs constitutes a higher priority in remote areas primarily inhabited by small-scale farmers because prices for inputs are most likely higher in those areas than in areas with more large-scale farmers and a greater demand for these inputs. Interviewed farmers in the municipality of Santarém stated that input prices (of fertilizer, seed, and machinery) tended to be higher in the more remote Santarém area than in large-scale soy growing municipalities located in the state of Mato Grosso, even though land prices and costs of transporting soybeans from farms to the port were lower (see also Nepstad et al., 2006). One of the interviewed farmers mentioned that these factors made some farmers leave the Santarém area because the high cost of inputs made production in the area unprofitable. According to a SEMA official, the biggest challenge for farmers in the Amazon was limited infrastructure, which caused a shortage of important inputs such as equipment and technical assistance. The interviewed farmers in the Cerrado biome also had little access to inputs. Therefore, access to inputs that farmers can potentially gain through CAR registration by government's or private company's assistance programs may help farmers increase their profits from farming.

Finally, the aforementioned changes in natural, human, and financial capital assets might also have subsequent impacts on social capital because farmers' livelihood aspirations will change as the availability of other capital assets change. For example, changes in financial capital resulting from increased accessibility to credit may replace their use of social capital to borrow money from family or friends.

3.4.5. Physical Capital

Physical capital is defined as "a producer good that is purchased in order to create a flow of outputs into the future" such as roads, machines, irrigation canals, and buildings (Ellis, 2000). While our interviewees did not expect any direct impacts of the CAR and CAR related programs on the physical capitals, understanding potential indirect impacts is important because infrastructure facilitates or increases the likelihood of development (Ellis, 2000). For example, increased production through improved access to credits and markets might increase or decrease the number of producers, which may then change the size of the market and extent of investments in road and crop processing facilities. Infrastructure improvements can have direct positive impacts on livelihoods by decreasing costs and increasing accessibility to markets. However, discontinued infrastructure development in areas with decreased production or that need preservation of the environment will by contrast have adverse impacts on livelihoods.

4. Discussion

In this section, we discuss major mediating factors and channels of environmental and livelihood security outcomes, and linkages among them. Table 1 summarizes the changes in natural, financial, human, social, and physical capital assets caused by the CAR and CAR related programs. It also provides a summary of positive and negative livelihood and environmental outcomes as well as mediating factors through which the positive and negative outcomes are generated.

The role of access modifiers, i.e., governments, associations, and firms, appears critical in how mediating factors affect farmers' access to assets. Without monitoring efforts by the government, farmers who initially have less than the required LR area will less likely change their production or restoration decisions to comply with the Forest Code. This will invalidate the changes in the amount of land for cultivation and resulting changes in the provision of ecosystem services. The government also plays an important role in making financial and physical capital assets available to farmers by providing access to credit and infrastructure that can enhance agricultural production. Financial and physical capital assets also become available through farmers' increased access to social capital by formation of new networks created by the CAR registration. Also, human capital in the form of education about the Forest Code, how to comply with it, and changing consumer demands by governments, firms, or associations become available by supportive institutions and organizations (access modifiers).

Table 1
Examples of livelihood impacts of CAR and CAR related programs: mediating factors and channels of capital assets through which the impacts are delivered – lighter grey rows indicate positive channels and outcomes; darker grey rows indicate negative channels and outcomes. LR: Legal Reserves. APP: Areas of Permanent Preservation.

Assets	Mediating factors	Channels of capital assets affecting livelihoods
Natural capital	Amount of initial LR area and monitoring efforts by the government	Increased productivity and provisioning of ecosystem services, e.g., water quality, through preservation of LR and APP
		Less available land to cultivate if initial amount of LR was lower than 20%; Expenses related to restoration/purchasing additional land to comply with the Forest Code; Expenses related to intensification and expansion of agricultural land into new areas; Decreased provisioning of ecosystem services through increased input use, e.g., fertilizer
Financial capital	Use of credit lines	Continued or improved access to credits and help with the registration for CAR
		Expenses related to geo–referencing property boundaries (compensated by CAR related programs) Inability to pay back loans (e.g.,in case of crop failure due to weather events)
Human capital	Education, participation, and interaction among farmers	Increased knowledge on the Forest Code, how to comply with it, and consumer demands for sustainable products
		Less cultivation and no compensation for compliance or lack of other economic opportunities, e.g., off–farm jobs
Social capital	Formation of new networks and shared knowledge among members of the network	Increased access to inputs and markets and shared knowledge on restoration/preservation of LR and APP
Physical capital	Existing infrastructure and the number of farmers	Decreased costs of production and market accessibility if improvement in infrastructure
		Increased costs of production and market accessibility if decrease in infrastructure

