

Small-scale farmers' needs to end deforestation: insights for REDD+ in São Felix do Xingu (Pará, Brazil)

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SUMMARY

REDD+ has been perceived in Brazil as a way of complementing an effective command-and-control policy to help small-scale farmers transition out of deforestation. A large array of incentives have been suggested within the REDD+ framework, involving trade-offs between efficiency and equity. However, few studies have so far addressed the adaptation of these incentives to the needs of the farmers. In order to develop this perspective, our work aims at understanding how small-scale farmers perceive deforestation and what would make them engage in a transition towards sustainable alternatives. Interviews were conducted in São Felix do Xingu, where The Nature Conservancy has been developing a REDD+ pilot programme. The three discourses identified following the application of Q methodology reveal differing needs to reduce deforestation. If equity is defined as the opportunity for all to engage in a transition, a differentiated REDD+ initiative targeting the farmers' needs may be more equitable than standardized support options.

Keywords: deforestation, REDD+, Brazil, small-scale farmers, equity, Amazon

Besoins des agriculteurs familiaux pour arrêter la déforestation: perspectives pour REDD+ à São Felix do Xingu (Pará, Brésil)

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Au Brésil REDD+ est conçu comme un instrument complémentaire à l'approche de régulation afin d'aider les agriculteurs familiaux à arrêter de déforester et pour qu'ils s'engagent dans une transition vers des alternatives de production durable. Dans le cadre de REDD+, une série d'incitations sont envisagées impliquant des arbitrages entre efficacité et équité. Néanmoins, peu d'études ont jusqu'à présent analysé comment aligner ces incitations avec les besoins des agriculteurs. Afin d'explorer ce champ, notre étude vise à comprendre comment les agriculteurs familiaux perçoivent la déforestation et ce qui les feraient changer de pratiques pour adopter des alternatives durables. Des entretiens ont été réalisés à São Felix do Xingu, en Amazonie brésilienne, où The Nature Conservancy a développé un programme pilote de REDD+. Les trois discours identifiés d'après la méthodologie Q révèlent des besoins différents pour arrêter de déforester. Si l'équité est définie comme l'opportunité pour tous de s'engager dans une transition durable, une initiative REDD+ différenciée ciblant les besoins des agriculteurs pourrait être plus équitable que des options d'appui uniforme.

La necesidad de agricultores a pequeña escala de terminar la deforestación: Ideas para REDD+ en São Felix do Xingu (Pará, Brazil)

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REDD+ ha sido percibida en Brasil como una forma de complementar políticas de comando y control para ayudar a los agricultores a pequeña escala de salir de la deforestación. Se ha propuesto una gran variedad de incentivos en el marco de REDD+, que implica compromisos entre eficiencia y equidad. Sin embargo, pocos estudios han abordado hasta ahora la adaptación de estos incentivos a las necesidades de los agricultores. Para elaborar estas perspectivas, nuestro trabajo apunta a la comprensión de cómo los pequeños agricultores perciben la deforestación y como se obtendrá un compromiso de ellos para una transición hacia alternativas sostenibles. Se hizo entrevistas en São Félix do Xingu, donde The Nature Conservancy ha estado desarrollando un programa piloto de REDD+. Después de aplicar la metodología Q, se identificó tres discursos distintos que revelan las diferentes necesidades para reducir la deforestación. Si la equidad se define como la oportunidad para que todos puedan participar en una transición, una iniciativa REDD+ diferenciada concentrada en las necesidades de los agricultores puede ser más equitativo que las opciones comunes de soporte externo.

INTRODUCTION

The deforestation rate in the Brazilian Amazon declined by 83% between 2004 and 2013 according to Brazil's National Institute for Space Research (INPE 2014). However, the country remains second only to Indonesia in terms of Greenhouse Gas (GHG) emissions caused by land-use change (Margono *et al.* 2014). In 2004, Brazil started adopting a series of command-and-control measures to reduce deforestation, which culminated in 2008 with strong action against the most deforesting municipalities. This regulatory approach was, on the whole, successful in tackling deforestation by large farmers, but only marginally affected the behaviour of small-scale farmers, and often aggravated their conditions of poverty (Assunção *et al.* 2013).

In consequence, the relative share of responsibility of small-scale farmers for the remaining deforestation increased in comparison to that of large landowners (Godar *et al.* 2014). It is more difficult for the former to stop deforesting and to engage in a transition towards sustainable alternatives to deforestation because they lack technical capacity, the resources to invest in their properties and a long-term vision. Slash-and-burn agriculture remains the best economic option for them (Börner *et al.* 2007, Costa 2008, Villemaine *et al.* 2012). As command-and-control policies proved to have limited impact in inducing a change in practices – in addition to being ethically questionable (Gezelius 2004) – the incentives discussed as part of Reducing Emissions from Deforestation and Degradation (REDD+) initiatives have been considered as an interesting option to fill these technical and financial shortcomings (Angelsen *et al.* 2008).

In REDD+ initiatives, small-scale farmers are often included for reasons of equity (Grieg-Gran *et al.* 2005) although it may be more efficient to only target large landholders as they involve less transaction costs. However, the reality of small-scale farmers in the Amazon is very diverse (Pacheco 2009), and encouraging them to engage on a low deforestation production path will most certainly require differentiated measures. Instead of dwelling on how a REDD+ initiative could be made more equitable, we wished to consider the perspective of the farmers themselves and then question whether this would be equitable. What type of support do the farmers themselves identify as necessary to engage in a transition and in what way would it contribute (or not) to equity?

To address this question, we carried out an exploratory study in 2012 in São Felix do Xingu (SFX), a municipality that figures among the most deforesting municipalities in the Brazilian Amazon and where the NGO The Nature Conservancy (TNC) was initiating a REDD+ pilot programme. In the face of the exacerbated challenges confronting small-scale farmers, our objective was to analyse what could encourage a change in their deforesting practices. At the time, a national debate about Forest Legislation and the potential role of Payments for Environmental Services (PES) (Coudel *et al.* in press) brought this instrument to the forefront. A theoretical debate opposing use-restricting and asset-building payments led us to question how such payments would be perceived by

the farmers themselves and what other type of REDD+ measures would be most appropriate to support them in stopping their deforesting practices.

After a literature review of the different types of incentives that can be funded by a REDD+ programme and their implications for equity, we will briefly explain the political context of deforestation reduction in Brazil. We then present the methodology used to analyse the current situation of SFX and the perception of small-scale farmers. Based on the interviews with these smallholder farmers and with local institutions, as well as the long experience one of the authors has of the situation in SFX, our results show that the needs differ according to the different types of farmers. In the discussion, we will identify the implications for equity of a differentiated REDD+ initiative that is capable of taking actor diversity into account.

LITERATURE REVIEW

Incentives considered within REDD+ initiatives

REDD+ initiatives are based on the concept of *compensated reduction*, put forward by Brazil at the Conference of Parties on Climate Change at The Hague in 2000 (Santilli 2005), as a means of both reducing carbon emissions from deforestation and facilitating the participation of developing countries in the Kyoto Protocol framework. Santilli (2005) suggested a series of options for the use of these funds in developing countries, including enforcing environmental legislation, supporting economic alternatives to extensive forest clearing, building institutional capacity in remote forest regions, and enhancing protected areas. While the modalities of the distribution of REDD+ funds at the national level remained unclear, using the funds for use-restricting payments became one of the most prominent models (Wunder 2005, 2006) as part of the new paradigm of Payments for Ecosystem Services (Pagiola *et al.* 2004). In this type of scheme, a service provider is awarded a payment by the user contingent upon service delivery (Wunder 2007).

However, the neo-liberal assumption that cash payments can form the major incentive for transforming resource-users' behaviour suffers from a series of shortcomings (Landell-Mills and Porras 2002, Milne and Nielsen 2009, Dennis *et al.* 2011, Pokorny *et al.* 2012). On the one hand, a use-restricting scheme creates a long-term dependence on the payment and may turn out to be more expensive over a long period, as it ignores demand-side pressures (Pirard *et al.* 2010). On the other, it does not release the capital necessary to engage in a new technical path of agricultural or agro-forestry production over the long term, but instead may lock the smallholders into a poverty trap by reducing local economic activities and transforming the poorest into '*conservation rentiers*' living off their compensation payments (Karsenty 2004, 2007).

For Angelsen *et al.* (2008) and Pirard *et al.* (2010), economic incentives should take the form of asset-building support provided to farmers, which would allow them to replace their slash-and-burn practices with sustainable alternative production practices not associated with deforestation.

Access to technical assistance and infrastructure support may be even more highly valued by the farmers than cash payments (Bartels *et al.* 2010). Even though roads can encourage and facilitate deforesting activities by reducing transport costs and providing market access, they are essential to allow a transition towards sustainable alternatives to deforesting activities, especially in places that are more advanced in the forest transition (Angelsen 2010).

Other authors focus on the importance of the institutional governance of forest management. Muradian *et al.* (2010) and Karsenty (2011) show that a use-restricting REDD+ scheme does not pay enough attention to the role of institutions and shared beliefs in shaping the resource-users' decisions. Hall (2013) argues that one of the emerging features of a REDD+ scheme is a potential 'social contract' that could underpin governance arrangements for forests and other natural resources involved.

Equity of these different incentives

A trade-off often results between environmental efficiency and equity in access to REDD+ benefits, since smallholders have a relatively smaller impact in terms of GHG emissions from deforestation when compared to large-scale commercial farmers (Wunder 2007, Corbera *et al.* 2007). Although poverty alleviation should not be central to PES or REDD+ design since the main aim is environmental (Kinzig *et al.* 2011), equity has been recognised as a key element to be taken into account when designing and implementing market-based mechanisms, especially if the poor and the most disadvantaged are to be involved in these initiatives (Grieg-Gran *et al.* 2005, Peskett *et al.* 2008).

In the context of a REDD+ initiative, the literature addresses three different elements of equity (Brown and Corbera 2003): equity in access to REDD+ credits or support measures, equity in decision-making, and equity in outcomes (in the sense of distribution of project costs and benefits). These elements are usually intertwined, as shown by Corbera *et al.* (2007): a carbon project in Chiapas, Mexico, favoured the richest local families in access to decision-making, which led to a higher share of access to credits and benefits for them.

