



Should payments for environmental services be used to implement zero-deforestation supply chain policies? The case of soy in the Brazilian Cerrado



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ABSTRACT

Over the past decade public and private actors have been developing a variety of new policy approaches for addressing agriculturally-driven deforestation linked to international supply chains. While payments for environmental services (PES) have been advocated in many contexts as an efficient and pro-poor environmental policy to incentivize conservation, they have been the subject of intense scrutiny and criticism for leading to mixed and sometimes adverse environmental and social outcomes. It remains unclear whether such an approach is an improvement over existing approaches to govern sustainability in supply chains and especially as a mechanism for reducing ecosystem conversion. Here we conduct an ex-ante analysis to examine the potential outcomes of using a standalone PES scheme versus existing standalone market exclusion mechanisms (MEM) to govern commodity supply chains. The analysis develops a theoretical framework to examine the potential effectiveness, cost-effectiveness, equity, and legitimacy of the two approaches and then applies this framework using qualitative analysis of secondary and interview data. Using this theory-driven evaluation approach we examine the case of the Brazilian Cerrado, where a PES mechanism is currently being proposed to achieve zero-deforestation targets in soy supply chains. We find that both standalone approaches suffer from different strengths and challenges and would be better used in combination. We conclude that a mixture of strict market exclusion with positive incentives and enabling programs that are targeted at the poorest farmers would be more effective, cost-effective, equitable, and legitimate. However, in the future such supply chain focused soy deforestation control efforts in the Cerrado must be complemented by broader jurisdictional approaches to addressing deforestation and sustainable development that include all land use actors, not just soy farmers. These more inclusive and balanced initiatives can help ensure that avoiding deforestation goes hand in hand with supporting sustainable livelihoods for a wider range of actors in the Cerrado.

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1. Introduction

Multinational companies that source deforestation-risk commodities from tropical countries have taken on a prominent role in the direction of global conservation governance over the last decade. Since 2010, companies have been developing a range of mechanisms to address deforestation risks in their supply chains. These now include: collaborative biome-wide agreements to exclude suppliers that clear land after a certain cutoff date, such as the Soy Moratorium (Gibbs et al., 2015b) and G4 Cattle Agreements (Gibbs et al., 2016) in the Brazilian Amazon; company 'No

Deforestation, no Peat, no Exploitation' (NDPE) policies for palm oil in Indonesia; and pledges by some companies who source soy, palm, cocoa, and coffee to only source products certified under third-party certification programs (Garrett et al., 2019; Rothrock et al., 2019). In a more recent development, companies are now debating the use of payments for environmental services (PES), "voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services" (Wunder et al., 2020, p. 23.2) to reduce deforestation among their suppliers (TFA, 2020). Although PES schemes are not new, their use by international commodity companies to address their deforestation risk is unprecedented.

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Historically, the concept and application of PES mechanisms rose to prominence in the early 2000s, when governments and NGOs looked for more efficient ways to incentivize (especially forest) conservation behavior. As of 2018, over 550 PES programs globally distribute annual payments of over US\$36 billion, and are especially prevalent in the Americas and China (Salzman et al., 2018; Wunder et al., 2020). PES-type arrangements have also featured prominently in the global climate change regime via REDD + programs in which high-emitting countries from the global North compensate forest-rich countries for maintaining their forest cover (Corbera, 2012). Among the suite of potential market-based options, PES schemes are often positioned as being “pro-poor” because low-income producers may have the lowest opportunity cost of providing environmental services and thus be the primary actors to participate in the programs and earn payments that offset income losses (Pagiola et al., 2005; Wunder et al., 2020). PES are popular in multi-stakeholder dialogues about next steps for reducing commodity-driven deforestation because they promise to compensate farmers for the high financial opportunity costs of avoided deforestation (Agrawal et al., 2011). In comparison to regulatory command-and-control approaches, PES aim to match beneficiaries’ willingness to pay for ES to providers’ willingness to supply those services, thereby providing a level of conservation that maximizes economic net benefits to society (Engel et al., 2008). These arguments have motivated the industry dialogue in the soy sector to turn to PES as an “effective and fair mechanism for creating financial incentives for soy farmers [...] to transition to producing soy only on existing agricultural land” (Walker-Palin, 2019).

Yet, to date, PES programs have only rarely, and under specific conditions, achieved improvements in conservation outcomes where they have been implemented (Chan et al., 2017). Furthermore, numerous theoretical and empirical concerns have been raised about their distributive, procedural, and contextual equity in practice (Etchart et al., 2020; Haas et al., 2019; McDermott et al., 2013; Pascual et al., 2014; Wunder, 2007). PES programs may fail to recognize and engage with key stakeholders (McDermott et al., 2013; Pascual et al., 2014), exclude land users that already safeguard their environment (Wunder, 2007), create restrictions to subsistence resources (Pascual et al., 2014), lead to loss of land or intracommunity conflicts (Pascual et al., 2014), be captured by local elites (Haas et al., 2019), or reinforce the dependence of ES stewards on unreliable ES buyers (Etchart et al., 2020). Wider-reaching critique from political ecologists and environmental justice scholars highlights the adverse effects of commodifying nature via PES and other market-based instruments (Fletcher, 2020; Smessaert et al., 2020). These include the introduction of neoliberal rationalities in conservation (Fletcher, 2020; Fletcher & Büscher, 2017), the reproduction of pre-existing power asymmetries and inequalities (Kosoy & Corbera, 2010), and the way in which PES create “new market, property, and power relations out of what were often common or public goods” (Kull et al., 2015, p. 132).

The potential use of PES as a zero-deforestation supply chain implementation policy warrants careful examination to determine, ex-ante, whether PES are likely to achieve their conservation and livelihood objectives, especially as compared to alternative supply chain policies. Our work advances the existing scholarship on project-level and national PES schemes by examining for the first time how well-known challenges with PES translate to forest-focused supply chain policies. Specifically, we connect the rich scholarship on PES to the growing field of analysis surrounding the effectiveness and equity of zero-deforestation commitments (ZDCs) in tropical areas of rapid commodity expansion, especially qualitative ex-ante analysis.

We focus on the Brazilian Cerrado, a global hotspot of soy-driven deforestation (Escobar et al., 2020), where supply chain PES initiatives are currently being discussed in several multi-

stakeholder governance forums described in more detail in Section 3 (Bastos Lima & Persson, 2020; TFA, 2020). Specifically, we aim to analyze the potential policy outcomes of a standalone soy-Cerrado-PES scheme that pays farmers not to plant soy on legally clearable areas compared to a standalone market exclusion mechanism that drops suppliers who plant on areas deforested after a specific cut-off date (MEM), as has been used to address soy-driven deforestation (with an initial deforestation soy cut-off date of 2006) and cattle-driven deforestation in the Amazon (with an initial cut-off date of 2009) (Garrett et al., 2019; zu Ermgassen et al., 2020). In focusing on supply chain initiatives (Lambin et al., 2018), we are examining options that can be implemented by multinational companies to govern producer behaviors. This analysis thus does not assess public sector options for conservation, such as more stringent property-level conservation set-aside laws within the Brazilian legislature or import restrictions in consuming countries that require compliance with zero-native ecosystem conversion (c.f. Bager et al., 2021). However, in the discussion we do relate our work on private sector supply chain policies back to ongoing efforts to design and implement jurisdictional approaches, “governance initiatives that promote sustainable resource use at the scale of jurisdictions through a formalized collaboration between government entities and actors from civil society and/or the private sector, based on practices and policies intended to apply to all affected stakeholders within the jurisdiction” (von Essen & Lambin, 2021, p. 3).

Since these policies have not yet been decided upon, let alone implemented, we pursue an ex-ante analysis (i.e., looking at potential future outcomes of each policy). Such an approach is essential at the policy design and selection stage to inform policy-makers decisions on which course of action to pursue. While focusing on a single policy criteria might help identify a clear “best policy”, we examine potential effectiveness, cost-effectiveness, equity, and legitimacy (as defined in Section 2) to reveal potential goal tradeoffs across policy options (Adger et al., 2003). A prolific literature has already examined the efficiency, effectiveness, and equity of PES (Börner et al., 2017; Ferraro, 2017; N. James & Sills, 2019; Martin et al., 2014; Wunder et al., 2020) and the effectiveness of MEM (Alix-Garcia & Gibbs, 2017; Garrett et al., 2019; Gibbs et al., 2015a, 2016; Heilmayr et al., 2020; Kastens et al., 2017). Yet there has been little emphasis on the legitimacy of such policies, or on the equity and financial costs of MEM (Grabs et al., 2021; Newton & Benzeev, 2018), despite the importance of these outcomes to overall social costs and benefits and the lasting success of such policies (Pascual et al., 2014). A notable exception is Bastos Lima & Persson (2020), which raises many of these important points in analyzing the dialogues surrounding soy sector sustainability governance in Brazil. We pick up where this study leaves off to systematically analyze how PES and MEM compare across multiple policy goals.

Our analysis draws on a combination of existing literature, primary and modeled data about agriculture and deforestation in the region, and 27 semi-structured interviews with soy sector stakeholders in 14 municipalities within the Matopiba region of the Brazilian Cerrado. We conclude that both PES and MEM have substantial limitations in the Cerrado, but these limitations could be addressed by combining the best attributes of both approaches. Requiring all producers to comply with an MEM, while targeting PES at only the most vulnerable soy producers would ensure greater effectiveness, lower the costs of the policy, offset some of the equity concerns, and increase its legitimacy to soy actors.

2. Analytical framework

Here we briefly define our four policy criteria and clarify how they will be applied to the context of supply chain policies for

the Cerrado soy sector. These criteria and indicators are summarized later in Table 1, columns 1–3, when we present the results of our analysis.