We find that the amount of initial LR area that a farmer has on his property appears to be a major determinant of how the CAR and CAR related programs affect livelihoods, particularly through changes in natural capital assets. Specifically, farmers with an area of LR that is less than what the law requires will likely suffer from a decrease in production or increasing costs for restoration/additional land purchases to make up for the required LR and APP. However, any increase or decrease in the area of LR and APP will likely lead to an increase or decrease, respectively, in the provision of ecosystem services. Further, regardless of the amount of LR, intensification or expansion of agriculture into new areas can also incur additional costs to farmers.

Other factors not reported in our interviews that may reinforce either positive or negative impacts of changes in capital assets on livelihood security include weather events and market conditions. For example, farmers who have invested in purchasing inputs facilitated by increased credit access may not be able to pay back the loan if they experience crop failure as a result of drought. In this case farmers will be in debt, which can potentially threaten their livelihood security unless other measures of support from the government are provided. Another example is the availability of off-farm employment opportunities that change with market conditions. Farmers who find agricultural production less profitable, either due to less available arable land or due to new knowledge about consumer demands for sustainable products, might search for off-farm employment opportunities. Increased employment opportunities with favorable market conditions will reinforce the positive livelihood impacts of CAR while the opposite case will hold for unfavorable market conditions with less off-farm employment opportunities.

Whether there are net livelihood gains or losses, accounting for all benefits and costs from changes in natural, human, financial, social, and physical capital assets, may of course vary by farm and region. For example, although the Brazilian government promotes continued access to credit as an incentive to register in the CAR, this benefit may in fact be outweighed by possible income losses, especially in the regions with higher baseline percentage of deforested area. The livelihood gains and losses will also be different by region, where variable weather events and market conditions are beyond the influence of organizations and institutions.

5. Conclusion

Brazil's revised Forest Code mandates registration in the CAR. As such, states are obligated to help smallholder farmers comply. Funding agencies such as the ICF, the KfW, and the Amazon Fund have invested money and resources in helping states to register smallholder farmers in the CAR system. The CAR might, on the one hand, be one of the few mechanisms of the revised and relaxed Forest Code (and now often referred to as an amnesty for illegal deforestation), that can provide environmental benefits. But on the other hand, the CAR actually legalizes these new lax standards and may eventually lead to environmental costs. Because the bulk of scholarly and policy attention has been devoted to better understanding the environmental impacts, CAR's livelihood outcomes remain largely overlooked. We fill this gap by outlining how the CAR may also affect the livelihoods of rural people.

Through our interviews, we found that the CAR and CAR related programs have affected rural livelihoods in the state of Pará and will likely affect them in the Cerrado biome by changing farmers' natural, human, financial, and social physical capital assets. Depending on the initial amount of LR area in rural properties and the monitoring efforts carried out by the government, CAR registration appears to have both positive and negative impacts mainly due to increased provision of ecosystem services (e.g., water quality) and increased production costs, respectively. The programs that facilitate CAR registration help farmers to accumulate human capital by providing knowledge and information on how to comply with the Forest Code and the value of ecosystem services generated by forests. Moreover, the programs appear to have helped farmers prepare for greater market demands for sustainably produced

products. However, improvements in livelihoods will not be guaranteed without proper compensation for farmers' compliance efforts.

Our findings suggest that the CAR and CAR related programs are expected to affect livelihoods even though these outcomes are not explicit goals. We argue that both governments and funding agencies that are implementing sustainability goals need to consider the possible livelihood impacts of their programs when they promote policies to bring famers into legality. Given the high poverty rates in many states in the Amazon and Cerrado biomes, the inclusion of such activities to raise income after the CAR registration may be a necessary step to improve livelihoods, albeit it remains unknown whether it will also promote environmental conservation or by contrast cause deforestation.