Luttrell *et al.* (2013) define equity in reference to the benefits from the implementation of a REDD+ initiative (financial benefits or support measures), which they differentiate from benefits resulting from changes in forest use (improved provision of ecosystem services or non-timber forest products) and indirect benefits from REDD+ implementation (such as improved governance, technology transfer, enhanced participation in decision-making, and infrastructure provision). To avoid corruption and benefit capture by a small group or the political leader of a community, thus an inequitable distribution of the benefits, Sommerville *et al.* (2010) show that offering in-kind, non-rival and non-excludable incentives are more suited than payments to a community. Financial compensation for large-scale 'set aside' conservation projects, which restrict the farmers' use of resources,

have been shown to have harmful impacts on the income of the community's poorest members (Bond *et al.* 2009).

However, even providing asset-building support in the same way to all beneficiaries is not necessarily the most equitable way of implementing a policy (Pascual *et al.* 2010) because the level of the support is usually determined on the basis of the average opportunity cost of the community (Karsenty 2010). The resource-dependent poor have a relatively higher opportunity cost than this estimated average because they rely on the forests for their livelihoods. Gross-Camp *et al.* (2012) show that the households living closest to the Nyungwe National Park in Rwanda, who are also the poorest, considered a PES project unfair as they consumed a higher equivalent in forest products than the payment provided under the intervention.

In fact, guaranteeing equity in individual benefits or losses does not guarantee that equality is achieved across the targeted populations. Aristotle defines this as proportional equality, which involves treating all relevant persons in relation to their due instead of granting them the same quantity of a good. Although it involves unequal treatment, Aristotle considers it is morally just and acceptable. Applied to REDD+, this would imply considering differentiated forms of support to farmers but with the same aim of giving them the opportunity to exit deforestation (Gebara 2013). Similarly, McDermott *et al.* (2012) define contextual equity as one that incorporates the pre-existing conditions that limit or facilitate people's access to decision-making procedures, resources and, thereby, benefits. These pre-conditions constitute the political root causes of inequalities in REDD+ initiatives, which policy actors need to address, instead of just dealing with the symptoms (Di Gregorio 2013). Thus, as summarized in Table 1, the different instruments that could be implemented within a REDD+ scheme all present different advantages and limits in terms of equity. In fact, as highlighted by Brown and Corbera (2003), Luttrell *et al.* (2013) and Gebara (2013), the degree of local participation and equity in decision-making in the process of developing and implementing REDD+ is one of the strongest guarantee that benefits will be equitable. This led us to investigate the farmers' perspective on what would be the specific needs that have to be met before they can each engage in a transition out of deforestation.

CONTEXT

Federal policies against deforestation

Deforestation is one of the main contributing drivers of climate change, as it accounts for 18% of GHG emissions globally (Meridien Institute 2011). While annual deforestation rates in the Brazilian Amazon declined by almost 84% between 2004 and 2012, deforestation and land-use change still accounted for 32% of GHG emissions in 2012 (SEEG 2013).

Starting in the 1950s, the Brazilian federal government promoted deforestation as a way of territorial conquest and

TABLE 1 Possible REDD+ instruments, types of equity aimed at and possible limits in terms of equity

Type of REDD+ instrument	Principle	Type of equity aimed at	Possible limits in terms of equity	References
Use-restricting payment	Offer payments to compensate non-use of resources	Equity in access	Can have a harmful impact on income of poorest and most resource-dependent members	Bond <i>et al.</i> 2009 Gross-Camp <i>et al.</i> 2012
Asset-building payment	Offer payments to help build assets	Equity in access	Average level of support can be insufficient for poorest members	Pascual <i>et al.</i> 2010 Karsenty 2010
Enforcement	Applying the same rule to all, and sanctions in case of non-compliance	Equality	Harmful impacts on poorest members, who can't comply and decrease their income	Coudel <i>et al.</i> 2012 Gezelius 2004
Public infrastructure	Investment to provide the conditions for production (roads, etc)	Equity in access	Often realized under pressure of certain groups which it will benefit more, leaving aside poor communities	McDermott <i>et al.</i> 2012 Di Gregorio 2013
Public welfare	Targets the poorest members to address the roots of inequality through social grants	Equity in outcome	To bring the poorest out of their situation, the poorest require more than social grants, also political rebalancing	Di Gregorio 2013
Community asset-building	Bring non-rival non-excludable incentives (cooperatives, processing plants, etc)	Equity in outcome	May result in elite capture within the community	Sommerville <i>et al.</i> 2010
Technical assistance	Providing all members with the means to increase their income	Equity in access if applied uniformly If targeted to farmers' needs, equity in outcome / in benefits	Members who are not engaged in the transition are disadvantaged Only members who refuse to change their practices are disadvantaged	Brown and Corbera 2003 Luttrell <i>et al.</i> 2013 Gebara 2013
Targeted mix (including all of the above)	Takes into account the differences between landholders to differentiate support	Proportional equality	Although unequal support, aims at providing equal opportunities to engage in transition. But outcome will fundamentally depend on farmers motivations.	Coudel <i>et al.</i> 2012

occupation (Moran 1981). Between the 1970s and 1990s, government-sponsored colonization consisted of selling properties of thousands of hectares to private companies and granting 100-ha parcels to landless peasants or small-scale farmers in order to secure national borders (Pacheco 2009, Simmons *et al.* 2011).

When deforestation reached a historical high in 2004 with over 25,000 km² deforested – a situation strongly denounced by NGOs and citizen movements – the Brazilian federal government took strong regulatory action against it. The Action Plan for Prevention and Control of Deforestation in the Brazilian Amazon (PPCDAm) was its flagship programme, and aimed at reducing deforestation through command-and-control measures, while promoting an institutional culture to stimulate legal activities through market incentives, social control and capacity-building (Barreto and Araújo 2012).

Deforestation is mainly concentrated along what is called the 'Fire Arc', which goes from the north-east to the south-west of the Amazon. After an increase in deforestation in 2007, the federal government chose to specifically target the municipalities of this Arc and a presidential decree blacklisted the 43 most deforesting Amazonian municipalities. Several restrictive measures are enforced in these municipalities, including restriction of access to markets and rural credit for farmers who do not have any legal proof of land ownership or do not comply with environmental regulations (Assunção *et al.* 2012). The government declared an embargo on areas with illegal deforestation and published them publically¹, making anyone who acquired products from these areas guilty of environmental crimes (Barreto and Daniel 2009, Barreto *et al.* 2009). The Federal Public Ministry (MPF) used this rule to shut down slaughterhouses that continued to buy cattle from embargoed areas (Brasil 2007).

¹ The list is available on the site of the Brazilian Federal Environmental Agency: http://siscom.ibama.gov.br/geo_sicafi/

Both the blacklist and the embargo are aimed at enforcing the Brazilian Forest Code (from 1967, modified in 2012), a law that requires farmers to maintain a forest reserve on their properties (80% in the Amazon region, although since 2012 it is permitted to maintain only 50% if the property has already been deforested), along with permanent preservation areas around water sources, streams, and hills (Senado Brasileiro 2012).

To facilitate its implementation, the new Forest Code approved in 2012 requires that farmers submit a geo-referenced Rural Environmental Register (Cadastro Ambiental Rural or CAR), a system used to identify the owner, to delimitate the property, its legal reserve and permanent preservation areas. For property owners with less than 80% of their areas under forest, the CARs expire in 6 months if not followed up with recovery plans for ensuring environmental compliance (Duchelle *et al.* 2014). CAR has thus become a strong monitoring instrument, used for example by slaughterhouses to control the legal provenance of cattle.

Along with strong field operations by the Federal Environmental Agency IBAMA and Federal Police to fine illegal businesses, these measures led to a significant reduction in deforestation (Barreto and Araújo 2012, Nepstad *et al.* 2009), with deforestation rates falling by 84% between 2005 and 2012 (INPE 2014). However, they started to rise again in 2012 and 2013 (INPE 2014), suggesting that other measures may be needed to reach a zero-deforestation goal over the long term. In fact, the regulatory approach to the 'Fire Arc' has not proven to be effective for small-scale farmers over the long term (Coudel *et al.* 2012). This can partly be explained by the fact that small-scale farmers often cannot be held accountable as they are not officially registered as owners, their areas are too small to be noticed through satellite imaging when compared to those of large landowners, and they rarely sell to controlled markets, so non-compliance has no consequences in many cases (Coudel *et al.* 2012).

The fundamental challenge is that, for small-scale farmers, income is still directly correlated with the deforested area through the common practice of slash-and-burn (Brondízio *et al.* 2013). As Le Tourneau *et al.* (2013) show in 12 sites across the Amazon, communities continue to face the classical dilemma of either enjoying a preserved ecosystem but enduring adverse living conditions or enjoying a better living standard at the expense of forest cover. This means that small-scale farmers need to be included in further efforts to reduce deforestation.

Sustainable ways to reduce the deforestation include the production of milk, and fruit and vegetables. Mechanization (or technology-induced intensification) and intensification of agricultural production can lead, though not necessarily, to a reduction in deforestation (Angelsen 2010, Phelps *et al.* 2013). Byerlee *et al.* (2014) have shown that different kinds of intensification can lead to different effects on deforestation rates, and that they should always be embedded in a strengthened governance of natural resources.

São Felix do Xingu: a priority for preventing deforestation

The municipality of São Felix do Xingu (SFX), located in the State of Pará (see Figure 1), has experienced one of the highest deforestation rates in the Amazon since 2001. As SFX is part of the 'Fire Arc', the Brazilian government considers it as one of its priority municipalities for preventing, monitoring and controlling illegal deforestation (Guimarães *et al.* 2011). It is the municipality with the largest cattle herd in Brazil, with over two million heads in total (IBGE 2010). The high profitability of cattle farming with its secure and timely returns, combined with minimal labour and input requirements – and the product's ability to walk to market (i.e., no transportation costs) – has led to the significant expansion of pasture areas (Bommel *et al.* 2010). Other products cannot be sold easily outside the municipality due to limited infrastructure and poor quality roads (Gebara 2014). Other important activities that drive the local economy are mining, logging and cocoa production.