2.1. Effectiveness & cost-effectiveness

Effectiveness is defined as meeting the objectives of a given policy (Martin et al., 2014). Yet, the scope of many zero-deforestation targets and supply chain policies (i.e., which actors and regions are included) is often unclear (Garrett et al., 2019). If a policy only aims to prevent deforestation from entering an individual supply chain, like some individual company ZDCs (Garrett et al., 2019), it can be effective in attaining its goals by merely excluding non-compliant actors (i.e., “individual supply chain effectiveness”). But if the policy aims to eliminate deforestation for a specific commodity across a whole region, as formulated in the collaborative, industry-wide Brazilian Amazon Soy Moratorium, it will only be effective if all deforestation for the targeted commodity is eliminated within that region (i.e., “regional effectiveness”) (Garrett et al., 2019). Since ongoing industry-wide dialogues about a Brazilian Cerrado PES or MEM focus on halting deforestation throughout the Cerrado, we focus here on assessing whether either implementation approach is likely to be regionally effective. While the broader global effectiveness of a soy Cerrado PES is not the subject of this paper, in the discussion section we do briefly examine how a policy targeting soy farmers within the Cerrado could influence nearby soy producing regions through land markets.

Ideally the policy's zero-deforestation objectives can be met at the lowest financial cost (*cost-effectiveness*) to free up scarce resources for additional conservation or social projects (Martin et al., 2014). In terms of financial costs, here we focus on costs to the policy makers (and implementers) – the traders and retailers involved in the program. We focus on the monitoring and enforcement associated with PES and MEM, and for PES we further include the payments themselves as a cost borne by the implementing party.

An examination of individual supply chain effectiveness can be operationalized by examining whether the policy has a credible means to enforce compliance (i.e., through a sufficient reward or penalty) among all suppliers (Garrett, Levy, et al., 2021). Compliance with both PES and MEM supply chain policies is monitored at the individual property scale, which requires access to information about individual suppliers' property boundaries and monitoring at a fine enough spatial and temporal scale to detect deforestation and prohibit sales or retract payments (Azevedo et al., 2017; Rausch & Gibbs, 2016). For MEM, identification of non-compliant behaviors must trigger the sanction of market exclusion, whereas PES incentivizes good behavior through the promise of future or continued payment. For the MEM there is a question of how long the market exclusion should last and under what conditions (e.g., via restoration of cleared areas) it can be reconciled. For an MEM, the penalty of exclusion might be watered down if the farmer that cleared their land can just “launder” their soy through compliant farms (i.e., sell their soy to an intermediary farm to obscure its origin) (Rausch & Gibbs, 2016). However, the potential for this laundering is somewhat limited vis-à-vis other crops or livestock given the relative consistency of soy yields across farms (Garrett, Lambin, et al., 2013), which would make it difficult to obscure abnormally high volumes of soy coming from a given area. For PES there is a key question of when the payments are distributed and what happens if the producer defaults on their contract. Land users may have an incentive to deforest after receiving the PES (the moral hazard scenario) if there are no penalties defined and if no payments are planned for the future (Etchart et al., 2020). This only postpones the undesired behavior at large cost.

An examination of regional effectiveness requires identifying whether the policy is likely to lead to a change in behavior relative to what would have occurred in the absence of the policy (i.e., *additionality*). In this case, the PES or MEM must motivate farmers that would have otherwise cleared their remaining forest areas to now conserve those areas. If an MEM just results in farmers dropping out of the committed actor's supply chain, and continuing to deforest, it will not be regionally effective. Similarly, if the PES is not adopted by farmers who would have deforested in the absence of a payment and those farmers instead continue to clear their land, it will not be regionally effective.

Numerous empirical assessments have shown that the users who should be targeted by the PES (those with a high likelihood of deforesting their land) are not always the ones who apply to such schemes, due to either very high opportunity costs, a lack of awareness or capacity, or a lack of eligibility (for example, because they do not hold definitive land titles) (Wunder et al., 2020). For PES targeted at commercial agricultural producers, the potential for additionality first depends on whether it will reach areas where there is existing forested land that is suitable for the target agricultural commodity and legally clearable under existing current policies (Garrett et al., 2016; Rajão et al., 2020). Second, the payment level should be higher than land users' opportunity costs of not-clearing (i.e., soy or other agricultural profits), otherwise it is unlikely that the farmer would voluntarily adopt the PES on their suitable and legally clearable areas.

For the MEM, the penalty for not complying and not selling to the committed actors must be greater than the forgone profits associated with new soy production. Otherwise, farmers that would have otherwise cleared will just avoid the committed firms and sell to noncommitted actors and only the farmers that had already cleared all areas would sell to companies with commitments (Garrett et al., 2019). As such, it is important that the companies who have adopted zero-deforestation policies control a high proportion of the market, otherwise farmers will face a low penalty in their marketing opportunities if they just continue to clear and sell through uncommitted firms (Gollnow, Cammelli, Carlson, & Garrett, 2021; Levy et al., 2021).

The need to pay farmers a sum higher than their opportunity costs from not clearing (i.e., higher than forgone soy profits), puts the costs of PES squarely on the policy makers (i.e., the companies). By shifting the costs from the producer to the policy maker, PES will always be less cost-effective than MEM from the policy maker's perspective, even when both approaches are expected to have similar levels of compliance and additionality. In light of financial constraints stemming from companies' limited willingness to pay for conservation, the high cost of PES relative to MEM could further undermine its regional effectiveness by diminishing the overall amount of area that can be protected.

Finally, there is the issue of *spillovers* – the degree to which adoption and compliance with the policy among target land users may spur additional clearing among non-target users and in other regions. The first key potential spillover is *motivational*. The establishment of financial rewards for conservation, as would occur for PES, could lower a priori intrinsic conservation motivations, especially in contexts where market systems are not yet very prevalent, such as in indigenous communities (Farley & Costanza, 2010; Wunder et al., 2020). The second set of spillovers are more related to *markets*, having to do with changes to the supply and demand of capital, land, and commodities. Capital-induced spillovers can occur when a cash infusion is provided to producers that are otherwise capital constrained, enabling them to take payments in one area and invest the money in clearing another region. Activity leakage (le Polain de Waroux et al., 2016) can occur when unused capital for the production activity is redirected to the areas with the next best economic opportunity (Henders & Ostwald, 2012). This

re-direction can include moving to new regions, marketing to different suppliers, or attempting to launder products illegally. Activity leakage is particularly likely when farmers are not able to comply with the criteria of the policy (Garrett et al., 2019). Finally, market leakage occurs when changes in the location of production are induced by changes in the price of agricultural commodities as a result of the production restriction (Villoria & Hertel, 2011). Capital-induced leakages would be more likely for the PES because it provides additional financing, whereas activity and market leakage would be more likely for the MEM because it restricts production activities.

2.2. Equity

As a policy goal, *equity* encompasses many elements, but generally refers to having a goal of reducing socio-economic inequalities or at least not harming more vulnerable actors (Martin et al., 2014; Pascual et al., 2010). We focus on equity rather than equality as it conceptually includes avoiding negative impacts for the most marginal and vulnerable actors within a system in order to mitigate systemic and historical inequities, which may conflict with a goal of obtaining equal outcomes. *Procedural equity* is the degree to which all participants, especially less powerful ones, have the opportunity to take part in and influence the policy development (Mickwitz, 2003), *contextual equity* refers to whether participants have similar abilities to benefit from the policy conditional on the uneven playing field and power disparities, whereas *distributive equity* pertains to how the benefits and costs of a policy are distributed across affected parties, and especially considers the degree to which the most vulnerable actors incur costs (McDermott et al., 2013). All three types of equity are related. Procedural equity can set the conditions for greater contextual equity, and contextual equity can ensure a more even distribution of costs and benefits among actors.

As implementation mechanisms for supply chain policies, PES and MEM suffer from the same procedural equity challenge, the exclusion of affected actors from the policy making process, since the policy is defined by individual companies (Bastos Lima & Persson, 2020; Elgert, 2012). What is more important then, is whether these procedural and contextual inequities manifest differently in PES or MEM, or whether the mechanisms themselves contain distributive differences. An MEM is likely to cause more harm to households that still have clearable forest reserves (or fallow systems that may be categorized as forest) because it restricts farmers' ability to generate additional income from clearing more land (Grabs et al., 2021; Lyons-White et al., 2020; Wunder, 2008). However, a PES could potentially cause greater economic inequality if only wealthier farmers are able to access the PES, as has often been the case (Corbera et al., 2007; Klein et al., 2015; Pascual et al., 2010). Furthermore, to be effective, a PES often requires that payments are determined by opportunity costs, which implies unequal treatment and tends to favor those land users who already own more productive assets (Martin et al., 2014).

2.3. Legitimacy

Legitimacy is the extent to which the policy is acceptable to participants, including the acceptability of who designs and implements the policy (Adger et al., 2003). Legitimacy also considers how policies conform to formal and informal rules and norms, including the way that outcomes are negotiated and administered (Corbera et al., 2007). Legitimacy can be influenced by existing *entitlements*, i.e. how much effective command over resources an individual has (Leach et al., 1999). In the case of deforestation processes, it is necessary to consider whether or not legal institutions

and development paradigms have historically provided land actors with the rights to clear the land, and whether or not they have explicitly encouraged such clearing through development and sovereignty narratives. Legitimacy, therefore, has the potential to vary substantially across local and international stakeholders. Here we specifically focus on how legitimacy is likely to vary between soy and non-soy land users in the Cerrado and between soy land users and international actors.

Of primary concern in the case of PES and MEMs as implementation mechanisms for ZDCs is *how responsibility for deforestation activities is framed*. PES schemes support the notion that beneficiaries of ecosystem protection should pay for that protection, while MEMs follow the logic of traditional regulatory approaches, i.e., that actors who degrade ecosystems should pay for the harms associated with their behaviors (Wunder et al., 2020). An MEM thereby assigns responsibility for social harms to land owners, whereas PES reinforces land owners' entitlements to deforest. The latter clearly creates a political risk of entitling further deforestation that may weaken the legitimacy of other institutions, including public regulations, that restrict forest clearing.