Acknowledgements

We are grateful for financial support from Department for International Development, UK Government (DFID) (Accountable Grant Agreement PO #40099095) and the Center for International Food and Agricultural Policy (Travel Grant) at the University of Minnesota. We thank Jose Benito Guerrero, David Cleary, Ted Olson, Frank Pantoja, Francisco Fonseca, and Lorenda Raiol from TNC and Gilmar Tirapelle and Jusciedison Roco Cella from Cargill for arranging interviews. We also thank all interviewees from the International Climate Fund (ICF), the Amazon Fund, the German Development Bank (KfW), Cargill, TNC, state and municipality governments, and the International Finance Corporation (IFC) as well as interviewed farmers for their time. We thank two anonymous reviewers for their very useful comments.

Appendix 1

The interviews from 2011 were carried out with eight small-scale farmers and four truck drivers in the municipalities of Santarém and Belterra in Pará state, as well as three governmental officials from municipality government and state environmental agency (SEMA), four TNC employees working in TNC offices in Santarém, Belem, and Washington DC, five Cargill employees in Santarém and Belterra, and one person from International Finance Corporation (IFC) in São Paulo. They represent representative stakeholders that are directly involved in the Responsible Soy Project and in the process of helping farmers register for the CAR system. The interviews with farmers and governmental officials were conducted in person from June 13 to June 24 in 2011. The interviews with NGOs and Cargill consisted of both face-to-face interviews in the same period and phone interviews done in May and June 2011. All interviewees were asked about the benefits of the activities done by the Responsible Soy Project including helping farmers register for the CAR and comply with the Forest Code.

The interviews with key personnel from KfW, ICF, and Amazon Fund in 2015 were conducted through a series of conference calls. Interviewees were in charge of managing and overseeing the use of funds for CAR related programs. We asked questions on their specific activities on the ground, expected livelihood impacts of the project, and pathways through which the livelihood impacts might occur. The KfW supports CAR registration programs in 11 and 58 municipalities in the Triple Frontier and Atlantic Forest, respectively, and 18 municipalities in each state of Pará and Mato Grosso. The ICF supports 22 municipalities in the states of Bahia, Maranhão, Piauí, and Tocantins within the Cerrado biome. The Amazon Fund is working in 482 municipalities in the Amazon and Cerrado biomes.

The interviews with 42 farmers in the Cerrado biome were face-to-face interviews conducted in the municipalities of Formosa do Rio Preto, Luis Eduardo, Riachão das Neves, and São Desidério in Bahia and Uruçui, Ribeiro Gonçalves, Currais, Palmeira do Piauí, Baixa Grande do Ribeiro, and Santa Filomena in Piauí. These farmers have registered their properties in the CAR with the help of the ICF's *ProCerrado* program.