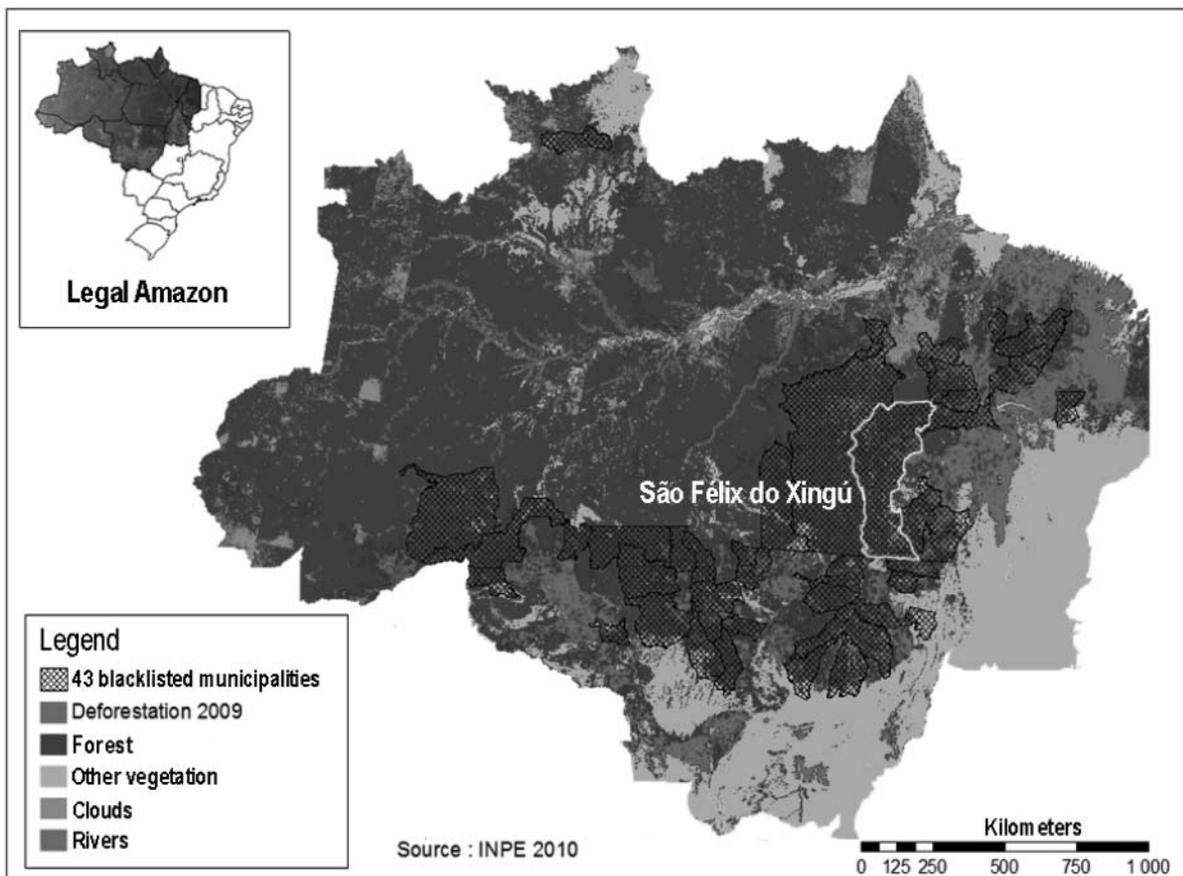
Following the 2007 federal edict imposing an embargo on cattle production from SFX as part of the blacklisted municipalities, this municipality benefitted from a series of support programmes, which, however, came attached with certain conditions.

Since 2010, the 'Green Arc' programme has provided assistance to SFX in its efforts to exit the blacklist. This programme has supported the creation of municipal institutions and increased access to credit and capacity-building. The Municipal Environmental Service (Secretaria Municipal de Meio Ambiente – SEMMA) was remodelled, equipped and its personnel trained. In addition, the Project Pacto Xingu of the Pará State and Federal Ministry of Environment (Ministério de Meio Ambiente – MMA), financed by the European Union, also took off to train local institutions and agricultural technicians.

In 2011, the Municípios Verdes (Green Municipalities) programme of Pará State was launched. To participate in the programme, municipalities had to sign a pact for stopping all illegal deforestation by 2020. Although in SFX the first attempt failed due to the lack of inclusion of the various local representatives and producer associations, the municipal pact was finally signed with these sectors. To help implement this pact, the local government created a commission which includes the signatories of the pact and a wide range of stakeholders from different sectors. The involvement of smallholders in the commission has been a crucial step, given their exclusion from previous political processes. The commission meets regularly to discuss a post-pact agenda encompassing anti-deforestation efforts in the long term. However, it lacks a clear decision-making process and financial resources, currently relying on funding from The Nature Conservancy (TNC) NGO, which was invited in 2009 to support this process.

These programmes have led to a significant decrease in the annual rate of deforestation in SFX, from 877 km² in 2007

FIGURE 1 Localization of São Felix do Xingu, one of the 43 blacklisted municipalities in the “Fire Arc” in the Brazilian Amazon



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to just 140 km² in 2011 (INPE 2014). However, in order for a municipality to be removed from the federal blacklist, its annual deforestation must be equal to or less than 40 km². Furthermore, at least 80% of the private lands of the municipality have to be registered with CAR (Rural Environmental Register).

According to the CAR, the total number of farmers in SFX was around 8000 in 2012. Small-scale farmers (who own less than 300 ha each) represented 86% of the total number of farmers, but only 24% of the area of private land, with the average size of their properties being 125 ha (Adafax 2012). Among the small-farmers, 4000 have been more recently settled on 50 ha plots in the *assentamentos* (agrarian reform settlements), areas which are still considered public land.

Local associations and NGOs have promoted the expansion of cocoa production as an alternative to slash-and-burn or cattle farming, because cocoa is grown in an agroforestry system and because it has the potential to be more profitable than cattle (Sablayrolles *et al.* 2012). This expansion has benefited from a recent price increase and TNC support for implementation of best management practices (Gebara 2014).

The production of fruit and vegetables and the extraction of wood in agroforestry systems (AFS) are less common

alternatives in SFX so far, as they require a certain level of technical knowledge for the planting and growing. A transition towards any alternative production system requires an initial investment and a medium-to-long term vision. The small-scale farmers who are most constrained by their immediate needs often lack the financial means for this initial investment and cannot afford the luxury of a long-term vision (Adafax 2012).

The Central Xingu REDD+ pilot programme

As part of its municipal action, TNC has been planning the Central Xingu REDD+ pilot programme in SFX since 2009 in partnership with the State Environment Service (SEMA), SFX Municipal Environmental Service (SEMMA) as well as Adafax (Association for the Development of Family Farmers in Alto Xingu). The initial pilot programme has focused on financial and technical support for CAR implementation. Due to the lack of state resources and institutional capacity for CAR implementation, TNC supported the process in 12 Amazonian municipalities with a USD 19 million grant from the Amazon Fund (created by the federal government) and financial resources from USAID and the Vale Fund (Gebara 2014).

Confronted by a series of challenges, the REDD+ initiative has evolved over time. According to TNC, the REDD+ nomenclature was initially misunderstood at the local level. For small farmers, the market-based connotation of REDD+ was of little interest; for large producers it seemed like an opportunity for profit; and for indigenous groups it fed into anti-REDD+ sentiments. Because of these misunderstandings, TNC eliminated the term 'REDD+' from the name of the initiative even though actions to reduce deforestation remain at its core. It thus became known as the Sustainable Landscape Programme (Gebara 2014).

SFX was selected for this pilot programme for various reasons. First, it still has large areas of standing forest that need to be protected and has a history of high rates of deforestation. Second, it is like a microcosm of the entire Amazon, with all major types of land ownership (federal conservation units, indigenous lands with federal protection, state protected areas and private lands), land uses and actors, allowing TNC to gain wide-ranging experience. Third, it has a high diversity of ecosystem services. Finally, it is supported by the local government and there are civil society organizations present in the area that could lead different aspects of the initiative (TNC 2013a).

In 2012, when our study was carried out, the TNC team was still in the initial phase of informing the municipal actors about the project and assessing the expected reduction in emissions, based on the carbon stocks in the project area. The specific interventions were clarified in 2013 and include: land-use zoning; improved enforcement and compliance with environmental legislation; sustainable financing for and management of indigenous and protected areas; sustainable production alternatives for local actors; technical assistance and promotion of alternative livelihoods; restoration of degraded lands; enhanced participation of vulnerable groups in REDD+-related decision making; economic opportunities; and shared lessons (TNC 2013a). The first support measures were launched in 2012, with a focus on the restoration of permanent protected areas and degraded areas, and support for the intensification of small-scale ranching, best practices for agricultural production and diversification (Ibid). At the time of our field visit, the proponents were still deciding whether to offer PES as a positive incentive, since opportunity costs are high in the area.²

It is important to note that both performance-based and up-front benefits are part of the pilot programme. CAR, for example, is an up-front benefit that positions actors to receive performance-based benefits, such as access to the Terra Verde environmental fund and technical assistance for the implementation of best management practices. Performance-based benefits will be based on progress in reducing emissions (Griscom and Cortez 2011).

METHODOLOGY

Selection of interviewees

To understand how small-scale farmers perceive deforestation and what would be required for them to stop deforesting, interviews were conducted by the first author, both with the farmers themselves and with the institutions who work closely with them. The Association for the Development of Family Farmers in Alto Xingu (Adafax) generously received us in SFX, and facilitated our meetings with local institutions and small-scale farmers in their communities during the six weeks we spent in the field. Thanks to its position within the municipality's institutional mosaic, the association helped us to make fruitful contacts with the representatives of local institutions and with farmers.

The 18 institutions we interviewed all work with farmers or impact them with their policies. Four institutional categories can be identified:

- NGOs playing a political role in SFX, including Adafax, TNC and the French NGO Gret;
- Technical assistance organisations, including Emater, Cootagro, Procampo, Ceplac and Cappru³;
- Public institutions, such as the Municipal Environmental Service (SEMMA), the State Environmental Service (SEMA), the Municipal Agriculture Service (SEMAGRI) and the National Institute for Colonisation and Land Reform (INCRA). The bank providing most rural credits is BASA;
- And, finally, organisations representing social movements, including the Union of Rural Workers (STTR), the Union of Rural Producers (SPR), the Rural Family House (CFR), and the Pastoral Commission for Land (CPT).