3. Case study context and methods

3.1. Case study context

The Cerrado is a highly biodiverse biome that covers 21% of the Brazilian territory, spanning dense forests, open savannahs, and grasslands (Fig. 1a). Yet, it is also one of the most poorly protected biodiversity hotspots in the world (Klink & Machado, 2005). Brazil's Native Vegetation Protection Law (NPVL), referred to colloquially as the "Forest Code", allows 65–80% of a property's native vegetation to be cleared in the Cerrado and protected areas cover only 8% of the region (Law 12,651/2012) (Strassburg et al., 2017). Because of this lack of protection and its high suitability for large scale soy production, since 2000 the Cerrado has experienced more than double the amount of soy-driven deforestation than the Brazilian Amazon (Song et al., 2021). Direct conversion for soy accounted for 16–32% of annual clearing between 2003 and 2014 (Rausch et al., 2019). In total, soy replaced at least 1.3 million hectares (Mha) of native vegetation during this period, averaging over 108,000 ha per year (Rausch et al., 2019). This resulted in carbon dioxide emissions totaling 1.8 million Gg of carbon dioxide between 2002 and 2010 (Global Canopy, 2018). Given the high amount of legally clearable area remaining, the private sector could play a huge role in blocking further conversion of forest to soy, potentially preventing the direct conversion of 3.6 million ha of native vegetation to soybeans by 2050 (Soterroni et al., 2019).

Within the Cerrado, the region of Matopiba (the states of Maranhão, Tocantins, Piauí, and Bahia) (Figure 1, outlined in orange) is of particular concern, since there are still many legally clearable areas that are potentially suitable for production (Rausch et al., 2019). Between 2009 and 2013, 73% of soy deforestation and 45% of the total carbon emissions from cropland expansion in the Cerrado took place in this region (Figure 1a, Global Canopy, 2018). The other major region for soy deforestation within the Cerrado is Mato Grosso (MT in Figure 1), where deforestation for soy is also ongoing. However, this region is slightly more protected by the NPVL than Matopiba because it is designated as part of the Legal Amazon political boundary, which means that only 65% of the Cerrado vegetation can be cleared.

In 2017, many EU companies expressed support for conservation in the Cerrado via the "Statement of Support (SoS) for the Cerrado Manifesto", with 23 companies committing to "working with local and international stakeholders to halt deforestation and native vegetation loss in the Cerrado" associated with soy and cat-

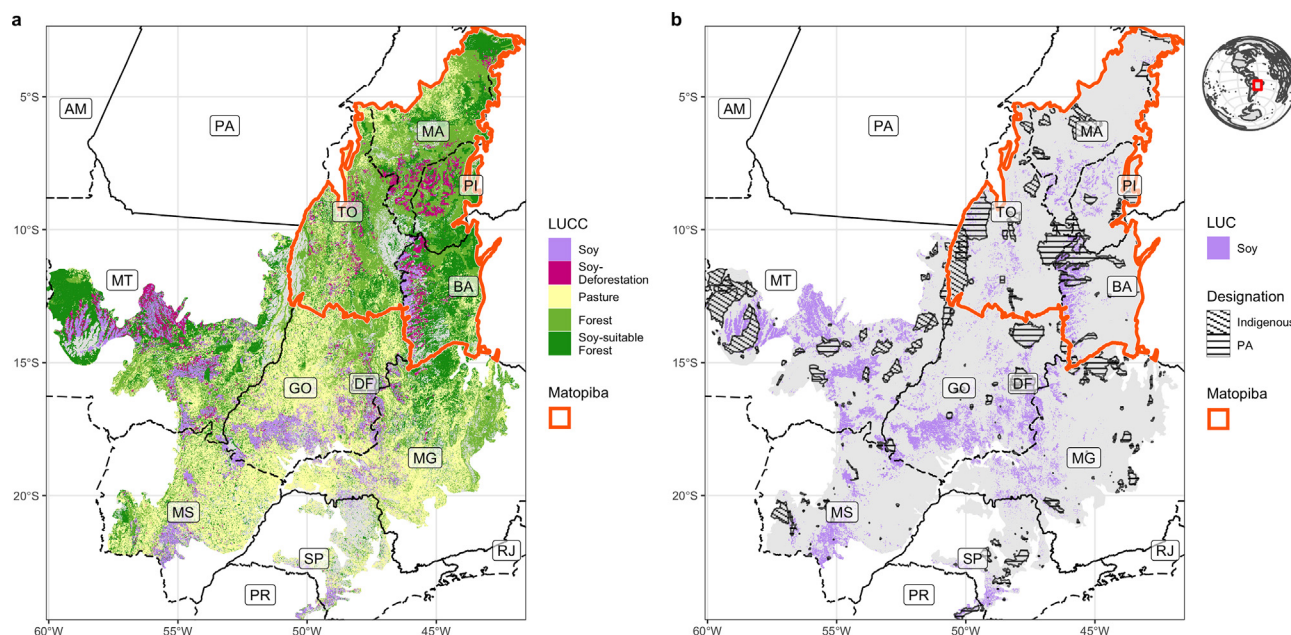


Fig. 1. Land use and cover change (LUCC) and land use cover (LUC) in the Brazilian Cerrado biome: a. 2019 main land use cover (based on MapBiomas v5) and soy-deforestation (i.e. all deforestation for soy between 2001 and 2019, based on MapBiomas v5), b. 2019 soy area (based on MapBiomas v5), protected areas (PA), and indigenous land (IBGE, 2020). Soy deforestation was defined as the conversion from forest (MapBiomas class 4, 5, 6) to soy cropland in the 5 years after forest loss is detected. Forest suitable for soy was defined by intersecting soy suitability maps from the Global Agro-Ecological Zoning (GAEZ, moderate to high soy-suitability derived for high-input, rainfed soybean production) with areas that have a high aptitude for treatment with heavy machinery (IIASA, FAO, 2012; Soares-Filho et al., 2014).

tle production (Bastos Lima & Persson, 2020; Walker-Palin, 2019). The group supporting the manifesto (the SoS Working Group, coordinated by the Farm Animal Investment Risk and Return (FAIRR) initiative, Consumer Good Forum, and others) now includes 160 members, including investors, Western and Chinese buying groups, food retailers, and Brazilian stakeholders (FAIRR, 2021). The SoS Working Group then engaged with the Cerrado Working Group, a commodity-centric, multi-stakeholder landscape governance initiative that was launched in 2018 to address land use change in the Cerrado savanna (Bastos Lima & Persson, 2020). Notably, the Cerrado Working Group is composed not only of industry representatives, civil society, governmental and financial institutions, and consumer goods companies, but also soy producer associations. The Cerrado Working Group has emphasized the importance of creating “fair financial incentives for farmers to go beyond regulatory requirements and take part in conservation efforts” to the SoS Working Group (FAIRR, 2021). This resulted in the launch of the Cerrado Funding Coalition to provide funding for PES-like schemes.

The actual mechanics of the proposed PES-like policy are not yet clear. Farmers would likely only be eligible if they can prove they have a legal right to clear their land (Bastos Lima & Persson, 2020) and it is not decided whether the payment level would be equal to opportunity costs or equivalent to the carbon value from avoided deforestation (Personal Communication with member of TFA dialogues on Cerrado governance). In these dialogues, a PES scheme is sometimes framed as a standalone policy initiated by supply chain actors to encourage reduced deforestation among their suppliers beyond the conservation levels legally required by the NPVL (TFA, 2020). At other times it is discussed as an “add-on” to a zero-native ecosystem conversion market exclusion mechanism (akin to the Soy Moratorium in the Amazon) (Nepstad et al., 2019) to compensate farmers for opportunity costs on legally clearable areas (Walker-Palin, 2019). However, Aprosoja, the largest soy producers’ association in Brazil, has made it clear that they don’t support any market exclusion approach (Bastos Lima & Persson, 2020) and current TFA materials about PES initiatives in the Cerrado do not mention any complementary market exclusion approach.

3.2. Methods

This project started after the first and second authors were asked by a member of TFA in July 2020 to provide feedback on a roundtable discussion about introducing PES in the Cerrado soy sector. This member elicited our input based on the first-author’s longstanding experience doing research on the social and ecological aspects of soy production in Brazil. Our initial response to TFA on the potential opportunities and drawbacks afforded by PES was based entirely on the existing literature and our own expert knowledge.

We then pursued a more holistic ex-ante analysis for the purposes of this paper, combining theory and empirical data from the existing literature with an analysis of remotely sensed data on soy deforestation and forest areas, modeled data on soy suitability and land rents in the Cerrado, and local census and municipal survey data on income, land tenure, and farm size. We further rounded out this birds-eye view of the issue across the Cerrado with qualitative data from semi-structured interviews in the region of Matopiba (as described below) that was collected in June 2018 on the subject of potential soy supply chain sustainability governance options for this frontier region. As we were analyzing the existing data and writing up the article, we realized we still lacked some details on how actors were anticipating organizing and distributing the PES, particularly in light of its high costs. At that point we contacted a leader at TFA for more details on the proposed policy, which is referenced above and below as “Personal Communication with member of TFA dialogues on Cerrado governance”.

The key inputs to quantitative figures referenced in the results include: i) an analysis of legally clearable and sustainable soy areas in the Cerrado from Rausch et al. (2019), ii) primary data on farm sizes, land tenure, and agricultural areas from the 2017 Brazilian Agricultural Census, iii) primary data on per capita income and income inequality (GINI index) from the 2015 Brazilian Demographic Census, iv) remotely sensed estimates of deforestation and soy area from MapBiomas v5 (MapBiomas, 2020), and v) three

types of modeled data: soy profits, market share of companies with zero-deforestation commitments (ZDCs), and deforestation for soy from two papers currently in preparation by the authors, Rivero et al. (In Prep) and Gollnow et al. (2021) (see SI).