References

Amanor, K., Chichava, S., 2016. South–south cooperation, agribusiness, and African agricultural development: Brazil and China in Ghana and Mozambique. World Dev. 81, 13–23.
Amazon Fund, 2015. State projects. http://www.amazonfund.gov.br/FundoAmazonia/fam/site_en/Esquerdo/Projetos/States_Projects.html.
Andam, K., Ferraro, K., Sims, A., Healy, M. Holland, 2010. Protected areas reduced poverty in Costa Rica and Thailand. Proc. Natl. Acad. Sci. 107 (22), 9996–10001.
Assunção, J., Gandour, C., Rocha, R., 2013. DETERring Deforestation in the Brazilian Amazon: Environmental Monitoring and Law Enforcement. Climate Policy Initiative Report.
Azevedo, A.A., Saito, C.H., 2013. Deforestation profile in Mato Grosso, after implementation of the environmental licensing in rural properties. SciELo Brazil 19 (1), 111–122.
Bebbington, A., 1999. Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty. World Dev. 27 (12), 2021–2044.
BNDES [Brazilian Development Bank], 2015. Conference Call Interview (Nov. 24).
Brazilian Forest Service, 2016. Números do Cadastro Ambiental Rural. http://www.florestal.gov.br/numeros-do-car.
Carney, D., 1998. Sustainable Rural Livelihoods: What Contribution Can We Make? Department for International Development, London
Caviglia-Harris, J., Sills, E., Bell, A., Harris, D., Mullan, K., Roberts, D., 2016. Busting the boom–bust pattern of development in the Brazilian Amazon. World Dev. 79, 82–96.
Chambers, R., Conway, R., 1992. Sustainable Rural Livelihoods: Practical Concepts for the 21st Century. IDS Discussion Paper, No. 296.
Cleary, D., 2007. Responsible Soy Production in the Amazon: the Work of the Cargill-TNC Partnership Around Santarém, 2004–2007. The Nature Conservancy.
Clements, Suon, S., Wilkie, D., Milner-Gulland, E.J., 2014. Impacts of protected areas on local livelihoods in Cambodia. World Dev. 64, 125–134.
DFID, 1999. Sustainable Livelihood Guidance Sheets. Department of International Development, UK.
Duchrow, A., Alencar, T.R., 2015. Mutirão Integrado – a Scalable Approach for Improving Tenure Security and Environmental Compliance in the Amazon. Paper Prepared for Presentation at the "2015 World Bank Conference on Land and Poverty" The World Bank - Washington DC, March 23–27, 2015.
Ellis, F., 2000. Rural Livelihoods and Diversity in Developing Countries. Oxford University Press, New York.
Fearnside, P.M., 2015. Environment: deforestation soars in the Amazon. Nature 521, 423.
Fearnside, P.M., 2016a. Brazilian politics threaten environmental policies. Science 353 (6301), 746–748.
Fearnside, P., 2016b. Environmental and social impacts of hydroelectric dams in Brazilian Amazonia: implications for the aluminum industry. World Dev. 77, 48–65.
Fernandes, L.A., Woodhouse, P.J., 2008. Family farm sustainability in southern Brazil: an application of agri-environmental indicators. Ecol. Econ. 66 (2–3), 243–257.
Ferraro, P.J., Hanauer, M.M., 2014. Quantifying causal mechanisms to determine how protected areas affect poverty through changes in ecosystem services and infrastructure. Proc. Natl. Acad. Sci. 111 (11), 4332–4337 Mar, 18.
Ferreira, J., Aragão, L.E.O.C., Barlow, J., Barreto, P., Berenguer, E., et al., 2014. Brazil's environmental leadership at risk. Science 346, 706–707.
Gibbs, H.K., Rausch, L., Munger, J., Schelly, I., Morton, D.C., Noojipady, P., Soares-Filho, B., Barreto, P., Micol, L., Walker, N.F., 2015. Brazil's Soy Moratorium. Science 347, 377–378.
Gibbs, H.K., Munger, J., L'Roe, J., Barreto, P., Pereira, R., Christie, M., Walker, N.F., 2016. Did ranchers and slaughterhouses respond to zero-deforestation agreements in the Brazilian Amazon? Conserv. Lett. 9 (1), 32–42.
Goldstein, J.H., Caldarone, G., Duarte, T.K., Ennaanay, D., Hannahs, N., Mendoza, G., Polasky, S., Wolny, S., Daily, G.C., 2012. Integrating ecosystem-service tradeoffs into land-use decisions. Proc. Natl. Acad. Sci. U. S. A. 109, 7565–7570.
Gregorio, M.D., Fatorelli, L., Pramova, E., May, P., Locatelli, B., Brockhaus, M., 2016. Integrating mitigation and adaptation in climate and land use policies in Brazil: a policy document analysis. Centre for Climate Change Economics and Policy Working Paper No. 257. Sustainability Research Institute Paper No. 94, CIFOR Working Paper No. 194.
IBAMA [Brazilian Institute of Environment and Renewable Natural Resources], 2015t. Public consultation of environmental charges and embargoes. Available online. https://servicos.ibama.gov.br/ctf/publico/areasembargadas/ConsultaPublicaAreasEmbargadas.php.
KfW [German Development Bank], 2015. Brazil – an emerging country and important partner in climate protection. https://www.kfw-entwicklungsbank.de/International-financing/KfW-Development-Bank/Local-presence/Latin-America-and-the-Caribbean/Brazil/.
Kröger, M., 2016. Inter-sectoral determinants of forest policy: the power of deforesting actors in post-2012 Brazil. Forest Policy Econ. (in press).
L'Roe, J., Rausch, L., Munter, J., Gibbs, H.K., 2016. Mapping properties to monitor forests: landholder response to a large environmental registration program in the Brazilian Amazon. Land Use Policy 57, 193–203.
Macedo, M.N., DeFries, R.S., Morton, D.C., Stickler, C.M., Galford, G.L., Shimbukuro, Y.E., 2012. Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. Proc. Natl. Acad. Sci. 109, 1341–1346.
Miranda, J.J., Corral, L., Blackman, A., Asner, G., Lima, E., 2016. Effects of protected areas on forest cover change and local communities: evidence from the Peruvian Amazon. World Dev. 78, 288–307.
Nelson, E., Sander, H., Hawthorne, P., Conte, M., Ennaanay, D., Wolny, S., Manson, S., Polasky, S., 2010. Projecting global land use change and its effect on ecosystem service provision and biodiversity with simple models. PLoS ONE 5 (12), e14327.