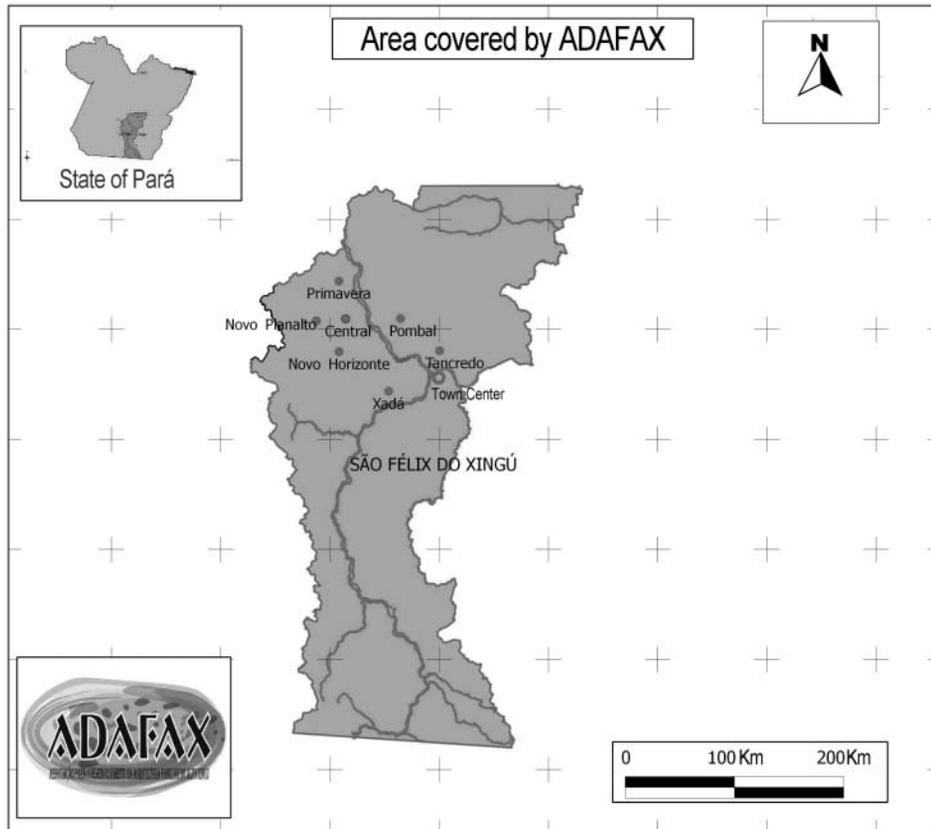
The interviews with farmers were conducted in cooperation with Adafax. Due to transportation difficulties within the municipality, we could not travel to the farmers' communities by ourselves. We therefore accompanied Adafax technicians when they had meetings with farmers or visited the communities to train the farmers (see Figure 2). Adafax was facing budget constraints, which limited us to three field visits in the six weeks we spent in SFX. Nonetheless, the farmers interviewed were selected with differing profiles in terms of age, production system, size of property, remaining forest cover and distance to the city of SFX (see Table 2).

The first visit was to the community of Tancredo to attend a meeting of the Women's Association for the Production of Fruit Pulp (AMPPF). During the lunch break, we interviewed three farmers, all men who were attending the meeting, as the

² Gebara (2014) states that no decision had been taken regarding payments as of 2014.

³ Emater: Empresa de Assistência Técnica e Extensão Rural; Cootagro: Cooperativa de Trabalho dos Técnicos Agropecuários do Xingu; Procampo: Programa de Apoio à Formação Superior em Licenciatura em Educação do Campo; Ceplac: Comissão Executiva do Plano da Lavoura Cacaueira; Cappru: Cooperativa Alternativa de Pequenos Produtores Rurais e Urbanos de São Félix do Xingu.

FIGURE 2 Map of localization of the farmers' communities visited within the municipality of SFX



women were very shy and refused to talk to us. These farmers were not formally working with Adafax.

On our second visit, a two-day trip on motorcycle, we visited the communities of Xadá, Casa de Tábuá, Vila Central, Vila Primavera, and the Pombal *assentamento*, during which we interviewed eight farmers. Adafax had to visit six of them to provide technical assistance but the other two were not formally engaged with Adafax.

During the last field trip, we accompanied two technicians by car to Vila dos Crentes (after Vila Primavera), approximately eight hours from the centre of SFX, where Adafax had to deliver seedlings for various types of fruit trees and provide technical assistance at the community level. We interviewed the only three small-scale farmers who showed up at the meeting with Adafax. (A communication problem prevented the attendance of more farmers.)

Although this form of contact might imply a certain bias, we tried to counterbalance it. Five out of the 14 farmers interviewed were not engaged with Adafax, and some of the others had only very recently started benefitting from its technical assistance. On the other hand, the presence of Adafax helped us gain the farmers' trust. Given the historic focus on enforcement in the study region, there was a risk that respondents provided researchers with biased responses based on their fear of repercussions and based on what they thought researchers 'wanted' to hear (i.e., social desirability, see Fischer 1993). Indeed, quite the opposite effect was noted: given that we came along with an association providing

assistance, they did not insist on their efforts and achievements, but instead clearly emphasized their needs and challenges.

Analysing farmer subjectivity with Q methodology

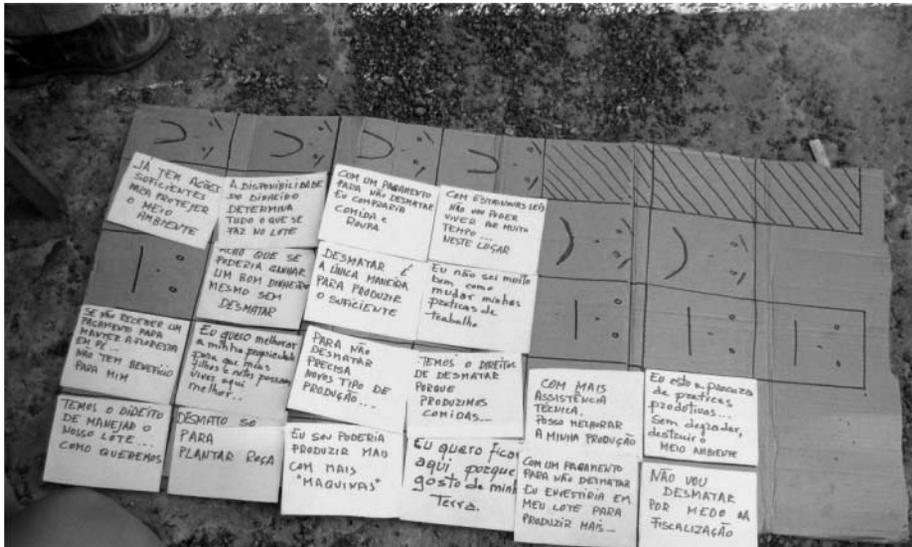
To analyse the perception farmers have of deforestation and its alternatives, it was crucial for us to obtain comparable responses by preventing the farmers from deviating from the questions or answers with their usual discourses, defined as the way of seeing and talking about something (Barry and Proops 2010). We thus chose to use Q methodology, developed by William Stephenson (Stephenson 1953), which has recently become popular in environmental studies (see, for instance, Brannstrom 2011, Baker *et al.* 2006, Barry and Proops 1999, Ockwell 2008 and Sandbrook *et al.* 2013). Q methodology is used to elicit and identify similarities and differences across discourses within a sample of persons. Respondents are asked to rank a variety of statements on a constrained quasi-normal distribution (see Figure 3). This generates quantitative data which can be analysed through statistical techniques. The final result, however, is rich qualitative information about the respondents' opinions on the predetermined set of statements. The results are indeed representative of the concurrence of statements used even with small, selected samples (Brown 1980).

We began the interview with four general questions pertaining to the farmer's characteristics, the size of his property

TABLE 2 Characteristics of the different farmers interviewed

Farmer	Gender	Age	Number of children living on the property	Localization	Distance to centre of SFX by car	Production type	Forest cover	Relationship with Adafax
A	M	35	2	Tancredo	< 30 min	Cattle for meat, cocoa, fruit	20–30%	Member
B	M	37	0	Tancredo	10 min	Cattle for milk, cupuaçu, acerola, chicken, fruit	20–30%	Occasional assistance
C	M	52	1	Maguary	< 30 min	Only cocoa	> 50%	No relationship
D	M	67	1	Tancredo	< 30 min	Cocoa, pigs, chicken, cattle for meat and milk	Around 30%	Occasional assistance
E	M	28	3	Casa de Tabua	3 hours	Cattle for meat	40%	No relationship
F	M	31	5	Xada	45 minutes	Cocoa, cupuaçu, cattle for milk, wheat	20%	Member
G	M	30	0	Maguary	< 30 min	Cocoa, banana, cattle for meat and milk	20%	Member
H	M	55	1	Vila Central	4 hours	Cattle for meat and milk, beans, cocoa, banana, cassava, rice	Around 50%	Occasional assistance
I	M	48	4	Vila Primavera	4.30 hours	Rice, corn, beans, cassava, cattle for meat and milk, pigs, chicken	80%	No relationship
J	M	59	4	Assentamento Pombal	6 hours	Cattle for meat	Almost all of his property	Member
K	M	43	2	Vila dos Crentes	> 6 hours	Cattle for meat and milk, corn	80%	Member
L	M	34	1	Vila dos Crentes	> 6 hours	Cattle for meat and milk	60%	Occasional assistance
M	M	67	3	Vila dos Crentes	> 6 hours	Cattle for meat, cocoa, beans	60%	Member
N	M	44	4	Vila dos Crentes	> 6 hours	Cattle for meat	40%	Member

FIGURE 3 Example of an interview using Q methodology (statements are placed between 'strongly approves' – on the bottom here – and 'strongly disapproves' – on the top)



and his production. Then, each farmer was presented with a series of opinion statements (hereafter S), which he had to classify according to his level of agreement or disagreement. The opinion statements, predefined by the research team based on answers in previous interviews, pertained to eight topics (see Table 4): the farmer's perception of his farm, of his capacity to change practices, of environmental regulations, of deforestation, of his responsibility, his requirements to be able to stop deforesting, his perception of payments for conserving forests, and the modalities of such payments. To facilitate the procedure, the opinion statements were written on cards that the farmers had to place on a paperboard (Figure 3). Administering each Q test took 30 minutes on an average. Although it was not always easy for the farmers to choose how to prioritize the statements, they were very willing to cooperate with such an interactive, tactile and dynamic methodology. Many farmers told us that they found this methodology interesting and original.

For each interviewee, the statements were coded (-2 for strongly disapproves, -1 for disapproves, 0 for indifferent, 1 for approves and 2 for strongly approves). The Q sorts obtained through the Q tests were analysed following the methods detailed in Brown (1980). Q methodology involves inverted factor analysis, where the Q sorts – and not the statements – are used as variables (Stephenson 1953). A cross-correlation matrix with Q sorts in columns and statements in rows is factored through principal component analysis. To individuate the most relevant factors, we followed Sandbrook *et al.* (2013) in adopting the Kaiser-Guttman criterion, in which only the three factors with eigenvalues greater than one were retained for rotation, accounting for 86% of total variance. We used a varimax rotation since no criteria justified a judgemental one. No farmer was excluded from the analysis, and all of them loaded significantly ($p < 0.05$) on at least one factor (Table 3).