Semi-structured interviews were conducted in the region of Matopiba in June 2018, given its priority concern for zero-deforestation policy. We visited 14 municipalities in all four states within the region (see SI). Municipalities were selected based on three criteria: i) there was soy production within the municipality (IBGE, 2020); ii) ZDC signatories were identified as sourcing locally; and iii) there was active deforestation for soy within the previous five years (SEI, 2020). The sampling approach was purposive in that we aimed to obtain a range of perspectives on zero-deforestation supply chain efforts from a diverse set of soy farmers and other local experts (agribusiness representatives, rural producer syndicate representatives). In total we conducted 27 interviews. Participants included soy farmers, government officials, producer organizations, agribusiness representatives, agricultural input vendors, researchers, non-governmental organization representatives, and farmers producing non-soy products, including smallholders. Non-soy producers were included in the study to gain insights into how soy and soy ZDCs are affecting individuals in the wider region, as the negative impacts of soy development often affect smaller, more marginal actors, such as smallholders (Eloy et al., 2016; Russo Lopes et al., 2021). Due to local ethics and legal restrictions we were unable to interview other marginalized groups in the region, such as members of traditional or indigenous communities (e.g. *quilombola* communities) that are often immediately adjacent to major soy areas and negatively affected by soy production (Figure 1b). We attempted to reach local workers' representatives (e.g. *sindicato dos trabalhadores e trabalhadoras rurais*), but were unable to reach them by telephone.

Contacts were obtained through a snowball approach, originating from an initial local expert within each city, most often within the municipal rural producer's syndicate (*sindicato dos produtores rurais*). To partially offset the 'elite' bias of the well-connected contacts, we supplemented our snowball sample by randomly visiting farms identified through roadside assessments (i.e., whether the property was producing agricultural goods and whether individuals were on the property to answer questions) whenever possible during the field season. The interview sample was constrained by financial and time resources, but met saturation guidelines, whereby responses were largely redundant across main themes by the end of the study period (Corbin & Strauss, 2014). The main themes participants were prompted to talk about were: i) the expansion of soy locally and its impacts, ii) the governance context of soy production, including supply chain policy options, and iii) relationships between soy farmers and soy buyers locally. More information on the interview process and the positionality of the fieldwork executors is provided in the SI.

4. Results

In the following section we assess the potential effectiveness (including cost-effectiveness), equity, and legitimacy of supply chain PES and MEMs within the case of the Brazilian Cerrado soy sector. We first present any regional quantitative data to support the analysis of each criterion and then complement these data with local perspectives from our interviews.

4.1. Potential regional effectiveness

4.1.1. Compliance

Both the PES and MEM face the challenge of detecting compliance (or non-compliance) in near real-time, which requires moni-

toring land cover changes at the level of individual producers. Yet, such monitoring is feasible within the Cerrado. The Brazilian Rural Environmental Registry (CAR) creates a public record of each farm's property boundaries, its existing environmental compliance with public regulations on forest conservation, and its plans to come into compliance (Soares-Filho et al., 2014). The Amazon Soy Moratorium already relies on linking these CAR boundaries to supplier lists to enforce its market exclusion criteria (Heilmayr et al., 2020), but self-reported CAR boundaries often overlap with each other or do not map to their true owners. There are still substantial areas of private properties that are not yet registered (Rajão et al., 2020), which could reduce compliance. In theory, farmers seeking a PES would need to clarify their property boundaries to demonstrate they have legally clearable areas and obtain a deforestation permit. However, farmers would not necessarily benefit from property boundary uncertainty under an MEM either, since non-compliant activity could be inaccurately detected resulting in temporary exclusion. Indeed, the Soy Moratorium MEM in the Amazon has fairly high rates of compliance (>80% of properties) (Azevedo et al., 2015), suggesting that current CAR challenges are not a major barrier to property-level monitoring.

In our interviews in Matopiba many farmers believed that CAR enabled fairly stringent monitoring of new deforestation activities by banks and public environmental agents and there were no detectable differences across states or municipalities. *"If you're doing anything illegal the government knows and will not supply credit"* (Farm_8). Several farmers and experts noted that the major multinational traders like Bunge and Cargill, and the larger cooperatives or some intermediaries already checked the CAR in the Cerrado, especially if they provided financing (Farm_12, Expert_4, Expert_6, Expert_7). *"[Company A] monitors who they buy from. You need to have CAR at the first negotiation. They have a clause in their contract that they can't buy from soy planted on 'terras preservadas' [areas where clearing is prohibited]"* (Expert_4). However, one expert thought that it is still possible for soy from areas where illegal deforestation has been detected ("embargoed areas") to enter into the supply chain. *"There are problems with traders buying from embargoed producers... The only way the traders can guess whether it's embargoed or not is that without CAR and other documents, the producers wouldn't have been able to access credit in the first place"* (Expert_1). This potential for laundering soy from embargoed areas was also noted in Rausch & Gibbs (2016), which found that few official documents were consistently required at the time of purchase to verify where the soy was produced or by whom.

4.1.2. Additionality

For any of the supply chain initiatives to have additionality they must reach the producers at risk of deforesting. In general, both PES and MEM have a high potential for additionality due to the degree of deforestation threat in the soy sector in the Cerrado and especially in Matopiba. According to a recent analysis by Rausch et al. (2019), as of 2015 there are still 15 million hectares, one-third of the remaining native vegetation in the Cerrado, that are suitable for soy and legally clearable. Yet, there were some differences in the degree to which this deforestation pressure was perceived across interviewees in different regions. Experts in Western Bahia, the nucleus of the Matopiba frontier, felt that the region was more settled and had less clearable area remaining, or rather, the remaining land was perceived as too expensive (Farm_7, Expert_2, Expert_3, Expert_7). This region has among the highest soy area as a proportion of the agricultural area and the highest coverage of soy traders with ZDCs (Figure 2a,c). Conversely farmers and experts in Piauí, Tocantins and Maranhão felt there was more land still to open (Farm_1, Farm_12, Expert_5, Expert_8, Expert_10). These differences in perceptions loosely match with

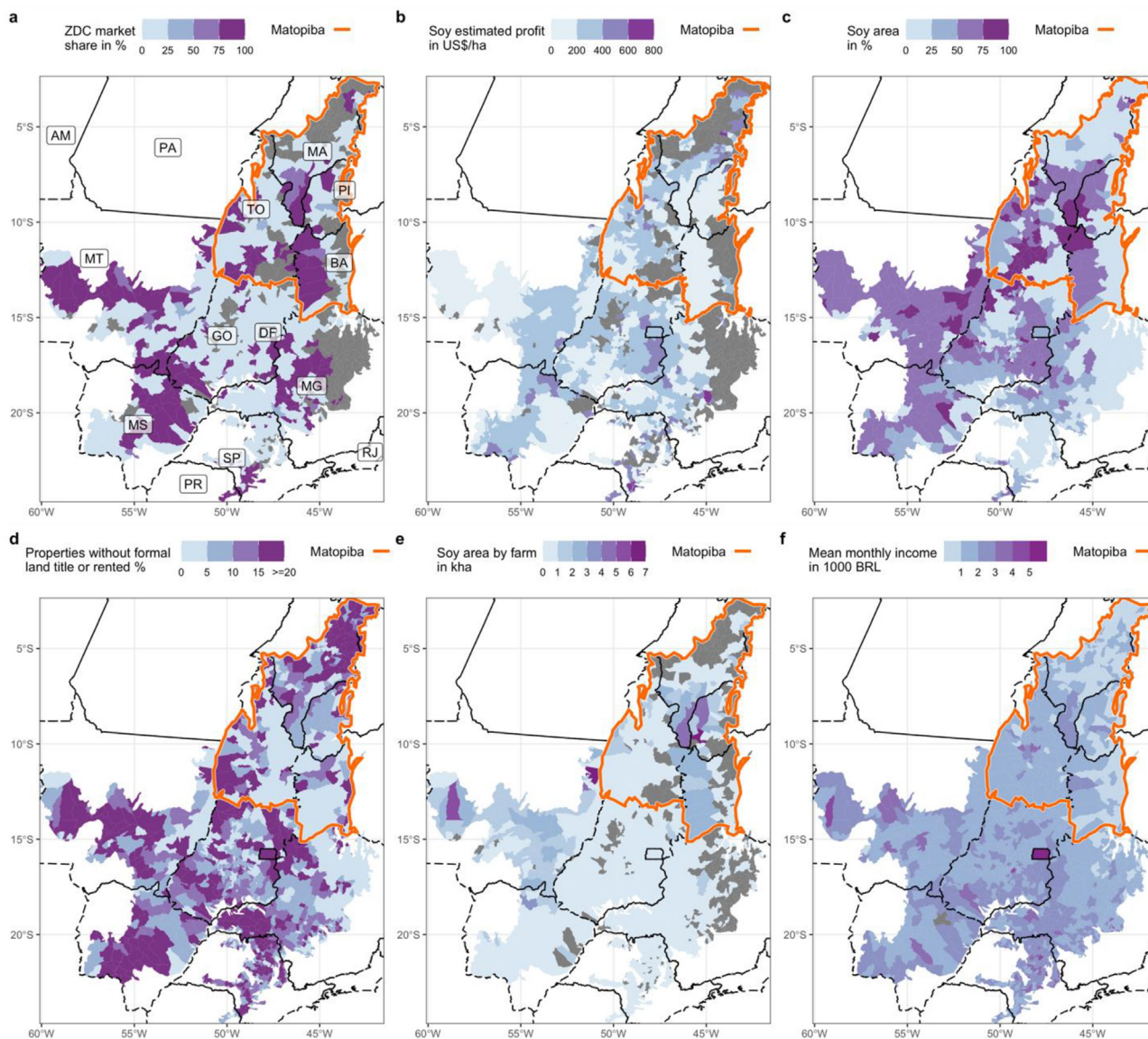


Fig. 2. a. Export market share of companies that adopted zero-deforestation commitments (ZDCs) (estimated in Gollnow et al. (2021) based on Trase v25); b. Estimated soy profits based on Rodrigo et al. (in prep); c. Soy area as a percent of agricultural area; d. Percent of agricultural establishments that are rented or occupied without definitive title or where land is owned by a partnership or corporation (Agricultural census 2017); e. Average soy farm area (Agricultural census 2017); f. Mean monthly income per capita (Demographic census 2015); Matopiba (Maranhão, Tocantins, Piauí, and Bahia), outlined in orange, is an area of significant importance for Cerrado supply chain policies due to the convergence of high conservation threats, mixed presence of firms with ZDCs and greater economic inequality and heterogeneity in farmer attributes (with many farmers lacking formal ownership or access to technical assistance). Grey areas indicate municipalities where no data was available for a particular metric. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

the locations where there are high amounts of soy-suitable forest remaining. Western Bahia is highly consolidated, with soy production already occupying a majority of the area, but high levels of soy-suitable forest remain in Eastern Bahia and scattered throughout the other Matopiba states (Figure 1a).