Nepstad, D.C., Stickler, C.M., Almeida, O.T., 2006. Globalization of the Amazon soy and beef industries: opportunities for conservation. Conserv. Biol. 20, 1595–1603.
Nunes, S.S., Barlow, J., Gardner, T.A., Siqueira, J.V., Sales, M.R., Souza, C.M., 2015. A 22 year assessment of deforestation and restoration in riparian forests in the eastern Brazilian Amazon. Environ. Conserv. 42, 193–203.
OECD, 2015. OECD Environmental Performance Reviews: Brazil 2015. OECD Publishing, Paris.
Rajão, R., Vurdubakis, T., 2013. On the pragmatics of inscription: detecting deforestation in the Brazilian Amazon. Theory Cult. Soc. 30 (4), 151–177.
Reinecke, J., Manning, S., Von Hagen, O., 2012. The emergence of a standards market: multiplicity of sustainability standards in the global coffee industry. Organ. Stud. 33 (5–6), 655–679.
Schouten, G., Bitzer, V., 2015. The emergence of southern standards in agricultural value chains: a new trend in sustainability governance? Ecol. Econ. 120, 175–184.
Scoones, I., 1998. Sustainable Rural Livelihoods: a Framework for Analysis, IDS Working Paper, No. 72.
Scoones, I., 2009. Livelihood perspective and rural development. J. Peasant Stud. 36 (1), 171–196.
SICAR, 2016. Consulte a legislação. http://www.car.gov.br/#/legislacao.
Soares-Filho, B., Rajao, R., Macedo, M., Carneiro, A., Costa, W., Coe, M., Rodrigues, H., Alencar, A., 2014. Cracking Brazil's Forest Code. Science 344, 363–364.
Sparovek, G., Berndes, G., Klug, I.L.F., Barretto, A.G.O.P., 2010. Brazilian agriculture and environmental legislation: status and future challenges. Environ. Sci. Technol. 44 (16), 6046–6053.
Sunderlin, W.D., Angelsen, A., Belcher, B., Burgers, P., Nasi, R., 2005. Livelihoods, forests, and conservation in developing countries: an overview. World Dev. 33, 1383–1402.
Tallis, H., Polasky, S., 2009. Mapping and valuing ecosystem services as an approach for conservation and natural-resource management. Ann. N. Y. Acad. Sci. 1162, 265–283.
TNC [The Nature Conservancy], 2015. Responsible soy in South America. http://www.nature.org/about-us/working-with-companies/companies-we-work-with/cargill-and-conservancy-case-study.xml.
UK Government, 2012. UK fast start climate change finance – supporting the world's poorest to adapt to climate change and promoting cleaner, greener growth. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/67449/fast-start-climate-change.pdf.
Winter, S.C., May, P.J., 2001. Motivation for compliance with environmental regulations. J. Policy Anal. Manage. 20 (4), 675–698.