Factor scores were calculated as a weighted average of the farmers' Q sort. Weights were calculated as a function of factor loadings, assigning more gravity to the Q sorts loading higher on the factor.

Table 4 reports the z scores obtained by standardising the factor scores. We also calculated a significance test to identify the statements which are more characteristic of each factor. Information gathered through interviews and other sources (see Table 2) can be linked to the farmers' loading on each factor, and enables us to complement the Q methodology results.

TABLE 3 Q-sorts allocation across factors according to factor loading

Q sorts	Factor 1	Factor 2	Factor 3
A	0.8155 X	0.1137	0.1968
B	0.8376 X	-0.0407	0.0318
C	0.5267 X	-0.2538	0.3152
D	0.7034 X	0.0928	0.0114
E	-0.0129	0.1517	0.5402 X
F	0.7139 X	-0.0991	0.2746
G	0.5006 X	0.4325	-0.1655
H	0.2383	0.357	0.3991 X
I	-0.1746	0.7457 X	0.0823
J	0.0942	0.6183 X	0.4285
K	0.4244	0.6705 X	0.0333
L	-0.1357	0.6947 X	0.1048
M	0.2051	0.0598	0.6843 X
N	0.2377	0.2256	0.629 X

X indicates the factor retained for allocation

TABLE 4 Characterization of the three discourses. Values correspond to standardized factor scores. Asterisks indicate most distinguished statements, when differences between scores are significant (* $p > 0.1$; ** $p > 0.05$; *** $p > 0.01$)

Categories of statements	Opinion Statements	Discourse 1	Discourse 2	Discourse 3
	Eigenvalue	3.96	2.28	1.16
	Farmers who most load on this discourse	A, B, C, D, F, G	I, J, K, L	E, H, M, N
The farmer's vision of the property	S 1. I want to stay on my property because I like working here.	0.83	1.16	1.3
	S 2. I am living here because I do not have any other employment opportunities.	-0.89	-1.79 **	-1.09
	S 3. I want to improve my property for my sons and grandsons.	1.41	1.4	0.84 *
Capacity to change practices	S 4. I do not know very well how to change my farming practices.	-1.27	0.59 ***	-0.86
	S 5. I am looking for new practices, which would allow me to produce without degrading the environment.	1.55	1.07	-0.09 ***
Perception of environmental regulation	S 6. I am worried that I will not be able to stay any longer on my property because of increasing environmental regulation.	-1.79 ***	0.18 ***	-0.79 ***
	S 7. For me it is easier to adapt to environmental regulation than for other farmers.	0.15	-1.62 ***	-0.14
	S 8. I think that deforesting is the only way for me to produce sufficiently.	-1.23 ***	1.82 ***	0.57 ***
Perception of deforestation	S 9. I think that I could earn enough without having to deforest.	1.31 ***	-1.82 ***	-0.37***
	S10. Money availability determines everything I do on my property.	0	-0.37	2.01 ***
	S 11. If I could produce more on my property, I could stop deforesting.	0.93	0 ***	1.23
	S 12. I stopped deforesting because of the frequent controls and sanctions.	-1.1	-1.46	0.92 ***
	S 13. I stopped deforesting because I like my forest.	1.24 ***	-1.29 **	-0.67 **
Responsibility of the farmer	S 14. I think that I have the right to deforest because I produce food for others.	-0.86 *	0.86 ***	-1.4 *
	S 15. Farmers have the right to manage their property as they please.	-1.37 ***	-0.28	-0.22
	S 16. Farmers who damage the environment have to be punished more severely.	0.86 ***	-0.33 ***	-1.46 ***
	S 17. There is enough environmental regulation and they should stop bothering the farmers.	-0.77	0.48 ***	-1.22
Needs of the farmer	S 18. To be able to stop deforesting, I need new production types.	1.42	0.44 **	0.99
	S 19. With new credit lines, I could produce more.	0.15	0.33	1.61 ***
	S 20. I think I could only produce more with more machines.	-0.15	0.17	-0.16
	S 21. My biggest problem is to sell my production.	0.03	-0.37	-0.8
	S 22. With more technical assistance I could improve my production.	1.12	1.4	1.06

to be continued

TABLE 4 *Continued*

Categories of statements	Opinion Statements	Discourse 1	Discourse 2	Discourse 3
	Eigenvalue	3.96	2.28	1.16
	Farmers who most load on this discourse	A, B, C, D, F, G	I, J, K, L	E, H, M, N
Perception of a payment to conserve the forest	S 23. With a payment to stop deforesting, I would buy food and clothes.	-1.34 ***	-0.26	-0.3
	S 24. With a payment to stop deforesting, I would invest in my property to produce more.	0.29	0.26	-0.07
	S 25. If I do not obtain any payment for my forest, it does not have any benefits for me.	-0.35 ***	1.03	1.07
Modalities of such a payment	S 26. Such a payment should be determined according to the size of the forest.	-0.64 **	-1.36	-1.69
	S 27. Such a payment should benefit more to the small-scale farmers.	0.78	-0.13 *	0.4
	S 28. In a municipal program against deforestation, the priority should be to increase actions of support to the farmers.	0.07	0.24	0
	S 29. In a municipal program against deforestation, they should give the money directly to the farmers.	-0.37	-0.33	-0.67

RESULTS

General tendencies among small-scale farmers in SFX

Applying Q methodology to our sample revealed certain issues on which the farmers' responses were homogeneous on the whole (see Table 4).

To begin with, all the 14 small-scale farmers we interviewed agree in their desire to stay on their property because they like it, and not because they have no other employment options (statements S 1 and S 2). They also want to improve their properties for their sons and grandsons (S 3). This tendency of raising the bequest value was unexpected, as farmers in SFX traditionally did not have such a long-term vision for their properties. According to our conversations with local institutions, SFX used to be characterised by a high turnover of properties. A farmer would sell his property once it was degraded and move on to a forested property, where he would use slash-and-burn practices to clear it. This approach has changed in the last decade: with the advent of command-and-control measures, accompanied by efforts undertaken by different social organizations to raise awareness, farmers know that it is more difficult and less desirable to apply slash-and-burn practices on forested areas. Instead, they now prefer to increase incomes from their existing properties.

The second common tendency is that all farmers agree that they could stop deforesting if they either could produce more on their existing properties (S 11), or if they had new

types of production (S 18). To achieve this, they agree that they would need new lines of credit, machines or technical assistance (S 19, 20 and 22), while selling their production is not a priority for now (S 21). This is why most of them would rather invest a payment for environmental services in their properties than use it to satisfy primary needs, such as food or clothing (S 23 and 24). In a municipal programme against deforestation, they agree that the support for the farmers is more important than direct payments (S 28 and 29).

These discourses translate intentions but, in practice, deforestation rates in SFX reveal that many small-scale farmers have not yet been able to stop deforesting. They seem to think the situation is unfair towards them, as they consider that a payment to stop deforesting should not be determined according to the size of the forest but should benefit more the small-scale farmers (S 26 and 27).

Characterization of the three main discourses

A more detailed analysis uncovers three specific discourses behind these general tendencies (see Table 4), revealing divergences between their fundamental motivations and the need to increase the incomes from their properties.

Discourse 1: *The environmentally aware farmers*⁴

The six farmers who are closest to the *environmentally aware discourse* have already stopped deforesting, which explains why they are not worried about abandoning their properties

⁴ These labels do not imply any judgment of the farmers or their activities but are only used to differentiate their preferences.

because of increasingly stringent environmental regulations (S 6). They do not think that deforesting is the only way to produce sufficiently (S 8) and they think that they can earn enough without deforesting (S 9), having already started diversifying their production and practicing alternatives to cattle farming. They agree that they stopped deforesting not only because of the controls and sanctions, but because they like their forests (S 12 and 13). In fact, they are the only ones who believe that even without receiving a payment to conserve the forest, it holds benefits for them (S 25).

Various explanations can be put forward to explain why these *environmentally aware farmers* adopt an environmentalist discourse. They all live in communities close to SFX (a maximum of 30 minutes by car), and thus have better access to market facilities, environment-related information, anti-deforestation messages and technical assistance. Perhaps also because of this proximity, the *environmentally aware farmers* already cultivate and sell fruit and cocoa, which are highly profitable.

Interestingly, their properties have a reduced forest cover (around 20–30%). Therefore, they are not allowed to deforest any more areas according to the Forest Code and may even have to reforest some areas. Conversations on the sidelines of the interviews revealed that by being closest to discourses of enforcement and sustainability, they have learnt from the NGOs the importance of standing forests in providing services pertaining to climate, water and productivity to the community.

Discourse 2: *The worried farmers*

The four farmers who are closest to the *worried discourse* have already tried to stop deforesting and to diversify their production, but they do not really know how to change their farming practices (S 4). They are on the lookout for new practices which would allow them to produce without degrading the environment (S 5).

They state that they are worried that they will not be able to stay on their properties due to increasingly stringent environmental regulations (S 6) and they feel it is much harder for them to adapt to environmental regulations than it is for others (S 7). For them, it is only through deforesting that they can have sufficient production (S 8) and they strongly disagree with the statement that they could earn enough without having to deforest (S 9).

The *worried farmers* also have a different perception about their responsibilities. They think that they have the right to deforest because they produce food for others (S 14). They find that there is enough environmental regulation and the authorities should stop bothering the farmers (S 17).

The *worried farmers* have limited resources and live farther away from the town of SFX. Even though some grow fruits and vegetables for their personal consumption, so far they only sell cattle, though some have plans to sell cocoa in the future. They have more forest cover on their properties (around 80%), which leaves little space for new production systems. This is an important aspect because most alternative production systems require deforested areas in the first place. Although cocoa can be produced within forests, it is easier and cheaper to plant a cocoa plantation on a degraded area.

Discourse 3: *The frontier farmers*

The *frontier farmers* are not yet looking for less degrading farming practices (S 5) and they seem to consider there is no problem with current practices (S 4).

For them, money availability determines everything they do on their property (S 10), so they will only stop deforesting if threatened by enforcement authorities (S 12). Surprisingly, they do not feel that there is too much environmental regulation (S 17), probably because they have not yet felt the pressure of new regulations and enforcement mechanisms.

They strongly agree that with new lines of credit, they could produce more (S 19), which may reflect their perception that with increased investment in their properties, it would be quite easy to increase their revenues. However, given their characteristics, they would probably apply this credit to cattle production and it would not be a guarantee for less deforestation.