Despite the high overall soy-driven deforestation threat across the Cerrado and especially Matopiba and Mato Grosso, PES faces a larger targeting challenge of getting farmers who would otherwise deforest to successfully enroll in the program. If having a definitive land title is a pre-condition for eligibility, the program would face the challenge that there are many municipalities where >25% of agricultural establishments are either owned by someone still awaiting their land title, or people that are renting or occupying the land (figure 2d). These land titling issues are a legacy of both historical colonization approaches and contemporary land grabbing dynamics whereby farmers have appropriated de facto

use rights of undesignated public lands, without ever receiving formalized de jure rights (Carrero et al., 2020; de Area Leão Pereira et al., 2020). Many long-colonized areas lack definitive title even if they are part of a current or former public settlement because the government distributed land parcels to migrants, but never formalized the land ownership rights to these lands (Russo Lopes et al., 2021).

In our interviews in Matopiba, several farmers and experts across three of the states (Piauí, Tocantins, and Bahia) mentioned that land titling was still a major problem (Farm_1, Farm_8, Expert_3, Expert_14). “I have been waiting several years to get title. One of my neighbours has had land in the family for around 100 years and is still waiting for their title” (Farm_1). In this context they were referring to the lack of land title being an impediment to obtaining credit from the government, but the lack of land title could also impede PES enrollment.

It was anticipated in the PES discussion that payments would only be dispersed to soy farms that obtain a permit¹ to legally clear their land, which was estimated to be only 8% of farms in the region (Personal Communication, member of TFA dialogues on Cerrado governance). Such a permit is difficult to get, even with title. As one farmer stated, “It takes 5 years to get a deforestation license” (Expert_2). While limiting the program to those with a permit to clear substantially reduces the costs associated with the program, it also dramatically reduces the policy’s scope for additionality, as eligibility will be reduced to the elite farmers with the connections (and money) needed to speed along the permit process.

Zero-deforestation as a result of any supply chain policy is also unlikely if companies enforcing a ZDC do not control the whole market. Our modeled estimates show that as of 2018, roughly 65% of soybean production in the Cerrado was handled by companies that have committed to deforestation-free supply chains. This market share reached 100% in a few high deforestation risk regions, but problematically covered less than 50% of the market in other regions (Figure 2a).

Additionally, in many regions of both the Amazon and the Cerrado, land speculators without any current links to soy production are most culpable for deforestation (Rajão et al., 2020), as they see an opportunity to secure land for future sale in the context of an advancing deforestation frontier (Richards et al., 2014). This speculation is fueled by the ongoing expansion of soy in the Cerrado since the 1970s, which accelerated in more recent decades with rapidly growing demand for soy in China (Peine, 2013). Speculators anticipate that current forest areas will one day become prime soy producing areas, once existing land to expand diminishes and the infrastructure for producing and exporting soy has arrived in the region (Campbell, 2015). This disconnect between the actors targeted by a soy PES or MEM and the actors actually pursuing deforestation was highlighted by several of the interviewees. Specifically, multiple respondents (Farm_6, Farm_8, Expert_1, Expert_2, Expert_10, Expert_13) noted that zero-deforestation efforts targeting existing soy producers could not tackle the problem of *grilagem* (land grabbing). Indigenous groups and small farmers are often the victims of such land grabbing by more powerful and capitalized actors that are not yet part of the soy supply chain. As one expert stated, “If Native Brazilians don’t have the document saying it is their land, it is open to be taken by force. This land grabbing happens mainly on land that is forested because the owners are small and not big farmers” (Expert_1). In this sense the potential effectiveness of any soy-focused policy to address broader deforestation is quite limited, since soy production comprises only half of the agricultural area in many regions (Figure 2c).

4.1.3. Cost-effectiveness

In terms of costs, both PES and MEM face a tremendous challenge of monitoring and enforcing behaviors across hundreds of thousands of farms, across a landscape the size of Germany and France put together. Cunha et al. (2016) estimate that the largely successful efforts of Brazil’s federal government to reduce deforestation from 2004 to 2012 came at the cost of US\$308–923/ha of avoided deforestation or US\$ 1 billion per year (and this does not even include municipal government costs). A vast majority of the operational costs estimated in this study are relevant for a Cerrado soy supply chain policy, as they pertain to setting up the enabling conditions for enforcement (conservation area mapping, property registration, education and awareness, monitoring, and farm visits). Given that operational costs were 24% of the implementation costs, this amounts to an anticipated enforcement cost

for companies implementing any type of Cerrado-soy supply chain policy of roughly US\$ 74–222/ha of avoided deforestation.

There are 8 Mha of legally clearable land that are highly suitable for soy, plus another 7 Mha of potentially suitable land for soy expansion (Rausch et al., 2019). Our estimates show that the highly suitable soy areas show an average profit of 250 USD/ha (See SI and Gollnow et al., 2021).² Summing the opportunity costs and policy enforcement costs estimated by (Cunha et al., 2016), a PES scheme for Cerrado soy could cost companies and the federal government >2.6 billion USD per year, or US\$ 325/ha of avoided deforestation, whereas the MEM cost to implementers would mainly include the monitoring expenses.

On the demand side, signatories of the Cerrado Manifesto are aiming to fundraise US\$250 million over a five-year period (US \$50 million per year) as an “indicative value of the resources that may be required to address the issue” (FAIRR, 2021). If the Cerrado Funding Coalition’s goal is met, a stand-alone PES would at best protect around 200,000 ha (2.5% of the most suitable, legally clearable area) from five years of soy-driven deforestation pressure.

4.1.4. Intrinsic and extrinsic conservation motivations

As mentioned above, there is a concern with PES that introducing individual payments to a limited set of soy farmers for avoiding conservation could undermine intrinsic conservation motivations among other land users who choose not to deforest for other reasons. For indigenous communities these intrinsic motivations include spiritual connections to the standing forest, which are often codified into cultural norms and practices (Ruiz-Mallén et al., 2015; Welch & Jr, 2021). Communities of all types often have an awareness of the ecosystem services provided by the forest and believe it is their duty to avoid harm to society by avoiding deforestation (Ezzine-de-Blas et al., 2019). However, impacts on monetary motivations are likely to be very heterogeneous both within and across the PES and MEM scheme given the diversity of actors in the region. Soybean production is primarily undertaken by commercial (as opposed to smaller “family farms”) in Brazil (Garrett & Rausch, 2015), who likely possess more market-oriented, profit-maximizing motivations in making land use decisions and would be less likely to make decisions based on intrinsic conservation motivations. Yet, the Brazilian Cerrado contains a large diversity of land users that may be affected by a PES or MEM indirectly. As Figure 1b shows, soy areas are adjacent to many protected areas, as well as indigenous, traditional, and Quilombola³ communities, in addition to many livestock farms.

With respect to the soy producers themselves, there were no secondary data on conservation motivations available. The presence of voluntary certifications could be a rough proxy for motivations to adopt better practices. It could, however, be mostly motivated by financial reasons, such as price premiums and market access. There have, for example, been instances of large corporate farms being certified in one region and continuing to clear on others (Chain Reaction Research, 2020). There are two primary certifications available for soy in the region, the Round Table on Responsible Soy (RTRS) standard and Proterra (Garrett, Rueda, et al., 2013). However, only 5% of the soy area is covered by these two certifications⁴. Only one farmer we interviewed was certified under RTRS, as well as under a national initiative focused on legal compliance called Soja Plus. As he stated with respect to these certi-

² This is even a conservative estimate compared to the Nature Conservancy’s estimate of USD 550 (2,800 BRL) per ha (Fishbein et al., 2019).

³ Quilombos are settlements first established by escaped Afro-Brazilian slaves. Their descendants (called Quilombolas), who continue to reside in quilombos, are protected as traditional communities by Brazilian law.

⁴ RTRS certified area is estimated at 789,323 ha in the Cerrado (according to data on responsiblesoy.org) and Proterra at a maximum of 300,000 ha (according to (IDH, 2019) of the 20 mha of soy currently in the Cerrado biome (Soterroni et al., 2019)).

¹ Such a permit (Autorização para Supressão de Vegetação or ASV) is a key mandatory element for “legal deforestation” compliant with the Forest Code. Those who deforest without a permit are doing it illegally.

fications, “It costs money to receive the certifications and buyers don’t pay more...I get these certifications because I want to do things right and it looks good internationally” (Farm_6).