The *frontier farmers* are typical of the farmers found on a new deforestation frontier. They are still very much focused on cattle farming. Most of them live very far from the city (at least 6 hours by car) and have, on average, about 50% of forest cover on their properties.

Divergent needs and options for REDD+

These three discourses in our sample reveal that small-scale farmers can have very different positions in relation to deforestation, are engaged to various degrees in a transition towards sustainable alternatives and thus have very different needs (Table 5).

At first glance, these three profiles seem to be in great part determined by geography, which makes sense in a Von Thünen perspective where alternatives depend on the distance to the town. A recent regional zoning undertaken by Adafax seems to confirm this perspective. It mapped out SFX in three zones: first, the region closest to the city, which benefits from good roads and access to energy and where plots have been occupied for a long period and are highly deforested (generally over 80%) (Follet 2002). The intermediate region is too far away from the city to commercialize perishable products (fruits and vegetables), but good road access allows a certain degree of diversification (cocoa and milk). The farmers have occupied this region for a long period as well (Ibid). Finally, the most recently occupied areas, including the north-east of the municipality, rely mainly on extracting value from the still disputed land. This is often only possible through deforestation given that the lack of access to market facilities makes it almost impossible to produce anything other than cattle (Sablayrolles 2006).

However, the extent of the forest reserve on a property seems to be a greater determinant of the discourses. In the zoning, the forest reserve would be expected to increase with the distance to the town. However, the *worried farmers* who are in the intermediate zone aren't in an intermediary situation between the environmentally aware farmers and the frontier farmers, but have a different situation in relation to forest reserve, with 80% or more forest on their property.

TABLE 5 Comparison of the three discourses and associated farmers

Discourse	Environmentally-aware Farmer	Worried Farmer	Unpreoccupied Farmers
Determining conditions	Proximity to SFX High diversification Little forest	Medium distance to SFX Almost no diversification Large forest areas	Large distance to SFX No diversification Medium forest areas
Position on deforestation	Have stopped because they value their standing forest	Would like to stop but consider it is not viable	Would only stop if sanctions or economic incentives
Engagement in transition	They want to change their practices or have already changed them	They would like to change their practices but do not know how to do so nor have the means	They do not want to change their practices
Needs	Need to be consolidated in their choice: better commercialisation and infrastructure	Need to be reassured that they can make it: discover new viable productions through technical assistance and build assets (payments or credit lines)	Need to encounter limits and view opportunities: Awareness raising, Use-restricting payments

Thus each discourse seems to be linked with the environmental state of the property. This has important policy implications for a REDD+ initiative, as this can form a basis for targeting actions.

The *environmentally aware farmers* seem to sincerely believe that their forest has value and they need to be consolidated in the trajectory they are taking. The farmers belonging to the Association of Women Producing Fruit Pulp (AMPPF) explained that their biggest challenge is the lack of electricity, without which they cannot transform the fruit into pulp. Due to bad roads conditions, the fruit cannot be transported to the next community. A REDD+ initiative focused on use-restricting payments would not be effective for them in increasing revenues. It would instead need to promote policy measures which include municipal investment in infrastructure (Angelsen and Rudel 2013).

The *worried farmers* seem to be in a tight situation, having little open space for alternative production systems since 80% or more of their properties are covered by forest. They are the ones who have preserved most until now, so they need to be reassured and supported. Technical assistance has to be provided to them to show that viable options exist without requiring deforestation, such as agroforestry systems. Compensating or rewarding them for the additional standing forest may make sense in their case, especially if it enabled them to invest in other activities, with asset-building payments or lines of credit. For them, a REDD+ initiative could implement payments but should, more importantly, address the lack of personnel, vehicles and equipment in the technical assistance organisations in the municipality.

As far as the *frontier farmers* are concerned, it is critical to address their future deforestation. They clearly have no intention of changing their practices and will probably continue clearing their frontier unless prevented from doing so by enforcement actions. Fining small-scale farmers who barely make a living is difficult and ethically questionable (Gezelius 2004), which leaves incentives as the only alternative. Since

they have less forest than is legally required, use-restricting payments would probably not be legitimate. Payments for reforesting their reserve or for riparian vegetation may be a better option to improve their perception of the environment.

DISCUSSION

Our analysis revealed that small-scale farmers do indeed have very different needs that have to be met before they can engage in a transition to stop deforesting. Differentiating support according to the needs of small-scale farmers may seem attractive, but such an approach raises an important question in terms of equity: can a policy that targets specific populations differently be equitable?

One of the main concerns raised by authors (Pagiola *et al.* 2004, Pascual *et al.* 2010) is whether it is equitable to provide more support to those who are still contributing to high deforestation rates than to those who have made early efforts to produce alternatives in a more sustainable way. Potential destroyers are rewarded more than 'forest guardians' such as indigenous and forest-dependent people (Karsenty 2012). In our study, the *frontier farmers* who still deforest may only stop if compensated, while the *environmentally aware farmers* primarily require investments in better roads and markets where they can sell production – which are arguably public services that should be provided by any state regardless of deforestation. However, our study also showed that the *frontier farmers* and *worried farmers* tend to be the poorest, lagging behind in the transition out of deforestation due to their lack of resources for the initial investment required to grow cocoa or fruit and vegetables. They also tend to live farthest away from the centre of SFX and to have the most forest on their properties. Thus, increased support could compensate them for their disadvantageous conditions and the forest they still maintain, instead of 'rewarding' them for their contribution to deforestation.

In the perspective of Aristotle's proportional equality we presented in the theoretical part of this article, this would be considered equitable since it would aim at offering them an equal opportunity to engage in the transition out of deforestation (see Table 1). Equity thus takes on a more dynamic sense and goes beyond the mere re-balancing of 'static' inequalities at a given moment. In fact, the diversity of the needs of the farmers can be better understood if we consider the transition towards sustainable alternatives as a complex process, and that these needs vary according to how far along the farmer is in this process. Based on the divergence of the farmers' needs according to their profiles, the debate on REDD+ should not be limited to what type of support should be provided to each profile. It should, in addition, involve a reflexion on which moment of the transition the different support measures would be most effective in enabling the farmers to adopt more sustainable practices while increasing their revenues over the long term.

The second critical issue in adapting a REDD+ programme to the needs of the farmers is how to target the different types of support to the specific categories of farmers, without disproportionately increasing the transaction costs involved. Targeted contracts are always challenging because of the difficulty of extracting private information from individuals seeking to receive benefits (Akerlof 1970), and this is exacerbated in contexts where reliable information is hard to come by. Techniques such as screening contracts can be used to induce individuals to share their true preferences and to complement publicly available information on opportunity costs (Ferraro 2008).

However, any type of market-based incentive can prepare the ground for environmental blackmailing by farmers owning unthreatened forests (Wunder 2007). This risk is reduced for an investment-oriented Payment for Environmental Services (PES) programme, including technical assistance and rural credit programmes, in comparison to direct payments (Karsenty 2012). In our case, our results show that if left to voluntarily choose their type of contract, the farmers would probably choose the type of support they most need in their phase of the transition towards alternatives to cattle-farming, given that the other forms of support are not really useful to them.

Spatial targeting has also been considered for the distribution of incentives and may be appropriate for those with land directly adjacent to the forest (Wätzold and Drechsler 2005, Wünschler *et al.* 2008). However, such forms of targeting typically involve relatively high transaction costs. In our case, it would make sense to target communities according to regional zones, determined on the basis of the distance to the city, which could help reduce transaction costs.

Any targeting option raises the issue of whether farmers who have already stopped deforesting, such as the *environmentally aware farmers*, should be included. It can be argued that from a standpoint of environmental effectiveness, it does not make sense to include them in a support project. However, the capital earned through diversification may lead to an increase of deforestation elsewhere if the farmer invests the additional capital in more land or more cattle, in a typical

leakage effect. An additional support for those who have already stopped deforestation and diversified their production would thus be an additional way of ensuring a reduction in deforestation not just at a property level but at a municipal level.

If considered as an administrative task, identifying the form of support adapted to the diversity of needs of the farmers and targeting the right farmers may seem as a highly complex and bureaucratic task. However, involving the local farmers themselves in defining such criteria may reveal much easier and result in interesting solutions. While we are conscious that including local people in defining the rules and monitoring poses collective action challenges (Stevens 1997), our point is that to address the specific needs revealed by our results and enable proportional equality in support, local actors must participate in the definition of a REDD+ initiative, as suggested by Brown and Corbera (2003) or Gebara (2013).

CONCLUSION

To reconcile a reduction in deforestation – which is being enforced as a legal obligation in recent years – with increased incomes, farmers are progressively moving away from slash-and-burn practices and the creation of new cattle pastures towards more sustainable practices. These include the production of cocoa, fruit and vegetables in the case of SFX, and also the intensification of pastures, production of milk and mechanization.

Our interviews with institutions and as well as results from Q methodology showed that there exist multiple obstacles in SFX preventing the farmers' transition towards more sustainable practices. These include not only the lack of knowledge about the alternatives, the lack of technical support and financial means but also insufficient market opportunities for these new products.

These challenges have not yet been rightfully addressed by the regulatory approach of the federal government, although some recent measures are aimed at correcting these shortcomings. The federal government is now encouraging local production for school canteens and restructuring a federal technical assistance institution (which had been dismantled during the liberalisation of the 1990s). These measures could be complemented by REDD+ funds, which could help address these flaws and encourage small-scale farmers to effectively transition towards more sustainable practices.

Despite the small sample, Q methodology revealed a substantial heterogeneity of views concerning deforestation, environmental regulation, farmers' responsibilities and capacities, and payments to avoid deforestation. Our results showed that since farmers are at different stages in a transition towards more sustainable practices, there exists no standardised solution to reduce deforestation even in a single municipality. A strong implication for the design of REDD+ initiatives is the need to address a wide array of farmer needs and to enable them to increase their income with activities rather than providing payments alone. Only if the specific

needs of the different categories of farmers are met – such as technical assistance, lines of credit for sustainable agriculture, and commercialisation-related infrastructure – will the farmers be able to engage in a transition towards sustainable practices. This is a solid argument for a strong engagement of local actors in defining the way REDD+ must be implemented.

The development and implementation of a targeted initiative might indeed be more complex than a uniform type of support, but it is also more equitable in offering different farmers equal opportunities to progressively adopt sustainable practices and engage on a low-deforestation development path over the long term. One of the challenges is the risk of perceived unfairness, for example by providing more support to the farmers who have not started engaging in a transition towards sustainable alternatives. The targeting method becomes essential to the equity of the REDD+ initiative. The results of our exploratory analysis provide a first basis for further research on the variety of farmer needs that have to be met as a pre-requisite to sustainable agriculture. More reflection is needed on how different initiatives can be more effective in addressing farmer needs in a perspective of proportional equality.

ACKNOWLEDGEMENTS

As first author, I would like to thank everyone who supported my field research. I was kindly hosted by the father Danilo Lago, who has always a word of wisdom supporting the rural poor. Celma de Oliveira and Pierre Clavier also greatly contributed to this work by explaining the specificity of the municipality and its recent evolution. I acknowledge Reinaldo José de Barcelos for taking me along on his field trips and facilitating the first interviews with the smallholder farmers. I thank Raimundo Nonata de Santos for sharing his historical and geographical knowledge about São Felix do Xingu, and for his support with using the mapping programmes. Lastly the authors really appreciated the comments from the reviewers, which greatly helped to improve and enrich the article. This work was carried out as part of the project “Payer pour l’environnement?” financed by the Repères program of the French Ministry of Ecology.

REFERENCES

- ANGELSEN, A. and KAIMOWITZ, D. 2001. *Agriculture technologies and tropical deforestation*. CAB International.
- ANGELSEN, A. and RUDEL, T. K. 2013. Designing and implementing effective REDD+ Policies: A Forest Transition Approach. Published by Oxford University Press on behalf of the Association of Environmental and Resource Economists.
- ADAFAX Association for the Development of Family Farmers in the Alto Xingu. 2012. *Livro Adafax 2012*.
- AKERLOF, G. 1970. The market for lemons: qualitative uncertainty and the market mechanism. *The Quarterly Journal of Economics* **84**(3): 488–500.
- ANGELSEN, A. and WERTZ-KANOUNNIKOFF S. 2008. Moving ahead with REDD: Issues, Options and Implications, A. Angelsen Ed., Center for International Forestry Research (CIFOR): 11–22.
- ANGELSEN, A. 2010. Policies for reduced deforestation and their impact on agricultural production. *PNAS* **107**(46): 19639–19644.
- ARISTOTLE. *Nicomachean Ethics*. In: *Aristotle in 23 Volumes*, Vol. 19. 1934. Translated by H. Rackham. Cambridge, MA, Harvard University Press; London, William Heinemann Ltd.
- MARGONO, B.A., POTAPOV, P.V., TURUBANOVA, S., STOLLE, F. and HANSEN, M.C. 2014. Primary forest cover loss in Indonesia over 2000–2012. *Nature Climate Change* **4**: 730–735.
- ASSUNÇÃO, J., GANDOUR, C., ROCHA, R. and ROCHA, R. 2013. Does credit affect deforestation? Evidence from a rural credit policy in the Brazilian Amazon, *Climate Policy Initiative, Núcleo de Avaliação de Políticas Climáticas, PUC*.
- BAKER, R., THOMPSON, C., MANNION, R. 2006. Q-methodology in health economics. *Journal of Health Services and Policy Research* **11**: 38–45.
- BALIEIRO, C. 2013. Nota técnica – Diagnóstico do desmatamento no município de SFX. Anos 2012 até Agosto 2013. Belém, Brazil: The Nature Conservancy.
- BARRETO, P. and SILVA, D. 2009. The challenges to more sustainable ranching in the Amazon. *IMAZON state of the Amazon report* **14**: 554–556.
- BARRETO, P., ARIMA, E. and SALOMÃO, R. 2009. What has been the effect of the new policies against deforestation in the Amazon? Retrieved February 06 2015, from *IMAZON*: http://www.imazon.org.br/novo2008/arquivos/db/110548effect_of_policies_against_deforestation_brazil.pdf
- BARRETO, P. and ARAÚJO, E. 2012. O Brasil atingirá sua meta de redução do Desmatamento? Belem, PA: IMAZON.
- BARRY, J. and PROOPS, J. 1999. Seeking sustainability discourses with Q methodology. *Ecological Economics* **28**(3): 337–345.
- BARTELS, W.L., SCHMINK, M., BORGES, E.A., DUARTE, A.P. and ARCOS, H. 2010. Diversifying livelihood systems, strengthening social networks and rewarding environmental stewardship among small-scale producers in the Brazilian Amazon: lesson from *Proambiente*, in: Tacconi, L., Mahanty, S. and Suich, H. (eds.), Payments for Environmental Services, Forest Conservation and Climate Change: Livelihoods in the REDD? *Cheltenham, Edward Elgar*: 82–105.
- BÖRNER, J., MENDOZA, A. and VOSTI, S.A. 2007. Ecosystem services, agriculture, and rural poverty in the Eastern Brazilian Amazon: interrelationships and policy prescriptions. *Ecological Economics* **64**(2): 356–373.

- BOMMEL, P., BONAUDO, T., BARBOSA, T., DA VEIGA, J.B., PAK, M.V. and TOURRAND, J.F. 2010. La relation complexe entre l'élevage et la forêt en Amazonie brésilienne: une approche par la modélisation multi-agents. *Cahiers Agricultures* **19**(2): 104–111.
- BOND, I., GRIEG-GRAN, M., WERTZ-KANOUNNIKOFF, S., HAZLEWOOD, P., WUNDER, S. and ANGELSEN, A. 2009. Incentives to sustain forest ecosystem services: A review and lessons for REDD. London, UK: *International Institute for Environment and Development* (IIED).
- BRANNSTROM, C. 2011. A Q-method analysis of environmental governance discourses in Brazil's northeastern soy frontier. *Professional Geographer* **64**(3): 531–49.
- BRASIL. 2007, December 21. Dispõe sobre ações relativas à prevenção, monitoramento e controle de desmatamento no Bioma Amazônia, bem como altera e acresce dispositivos ao Decreto no 3.179, de 21 de setembro de 1999, que dispõe sobre a especificação das sanções aplicáveis à conduta. Decreto/6.321 (2007). Brasília, Distrito Federal, Brazil: Diário Oficial da União.
- BRONDÍZIO, E.S., CAK, A., CALDAS, M.M., MENA, C., BILSBORROW, R., FUTEMMA, C.T., LUDEWIGS, T., MORAN, E.F. and BATISTELLA, M. 2013. Small farmers and deforestation in Amazonia, in: *Amazonia and Global Change* (eds M. Keller, M. Bustamante, J. Gash and P. Silva Dias), American Geophysical Union, Washington, D. C.
- BROWN, S.R. 1980. *Political subjectivity: Applications of Q methodology in political science*. New Haven, Yale University Press.
- BROWN, K. and CORBERA, E. 2003. Exploring equity and sustainable development in the new carbon economy. *Climate Policy* **3S1**: 41–56.
- BYERLEE, D., STEVENSON, J. and VILLORIA, N. 2014. Does intensification slow crop land expansion or encourage deforestation. *Global Food Security* **3**: 92–98.
- CORBERA, E., BROWN, K. and ADGER, W.N. 2007. The equity and legitimacy of markets for ecosystem services. *Development and Change* **38**(4): 587–613.
- COSTA, C.R. 2008. Pagamento por serviços ambientais: limites e oportunidades para o desenvolvimento sustentável da agricultura familiar na Amazônia Brasileira. Tese de doutorado em Ciências Ambientais, orientador: Abramovay, R. USP, São Paulo.
- COUDEL, E., PIKETTY, M.G., GARDNER, T., VIANA, C., FERREIRA, J., MORELLO, T., PARRY, L., BARLOW, J., ANTONA M. 2012. Environmental compliance in the Brazilian Amazon: exploring motivations and institutional conditions. In: 12th Biennial Conference of the International Society for Ecological Economics (ISEE 2012 Conference) 'Ecological Economics and Rio+20: Challenges and Contributions for a Green Economy', 2012, Rio de Janeiro.
- COUDEL, E., FERREIRA, J., AMAZONAS, M., ELOY, L., HERCOWITZ, M., MATTOS, L., MAY, P., MURADIAN, R., PIKETTY, M., TONI, F. (in press). The rise of PES in Brazil: from pilot projects to public policies. In: Muradian et al. (eds) *Handbook of Ecological Economics*. Edward Elgar.
- DENNIS, K., VAN RIPER, C.J. and WOOD, M.A. 2011. Payments for ecosystem services as a potential conservation tool to mitigate deforestation in the Brazilian Amazon. *Applied Biodiversity Perspective Series* **1**(2): 1–15.
- DI GREGORIO, M., M. BROCKHAUS, T. CRONIN, E. MUHARROM, L. SANTOSO, S. MARDIAH and MBÜDENBENDER M. 2013. Equity and REDD+ in the media: a comparative analysis of policy discourses. *Ecology and Society* **18**(2): 39.
- DUCHELLE, A.E., CROMBERG, M., GEBARA, M.F., GUERRA, R., MELO, T., LARSON, A., CRONKLETON, P., BÖRNER, J., SILLS, E., WUNDER, S., et al. 2014. Linking forest tenure reform, environmental compliance and incentives: Lessons from REDD+ initiatives in the Brazilian Amazon. *World Development* **55**(3): 53–67.
- FERRARO, P.J. 2008. Asymmetric information and contract design for payments for environmental services, *Ecological Economics* **65**(4): 810–821.
- FOLLET, C. 2002. Diagnostic agraire en front pionnier amazonien. SFX, Sud du Pará, Brésil, Mémoire de fin d'études d'Agronomie, *Chaire d'Agriculture comparée, Institut National Agronomique Paris – Grignon AgroParisTech*, Paris.
- GEBARA, M.F. 2013. Importance of local participation in achieving equity in benefit-sharing mechanisms for REDD+: a case study from the Juma Sustainable Development Reserve. *International Journal of the Commons* **7**(2): 473–497.
- GEBARA, M.F. 2014. Sustainable Landscapes Program in Sao Felix do Xingu, in: *REDD+ on the Ground* (eds E.O. Sills, S. Atmadja, C. de Sassi, A. Duchelle, D. Kweka, I.A. Pradnja Resosudarmo and W.D. Sunderlin), CIFOR, Bogor, Indonesia.
- GEZELIUS, S. 2004. Food, Money, and Morals: Compliance Among Natural Resource Harvesters. *Human Ecology* **32**(5): 615–634.
- GODAR, J., GARDNER, T.A., TIZADOB, E.J. and PACHECO P. 2014. Actor-specific contributions to the deforestation slowdown in the Brazilian Amazon, *PNAS* **111**(43): 15591–15596.
- GUIMARÃES, J., VERISSIMO, A., AMARAL, P. and DEMACHKI, A. 2011. *Municípios Verdes: caminhos para a sustentabilidade*, Belém, Imazon.
- GRIEG-GRAN, M., PORRAS, I. and WUNDER, S. 2005. How can market mechanisms for forest environmental services help the poor? Preliminary Lessons from Latin America, *World Development* **33**(9): 1511–1527.
- GRISCOM B. and CORTEZ R. 2011. Establishing efficient, equitable, and environmentally sound reference emissions levels for REDD+: A stock-flow approach. Arlington: The Nature Conservancy.
- GROSS-CAMP, N., MARTIN, A., MCGUIRE, S., KEBEDE, B. and MUNYARUKAZA, J. 2012. Payments for Ecosystem Services in an African protected area: exploring issues of legitimacy, fairness, equity and effectiveness. *Fauna and Flora International, Oryx* **46**(1): 24–33.