In our fieldwork many farmers indicated that they agree that it is important to follow the existing laws about deforestation, but many wished there were more legally clearable areas. For example, many expressed a clear sense of injustice about the stringency of the existing forest laws and a desire to be able to legally clear more land (Farm_1, Farm_2, Farm_6, Farm_7, Farm_8). One farmer expressed his disagreement with the fact that “66% of Brazil is still natural vegetation and yet we have to reserve 35% of our farm” (Farm_1). Another farmer explicitly stated that he would like to “buy new land because it’s cheaper and I know how to deforest it and make it productive” (Farm_2). However, some farmers indicated (sometimes despite the unfairness of the laws) that they thought it was important to avoid deforestation (Farm_2, Farm_5, Farm_7, Farm_10), “Deforesting hurts nature, which is bad for us, for example there used to be more water on the land” (Farm_5). Yet, these types of statements could be an artifact of our positionality as foreigners to the region (see SI).

4.1.5. Market spillovers

Recent work has shown that agricultural expansion in the Brazilian soy sector is driven largely by capital surpluses during high price years, rather than average expected profits into the future (Richards et al., 2014). By infusing more capital into the system, PES may enable more forest conversion. That is, it is possible that farmers would enroll in PES on one farm that has relatively low productivity and invest that money in opening a farm in a new area within the Cerrado or neighboring regions. Conversely an MEM could work to further restrict capital availability in the region, since a prohibition on selling to committed actors would also cut off annual financing from those actors, a dominant source of credit in the region (Garrett, Lambin, et al., 2013).

Since the Cerrado comprises a huge share of Brazilian soy production and ample room to expand, any policy that restricts soy expansion in this region has a high likelihood of impacting other regions via both activity and market leakage (le Polain de Waroux et al., 2017), especially since investment decisions for soy production are highly mobile across borders and biomes within South America (le Polain de Waroux et al., 2016). On the other hand, PES and MEM schemes may not severely restrict soy expansion in the Cerrado since producers can increase production on already-cleared pasture areas that currently have very low productivity and profitability (Nepstad et al., 2019). This would mitigate price changes that could lead to market leakage. Conversely, PES could lead to a positive land market spillover, by creating an expectation that forested land has a high value. As one expert we interviewed stated, “Some people leave their area natural so they can sell it as a legal reserve area someday, specifically to foreign investors that want to invest in natural lands” (Expert_3). This would create a positive spillover for conservation, whereby expectations of a growing price for carbon sequestration could eventually outpace expected profitability for selling the land for soy production.

4.2. Equity

4.2.1. Procedural equity

The stakeholder conversations from which both the PES and MEM conversations emerged suffer from substantial procedural equity challenges. As Bastos Lima and Persson (2020) argue, the efforts of the Cerrado Working Group were excessively skewed towards soy producer interests and excluded other actors from defining the goals of supply chain policies in the region. This is quite likely why the dialogues have shifted toward a PES, rather than an

MEM, as Cerrado soy producers and associations are largely against an MEM (see the legitimacy discussion below) (Samora, 2019).

Yet, even these dialogues don’t directly include many farmers, but rather producers’ association representatives. This lack of participation and direct engagement with farmers can lead to perceptions and conspiracy theories about a coalition of international forces working against soy farmers. As one expert stated, “People are still working on the moratorias. International people are working with Brazilian organizations, but I don’t know who they are. They are hidden forces that don’t want agriculture where it’s happening” (Expert_3).

4.2.1.1. Contextual equity. The average soy farm size is > 1,000 ha in much of Matopiba and up to 5,000 ha in some municipalities (Figure 2e), which could generate > 500,000 USD per year in operating profits in the regions where per hectare profits are 250 USD. The costs of establishing a soy farm are very high (Reis et al., 2019), making these production systems unavailable to farmers without very high levels of savings or leverage for obtaining a loan, and leverage cannot be provided without a definitive land title. Several of our interviewees confirmed that it is very difficult for smallholders to engage in soy production for various reasons, including a lack of experience and insufficient capital. As one expert stated, “Almost no native Piauíenses [inhabitants of Piauí] are producing soy because it’s newer agriculture that they don’t understand and it’s hard to enter” (Expert_1). Another one said, “Small producers usually have titles to the land, but don’t have it on paper or in real life, which makes it hard to get credit” (Expert_3). Additionally, there is growing evidence that soy expansion in the Cerrado has displaced smaller farmers, especially those who lack formal title (Schilling-Vacaflor et al., 2020). PES could exacerbate “maldevelopment” and already high income inequality in the region, by offering financial payments to soy farmers who have already profited through soy development at the expense of indigenous groups and traditional land users (Russo Lopes et al., 2021).

In the context of the financialization of land markets, there is also the potential for a ‘magnet effect’ spillover, whereby PES increase the value of land, attracting ‘green land grabbing’ by soy sector actors, further expelling more marginal farms (Fairhead et al., 2012; Sullivan, 2013). These risks are all particularly likely in the Matopiba of the Cerrado where income inequality and formal land ownership all are substantially lower than in the rest of the Cerrado (Figure 2d, Russo Lopes et al., 2021).

4.2.1.2. Distributive equity. By restricting all clearing, an MEM would “cost” soy producers (through lost potential income) two billion USD per year on the highly soy suitable forest areas alone. A key equity consideration of PES is that it shifts the costs of zero-deforestation activities to the actors implementing the policy, rather than placing them exclusively on the actors who control the land. In this sense it is seen by the major soy producers’ association, Aprosoja, as more equitable than a market exclusion mechanism which restricts even legal clearing and doesn’t compensate producers for this forgone income (Aprosoja, 2018; FAIRR, 2021). On the other hand, as outlined in the contextual equity section, this lost potential income would be borne by producers who are largely not poor and who have often displaced smaller, native inhabitants of the region (Russo Lopes et al., 2021). PES can further be considered inequitable when taking a broader lens, given that it offers payments to these relatively wealthier soy producers, without offering rewards to non-soy producing land stewards and communities, some of whom were displaced from their highly productive lands (Bastos Lima & Persson, 2020).

4.3. Legitimacy

The potential legitimacy of the PES versus the MEM approaches differs substantially across actors. Soy farmers in Brazil have been enthusiastic about positive incentive schemes and expressed their support for Law 14.119, passed on January 2021, which defines the concepts, objectives, guidelines, actions and criteria for the implementation of the National Policy on Payment for Environmental Services (PNPSA) and institutes the National Register of Payment for Environmental Services (CNPSA) and the Federal Payment Program for Environmental Services (PFPSA).

The current framing of PES by supply chain actors, alongside the newly created national PES law, helps reinforce the idea that deforestation is an entitlement. This entitlement is legitimized by international payments, as well as the NPVL, which allows deforestation up to 65% of the property. In contrast, Aprosoja firmly rejects any market exclusion approach to restricting deforestation on legally clearable areas as a challenge to national sovereignty to determine which areas can be cleared and by whom (Aprosoja, 2018). For example, in a recent Reuters article the vice-president of Brazil's largest soy organization, Aprosoja, was quoted as saying, *"The producer has to have the right to do what the law says. It's a matter of national sovereignty,"* (Samora, 2019). Yet, PES would likely suffer from legitimacy concerns by non-soy actors by only rewarding soy actors as "providers of avoided deforestation". These exclusions may generate perverse incentives for actors from other powerful sectors (such as cattle ranchers and slaughterhouses) that are not equivalently being compensated by the scheme.

The degree to which PES is perceived as more legitimate by soy farmers is strongly underscored in our interviews. Farmers and producer group representatives were adamantly against both public and private deforestation laws, no matter which state they came from (Farm_1, Farm_2, Farm_6, Farm_7, Farm_8, Expert_3). *"It's hard to obey all the environmental laws. There are too many laws against Northeastern producers"* (Farm_1). An expert from a producer organization stated, *"I am 100% against bringing the moratorium to Piauí. . . Producers are fighting back because they're tired of being attacked and thought of as the bad guys when in reality they are helping with development and producing in Brazil"* (Expert_1). One expert put this disdain for blanket bans on deforestation in clear words: *"[Soy Moratorium] is a crazy idea. It's not fair to limit a farmer who respects the [Forest] Code. . . Restricting areas or restricting buying sounds like it is coming from other countries trying to restrict profitability in Brazil"* (Expert_9).

Some interviewees explicitly mentioned the need for positive incentives (Farm_11, Expert_3, Expert_9, Expert_14). *"If people got paid to preserve land, they definitely would."* (Expert_3). Another representative of a producer organization stated, *"Right now it's 63 sacks of soy per hectare, generally around 60 with R\$70 per sack. There needs to be compensation for this for people to start preserving more"* (Expert_3). Very much reflecting the deforestation entitlement, beneficiary pays model, another expert stated, *"It's not fair that the farmers pay for this – society and the world should pay for this"* (Expert_9).

4.4. Summary

Our analysis indicates that both a standalone PES and a standalone MEM program in the Cerrado soy sector would suffer from challenges across each of the potential policy objectives (effectiveness, cost-effectiveness, equity, and legitimacy). Yet, there are notable differences between the two options (Table 1). The PES program is less likely to achieve additionality than the MEM, given that a sizeable proportion of the farmers running agricultural establishments in the region do not formally own the land with title and fewer yet would be able to obtain a legal right to clear the forest. Given the high opportunity costs on highly-suitable

soy regions, farmers might be inclined to only participate in the PES in areas at lower-risk of conversion (with lower opportunity costs), unless the payments are extremely high. Given the low amounts of pledged funds for the PES, offering such high payments would substantially reduce the amount of area that could be protected. Paying them to not clear those areas would offset those high opportunity costs, but would also support an entitlement to clear, which could have multiple negative repercussions, including reducing intrinsic conservation motivations and amplifying political counterpressure to regulatory deforestation governance. Additionally, a PES scheme, which excludes (generally poorer) non-soy land users that often adopt more conservation-based land uses, would be likely to exacerbate existing income inequality in the Cerrado and continue to reward those actors who are prone to deforest rather than those who already make efforts to keep forests standing. PES payments might reduce deforestation in the target region, but there is no reason to suggest farmers wouldn't just use the money to clear land in other regions that are also suitable for soy, but not protected or under the PES contract. A PES would be considered substantially more legitimate by many soy farmers in light of existing views on deforestation entitlements and national sovereignty, but would contradict the views of powerful international actors, non-soy actors, and local communities calling for a halt to deforestation in the Cerrado who believe that deforestation is a social harm that farmers should take responsibility for.

An MEM would face similar deforestation monitoring and scope challenges as PES, but would have higher overall expected additionality because farmers have less choice about whether or not to conserve legally clearable areas. However, this choice and its associated penalties depends on the amount of market leverage committed actors have within different parts of the Cerrado. In the few regions where the committed firms control less than 75% of the market, the expected costs of trying to sell to a non-committed actor would be substantially lower. The MEM would be substantially more cost-effective in that it doesn't require the policy maker to pay for farmers' opportunity costs. By framing deforestation avoidance as soy producers' responsibility, even where it is legal, the MEM faces strong legitimacy challenges from soy farmers and producer associations. An MEM presents some risks in terms of harming poorer farmers, though poor producers are already excluded from soy farming due to its high capital demands. Nevertheless, the MEM may have more support from non-soy land users in the region, especially indigenous and traditional groups who are directly harmed by ongoing forest conversion within their watershed.

5. Going forward: What is the best way to leverage private sector support for zero-deforestation in the Cerrado?

5.1. Any new supply chain led PES scheme should only be used as an add-on to an MEM

To address the targeting challenges associated with PES and avoid shifting the framing of deforestation from one of social harm to one of entitlement, any new supply chain PES scheme should only be used as an add-on to an MEM. There are ample areas – 36.8 million hectares – that were already cleared prior to 2008, occupied by other land uses, most often extensive cattle ranching, and suitable for soy expansion in the Cerrado (Nepstad et al., 2019). Restricting further agricultural expansion onto already cleared lands through strict zoning policies could stimulate the adoption of improved practices for both soy and cattle ranching systems that actual increase farm income, as has already occurred in response to increasingly stringent deforestation regulations within Mato Grosso (Garrett et al., 2018; Reis et al., 2019). Given the low access to technical assistance in the region, coupling

Table 1

Factors likely to influence supply chain policy effectiveness, cost-effectiveness, equity, and legitimacy and their application within the Cerrado.

Broad Policy Goal				
Specific goal	Criteria required to achieve goal	Potential indicators	Status in the Cerrado	Cerrado summary
HIGH REGIONAL EFFECTIVENESS & COST-EFFECTIVENESS				
High compliance (at lowest cost)	Incentives to comply with the payment contract (PES) or with the zero-deforestation committed firm (MEM) are sufficiently high.	Spatial scope and associated costs of the monitoring and enforcement system; Temporal structure of the payments and default penalties (PES) and nature and duration of exclusion outcomes (MEM)	<u>PES & MEM:</u> Near-real time monitoring of property level deforestation is available, reducing monitoring costs for both policies. <u>PES & MEM:</u> Farmers have an incentive to reconcile property boundary issues to make sure they are not falsely accused of non-compliance.	<u>PES & MEM:</u> moderate potential compliance.
	Economies of scale in monitoring compliance are achieved.	Costs associated with the monitoring and enforcement system	<u>PES & MEM:</u> Near-real time monitoring of property level deforestation is undertaken through the national government, rather than individual companies. Yet, individual companies still need to verify suppliers' locations and deforestation status with respect to the monitoring system.	<u>PES & MEM:</u> moderate potential cost.
High additionality (at lowest cost)	The payment (PES) or penalty from not selling to zero-deforestation committed firms (MEM) exceeds the opportunity costs of not clearing (profits associated with forgone soy production).	Scale of the promised funds (PES) and market share of committed actors (MEM); Soy profitability; Presence of legal hurdles to eligibility (for PES only)	<u>PES:</u> Pledged funding levels are low; soy profits are very high; and obtaining a deforestation permit to qualify for the PES is very difficult. <u>MEM:</u> Market coverage of firms with ZDCs is limited (less than 50%) in some regions, including some areas with high deforestation risk.	<u>PES:</u> moderate potential additionality at high potential cost. <u>MEM:</u> moderate potential additionality at moderate potential cost.
Low negative motivational spillovers	The policy increases or does not reduce intrinsic motivations to conserve.	Current producer motivations to conserve	<u>PES:</u> Presence of PES focused only at soy farmers may crowd out non-soy farmers and traditional communities' intrinsic conservation motives. <u>MEM:</u> Conforms to existing regulatory approach and thus is less likely to affect intrinsic motivations.	<u>PES:</u> moderate potential for motivational spillovers. <u>MEM:</u> low potential for motivational spillovers.
Low negative market spillovers	The policy reduces or does not increase targeted actors' financial <i>abilities</i> to deforest by overcoming capital constraints to deforestation.	Degree of capital scarcity	<u>PES:</u> The Cerrado is capital scarce so PES payments are likely to be important for investment decisions. <u>MEM:</u> The Cerrado is capital scarce and the MEM may further restrict access to credit from committed traders.	<u>PES & MEM:</u> moderate potential for market spillovers (capital and land market effects offset each other).
	The policy reduces or does not increase actors' financial <i>incentives</i> to deforest in non-targeted regions by increasing soy profitability.	Degree of land market integration across actors and regions; Differences in conservation policies across regions	<u>PES:</u> There is a high degree of market integration and few policies to incentivize conservation in other regions so PES could drive more people into buying land for conservation in the region. <u>MEM:</u> There is a high degree of market integration and large differences in conservation policies across regions, so greater restrictions in the Cerrado can drive farmers to other regions.	

(continued on next page)

Table 1 (continued)

Broad Policy Goal				
Specific goal	Criteria required to achieve goal	Potential indicators	Status in the Cerrado	Cerrado summary
HIGH EQUITY				
High procedural equity	All actors have an opportunity to participate in the policy development.	Policy design process in the region (how participatory; who participates)	PES & MEM: Only soy sector actors have been able to participate in dialogues and even then, this often doesn't directly involve producers.	PES & MEM: low potential procedural equity among all actors.
High contextual equity	All producers, including the most marginalized, possess attributes that enable their ability to verify eligibility to receive a payment (PES) or to comply (MEM).	Asset and income levels or producers that influence ability to comply; Education, information networks, and land tenure of producers	PES: The wealthiest soy farmers tend to have more forest remaining and are more likely to obtain deforestation permits. Poorer soy farmers and non-soy farmers may be excluded. MEM: Poorer farmers largely don't participate in soy, and are less likely to be negatively impacted by an MEM.	PES: moderate potential contextual equity among soy farmers and low potential contextual equity among other land users. MEM: low potential contextual equity among soy farmers and high potential contextual equity among other land users.
High distributive equity	Efforts are made to ensure equitable distributional outcomes and protect the most vulnerable actors from negative livelihood outcomes.	Exceptions made for more vulnerable actors	PES: Some farmers will be helped, whereas others would remain unaffected, but this could still exacerbate inequality both between soy farmers and between soy farmers and other, generally poorer actors. MEM: Some farmers will be excluded and thus may be negatively impacted by the policy.	PES: moderate potential distributive equity among soy farmers and moderate potential distributive equity among other land users. MEM: moderate potential distributive equity among soy farmers and high potential distributive equity among other land users.
HIGH LEGITIMACY				
Consistency with entitlements and values	Incentives are in alignment with historical rights and expectations.	Historical legal structures and paradigms	PES: Aligns with soy farmers' sense of entitlement to deforest, but would encounter legitimacy challenges from other actors who either feel similarly entitled or negate this entitlement. MEM: Does not align with soy farmers' sense of entitlement to deforest and dislike of punitive approaches, but would likely be supported by groups currently threatened by soy encroachment.	PES: high potential legitimacy among soy farmers, but low potential legitimacy among other land users. MEM: low potential legitimacy among soy farmers, but high potential legitimacy among other land users.

SUMMARY:

PES:

- high: potential legitimacy *among soy farmers*
- moderate: potential effectiveness *among all land users* and potential contextual and distributive equity *among soy farmers*
- low: potential cost-effectiveness and procedural equity *among all land users* and potential contextual equity, distributive equity, and legitimacy *among non-soy land users*

MEM:

- high: potential legitimacy *among non-soy land users*
- moderate: potential effectiveness and cost-effectiveness *among all land users* and potential contextual and distributive equity *among other land users*
- low: potential procedural equity *among all land users* and potential contextual equity, distributive equity, and legitimacy *among soy farmers*

greater land tightness with both credit and technical support for sustainable intensification could substantially improve agricultural practices in the region (Gil et al., 2016).

To offset negative impacts to the poorest soy farmers, and address legitimacy challenges from the soy producers' associations, PES could be used in combination with an MEM as a compensation policy in limited cases. Funds could be specifically targeted at soy farming households that still have forest remaining on their property, meet the Brazilian legal definition of a family farm⁵, and fall below a certain household income threshold, and would therefore be very negatively impacted by an MEM. Such an approach may also help avoid large, wealthy farmers capturing the majority of PES benefits and assist traditional families to resist pressures to sell their land. Even if it remains solely focused on soy producers, a PES policy that further includes payments for restoring land, focused on poorer farmers, could generate broader conservation benefits by enabling farmers who are otherwise pigeon-holed into selling to non-committed firms to not only comply with existing policies, but go beyond them by increasing net forest area. Given the high amount of Cerrado vegetation that has already been cleared, PES could be targeted at restoring areas that would provide the largest biodiversity conservation gains through improved ecological connectivity (Wood et al., 2020). For any property-focused policy options to be effective, land registration and monitoring systems would need to be improved. To avoid between-farm spillovers producers would need to disclose all of their land holdings and be compliant across all of those properties (not just where they produce soy) (Gollnow et al., 2018).