- HALL A. 2013. Combatting deforestation through REDD+ in the Brazilian Amazon: a new social contract. *Sustentabilidade em debate* **4**(1): 79–98.
- INPE. 2014. Prodes. Retrieved February 06, 2015, from: <http://www.obt.inpe.br/prodes/index.php>.
- KARSENTY, A. 2004. Des rentes contre le développement? Les nouveaux instruments d'acquisition mondiale de la biodiversité et l'utilisation des terres dans les pays tropicaux. *Mondes en développement* **127**(3): 1–9.
- KARSENTY, A. 2007. Questioning rent for development swaps: new market-based instruments for biodiversity acquisition and the land-use issue in tropical countries. *International Forestry Review* **9**(1): 503–513.
- KARSENTY, A., SEMBRES, T. and RANDRIANARISON M. 2010. Paiements pour services environnementaux et biodiversité dans les pays du sud. *Revue Tiers Monde* **202**(2): 57–74.
- KARSENTY, A. 2011. Combining conservation incentives with investments, *Perspectives CIRAD*.
- KARSENTY, A. 2012. Financing options to support REDD+ activities, *European Commission*.
- KINZIG, A.P., PERRINGS, C., CHAPIN III, F.S., POLASKY, S., SMITH, V.K., TILMAN, D., TURNER II, B.L. 2011. Paying for Ecosystem Services – Promise and Peril. *Science* **334**(6065): 603–604.
- LANDELL-MILLS, N. and PORRAS, I.T. 2002. *Silver bullet or fool's gold? A global review of markets for forest environmental services and their impact on the poor*. International Institute for Environment and Development, London, UK.
- LE TOURNEAU, F.-M., MARCHAND, G., GREISSING, A., NASUTI, S., DROULERS, M., BURSZTYN, M., LÉNA, P. and DUBREUIL, V. 2013. The DURAMAZ indicator system: a cross-disciplinary comparative tool for assessing ecological and social changes in the Amazon. *Philosophical Transactions of the Royal Society B: Biological Sciences* **368**(1619): 20120475.
- LUTTRELL C., L. LOFT, M.F. GEBARA, D. KWEKA, M. BROCKHAUS, A. ANGELSEN and W. SUNDERLIN. 2013. Who should benefit from REDD+? Rationales and realities. *Ecology and Society* **18**(4): 52.
- MERIDIAN INSTITUTE. 2011. Guidelines for REDD+ reference levels: Principles and recommendations, prepared for the Government of Norway. Eds: Angelsen, A., Boucher, D., Brown, S., Merckx, V., Streck, C., Zarin, D.
- MILNE, S. and NIESTEN, E. 2009. Direct payments for biodiversity conservation in developing countries: Practical insights for design and implementation. *Oryx* **43**(04): 530–541.
- MORAN, E.F. 1981. *Developing the Amazon*. Bloomington, USA: Indiana University Press.
- MURADIAN, R., CORBERA, E., PASCUAL, U., KOSOY, N. and MAY, P.H. 2010. Reconciling theory and practice. An alternative conceptual framework for understanding payments for environmental services. *Ecological Economics* **69**(6): 1202–1208.
- MCDERMOTT, M., MAHANTY, S. and SCHRECKENBERG, K. 2012. Examining equity: a multidimensional framework for assessing equity in payments for ecosystem services. *Environmental Science and Policy* **33**(9): 416–427.
- NEPSTAD, D., SOARES-FILHO, B., MERRY, F., LIMA A., MOUTINHO, P., CARTER, J., BOWMAN, M., CATTANEO, A., RODRIGUES, H., SCHWARTZMAN, S., MCGRATH, D., STICKLER, C., LUBOWSKI, R., PIRIS-CABEZAS, P., RIVERO, S., ALENCAR, A., ALMEIDA, O. and STELLA, O. 2009. The end of deforestation in the Brazilian Amazon, *Science* **326**(5958): 1350–1351.
- OCKWELL, D.W. 2008. 'Opening up' policy to reflexive appraisal: a role for Q Methodology? A case study of fire management in Cape York, Australia. *Policy Science* **41**(4): 263–292.
- PACHECO, P. 2009. Agrarian reform in the Brazilian Amazon: its implications for land distribution and deforestation. *World Development* **37**(8): 1337–1347.
- PAGIOLA, S., AGOSTINI, P., GOBBI, J., DE HAAN, C., IBRAHIM, M., MURGUEITIO, E., RAMÍREZ, E., ROSALES, M. and RUÍZ, J.-P. 2004. Paying for biodiversity conservation services in agricultural landscapes, *Environment Department Paper No. 96*. Washington, DC: World Bank.
- PASCUAL, U., MURADIAN, R., RODRÍGUEZ L.C. and DURAIAPPAH, A. 2010. Exploring the links between equity and efficiency in payments for environmental services: A conceptual approach. *Environmental Economics* **69**(6): 1237–1244.
- PESKETT, L., HUBERMAN, D., BOWEN-JONES, E., EDWARDS, G. and BROWN, J. 2008. Making REDD work for the poor. *Overseas Development Institute*.
- PHELPS, J., CARRASCO, L.R., WEBB, E.L., KOH, L.P. and PASCUAL, U. 2013. Agricultural intensification escalates future conservation costs. *PNAS* **110**(19): 7601–7606.
- PIRARD, R., BILLE, R., SEMBRES T. 2010. Questioning the theory of Payments for Ecosystem Services (PES) in light of emerging experience and plausible developments, *Institut pour le Développement Durable et les Relations Internationales (IDDRI)*, Idées pour le débat 10.
- POKORNY, B., JOHNSON, J., MEDINA, G., HOCH, L. 2012. Market-based conservation of the Amazonian forests: Revisiting win-win expectations. *Geoforum* **43**(3): 387–401.
- SABLAYROLLES, P. 2006. A problemática sócioeconômica da agricultura familiar na Terra do Meio (estrada Canopus), São Félix do Xingu: *Comissão Pastoral da Terra- CPT (Projeto Terra do Meio)*.
- SABLAYROLLES, P., OLIVERIA, C. and PINTO, C. 2012. Adequação ambiental e políticas públicas para a agricultura familiar do Alto Xingu, *Associação para o Desenvolvimento da Agricultura Familiar do Alto Xingu (ADAFAX)*, SFX – PA.
- SANDBROOK, C.G., FISHER, J.A. and VIRA, B. 2013. What do conservationists think about markets? *Geoforum* **50**(7): 232–240.

- SANTILLI, M., MOUTINHO, P., SCHWARTZMAN, S., NEPSTAD, D., CURRAN, L. and NOBRE, C. 2005. Tropical deforestation and Kyoto Protocol. *Climatic Change* **71**(3): 267–276.
- SENADO BRASILEIRO. 2012. Glossario do novo Código Florestal. <http://www12.senado.gov.br/codigoflorestal>, assessed 6 May 2013.
- SIMMONS, C., WALKER, R., PERZ, S., CALDAS, M., PEREIRA, R., LEITE, F., FERNANDES L.C. and ARIMA E. 2011. Doing it for themselves: Direction action land reform in the Brazilian Amazon. *World Development* **38**(3): 429–444.
- SISTEMA DE ESTIMATIVA DE EMISSÕES DE GASES DE EFEITO ESTUFA (SEEG). 2013. <http://seeg.observatoriodoclima.eco.br/>
- STEPHENSON, W. 1953. *The study of behavior: Q-technique and its methodology*, Chicago, University of Chicago Press.
- SOMMERVILLE, M., MILNER-GULLAND, E.J., RAHA-JAHARISON and M., JONES, J. 2010. Impact of a Community-Based Payment for Environmental Services Intervention on Forest Use in Menabe, Madagascar. *Conservation Biology* **24**(6): 1488–1498.
- TNC The Nature Conservancy. 2013a. *Curso introdutório sobre mudanças climáticas e florestas. Manual do curso para comunidades locais*. Belém: TNC.
- TNC The Nature Conservancy. 2013b. Fundo Terra Verde. A peça que faltava na virada ambiental de SFX. Belém: TNC. Retrieved on February 06, 2015, from: <http://www.tnc.org.br/nossas-historias/publicacoes/cartilha-fundoterraverde.pdf>
- TNC The Nature Conservancy. 2014. <http://www.tnc.org.br/UNEP/GRID-Arendal> 2009. Top 20 greenhouse gas emitters (including land use change and forestry), *UNEP/GRID-Arendal Maps and Graphics Library*.
- VILLEMAINE, R., SABOURIN, E. and GOULET, F. 2012. Limites à l'adoption du semis direct sous couverture végétale par les agriculteurs familiaux en Amazonie brésilienne. *Cahiers Agricultures* **21**(4): 242–247.
- WÄTZOLD, F. and DRECHSLER, M. 2005. Spatially uniform versus spatially heterogeneous compensation payments for biodiversity enhancing land-use measures. *Environmental and Resource Economics* **31**(1): 73–93.
- WUNDER, S. 2005. Payments for environmental services: some nuts and bolts. CIFOR Occasional Paper No. 42. *Center for International Forestry Research*, Jakarta, Indonesia.
- WUNDER, S. 2006. Are direct payments for environmental services spelling doom for sustainable forest management in the tropics? *Ecology and Society* **11**(2): 23.
- WUNDER, S. 2007. The Efficiency of Payments for Environmental Services in Tropical Conservation. *Conservation Biology* **21**(1): 48–58.
- WUNDER, S. 2008. Payments for environmental services and the poor: concepts and preliminary evidence. *Environment and Development Economics* **13**(3): 279–297.
- WÜNSCHER, T., ENGEL, S. and WUNDER, S. 2008. Spatial targeting of payments for environmental services: a tool for boosting conservation benefits. *Ecological Economics* **65**(4): 822–833.