To address the compliance and longevity challenge among the participants of PES, long-term contracts (>10 years) will be needed to provide a clear and secure horizon for the returns on sustainability investments and even then, such a contract length does not guarantee that an area will be permanently protected, particularly if soy prices rise at a greater rate than PES scheme funds. Payments would be disbursed at multiple intervals to compensate ongoing avoided deforestation, but the contracts would stipulate producers' contractual liability for past payments if they cleared their land at any point during the contract period (e.g., the payments would be set up as loans that were forgiven at the end of the contract period, but repayment plus interest would be expected in case of contract-term non-compliance). To enable this type of contractual liability it might be necessary to go beyond individual trader credit contracts and integrate supply chain PES disbursements into the new Federal Payment Program for Environmental Services (PPPSA). By integrating into the national system, the soy-focused PES system financed by supply chain actors could improve its credibility and longevity.

5.2. Policy development processes must go beyond individual sectoral interests

Stakeholder exclusion and adverse equity outcomes in conservation schemes can erode trust and result in local resistance (Pascual et al., 2014), which is critical to contractual compliance. If conservation interventions, even positive ones, are designed in ways that exclude large numbers of actors, it may drive them towards less sustainable supply chains or land uses (Klein et al., 2015). When designing any commodity specific policy, it is necessary to address procedural equity concerns by expanding the dialogues to include the voices of other actors beyond the targeted sector. These actors should have a voice in deciding the goals,

implementation modalities, and grievance management mechanisms that affect their surrounding landscape.

In the case of the Cerrado, convening groups such as the Cerrado Working Group, Soft Commodity Forum, and TFA should continue to build on recent efforts to engage a greater variety of Brazilian stakeholders beyond the soy industry, for example, by including representatives of additional stakeholder groups directly in commodity- or Cerrado-related multi-stakeholder efforts. In particular, greater efforts to include indigenous group representatives and smallholder and worker associations are needed.

All of the above conclusions point to the need to continue developing more collaborative public-private jurisdictional approaches. As mentioned in the introduction, such approaches should involve and reconcile the needs of all stakeholders in finding sustainability solutions that match existing governance structures within local jurisdictions (von Essen & Lambin, 2021). Any PES and MEM conservation scheme that is limited to individual supply chains will likely result in deforestation spillovers to actors that are not incorporated within those markets (Garrett et al., 2019; Meyfroidt et al., 2020). Thus, commodity specific supply chain approaches should only be used as a stop-gap solution until broader jurisdictional efforts can be established that encompass all actors.

Due to its greater likely effectiveness, cost-effectiveness, equity, and legitimacy among non-soy land users, we advocate for the establishment of a positive incentive scheme for avoided deforestation and restoration at the level of jurisdictions such as states or municipalities that is coupled to a Cerrado-wide supply chain market exclusion mechanism (Figure 3). A PES component targeted at the jurisdictional level (state or municipality), rather than the producer level, would involve recognition of the ES associated with zero-conversion in a way that is inclusive of all land users. Specifically, it would involve rewarding all actors for preserving ES and thus not implicitly entitle soy farmers to additional deforestation by directing rewards only towards this group.

Financing for the program could be generated from multiple sources, including companies, the target states, the Brazilian national development bank, and global climate funds. A combined PES + MEM approach at the jurisdictional level could leverage support and participation from multiple actors within the jurisdiction, ensuring more effective monitoring (Brandão et al., 2020). Such an approach would be more in line with what REDD+ (Reducing Emissions from Deforestation and Forest Degradation) initiatives of the United Nations Framework Convention on Climate Change intended (though such coordination hasn't often been realized) (Well & Carrapatoso, 2017). Clear benefit sharing mechanisms would need to be established to help ensure fair distribution of funds received (Ravikumar et al., 2015).

Mixed PES + MEM jurisdictional approaches have the added benefit of aligning with "smart mix [measures]" to halt import driven deforestation that are currently being discussed in the EU and UK (European Parliament Text P9_TA(2020)0285, UK Environmental Bill 220 2019–2020). These include requiring due diligence of importing companies, establishing preferential trade agreements (though downscaled to individual sourcing regions), and providing partnerships and positive incentives for sustainable production. EU and UK smart-mix measures could be aided by jurisdictional zero-conversion PES + MEM efforts by cooperatively establishing the territorial monitoring systems and incentives needed to bring down native ecosystem conversion. The need to verify that production meets import countries' requirements, not just individual company commitments, creates incentives for buyers to work with farmers currently beyond their supply chains (i.e., indirect suppliers and farmers currently selling through other channels) to bring entire regions up to zero-deforestation requirements, rather than attempting to verify deforestation policy compliance of individual supply chains or producers.

⁵ The legal definition (Lei 11.326/2006) of an "Empreendimento Familiar Rural" is a farm property that: i) is less than four fiscal/tax modules in size, ii) relies primarily on family labor, iii) meets a certain minimum threshold of how much income is derived from the farm, and iv) runs the farm with the family. The specific size of a fiscal module varies across municipalities and the threshold for income is defined by the executive branch (IBGE 2017a).

Improvements to a standalone MEM or PES supply chain policy	
MEM with a targeted PES	Jurisdictional MEM+PES
 Could increase compliance and reduce spillovers by targeting positive incentives towards those least able to comply.	 Larger scale of implementation helps reduce negative deforestation spillovers.
 Limits costs to those needed to offset most harmful effects.	 Coordination between governments and supply chains could reduce costs.
 Ensures inclusion of poor through targeted PES and won't exacerbate income inequality.	 Channels finance to a broader range of actors and activities.
 Entitlement to deforest based on economic need, not economic privilege	 Entitlements negotiated among a broader set of actors.
 = effectiveness  = cost-effectiveness  = equity  = legitimacy	

Fig. 3. Summary of the potential effectiveness, cost-effectiveness, equity, and legitimacy of two alternatives to a standalone payment for environmental services (PES) or market exclusion mechanism (MEM) for reducing soy-driven deforestation in the Brazilian Cerrado. "MEM with a targeted PES" indicates a biome-wide market exclusion mechanism with PES targeted only at the poorest producers and restoration activities. "Jurisdictional MEM + PES" also combines negative and positive incentive systems, but would be negotiated by all land users and implemented at the level of states within the Cerrado.

5.3. Spillovers and transformational change

As mentioned above, any positive incentive scheme has the potential to generate additional clearing by providing cash to a capital-constrained environment. Spillovers from new capital infusions could be mitigated if the PES are earmarked for the protection of conserved areas, restoration, and sustainable agricultural practices (i.e., PES are dispersed only to farmers who undertake conservation projects or take the form of a low-interest loan for sustainable agriculture activities). If PES are distributed through loan programs for sustainable agriculture and restoration, they could stimulate positive spillovers in the form of higher incomes and food production through higher-yielding agricultural practices or carbon sequestration, improved water quality and biodiversity protection through restoration.

Yet today's social and environmental challenges, including those of the Brazilian Cerrado, require major, fundamental changes to existing economic and political structures (Feola, 2015; Lahsen et al., 2016). To be transformative in actually changing the sustainability trajectory of the region, such efforts must tackle the sources of social and ecological harm at their root causes (cf. Pelling, 2010). In agricultural-forest frontier areas this requires supporting the development of alternative rural development pathways that do not rely on native vegetation clearing. These alternatives should include, but must also go beyond the sustainable intensification of soy and cattle systems by also strengthening the production, marketing, and transport of high-value crops (e.g., fruits and horticulture), non-timber forest products, and seeds for forest and landscape restoration. Without developing a new bioeconomy and a new cultural outlook on the pathways for improved wellbeing in the region, any efforts to tackle commodity-driven deforestation will be continuously undermined by strong countervailing political, economic, and cultural pressures (Garrett, Cammelli, et al., 2021).

6. Conclusion

Private sector discourses about supply chain sustainability governance are increasingly considering policies that pay land users not to clear their land due to industry backlash against purely

punitive policy approaches (TFA, 2020). While the appearance of PES in multi-stakeholder dialogues for supply chain governance is not surprising given its high potential legitimacy among farmers of the target commodity, it is clear that such an approach would be neither equitable, effective, nor cost-effective. An MEM would suffer from some of the same challenges, but a PES program is particularly concerning because it further legitimizes a "right to clear" among a small, elite group of actors.

A Cerrado-wide zero-conversion MEM that offers a PES only for the poorest farms in the biome would be more cost-effective, effective, equitable, and legitimate to non-soy land users and other actors. Yet, given the high implementation costs and narrow focus and inclusiveness of commodity-specific supply chain policies on export-driven deforestation, these types of supply chain approaches are best used as a stop-gap until public policies can be changed and improved. Public sector engagement in both exporting regions (through jurisdictional approaches) and importing regions (through smart mix policies) will be crucial to establish effective and equitable deforestation control and restoration policies, as well as promoting more sustainable and equitable agricultural and forestry systems globally.

Given the magnitude of the deforestation threat, the case of PES in the Cerrado is globally important in its own right. Yet, the ex-ante analysis presented here is relevant for other regions considering PES in supply chains, especially agricultural-forest frontiers with heterogeneous actors. It suggests, in line with many other recent studies (Azevedo et al., 2015; Garrett, Levy, et al., 2021; Gibbs et al., 2015a; Heilmayr et al., 2020; Lambin et al., 2018; von Essen & Lambin, 2021), that while private sector supply chain governance efforts offer a promising stop-gap approach to addressing ongoing commodity-driven deforestation in the short-term, there is an urgent need to supplement these efforts with broader jurisdictional approaches to establish zero-deforestation sourcing regions and encourage a broader transition toward sustainable agriculture and a forest economy.

Author contribution statement

RG and JG conceived of the study, SL undertook the field interviews; RG, JG, and FC co-developed the first draft, FG, RG, and SL

contributed to the figures, and all authors contributed to further comments, writing, and editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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