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Scaling up sustainability in commodity agriculture: Transferability of governance mechanisms across the coffee and cattle sectors in Brazil

R. Hajjar [a, b, *, 1], P. Newton [a, c, 1], D. Adshead [d], M. Bogaerts [a], V.A. Maguire-Rajpaul [d], L.F.G. Pinto [e], C.L. McDermott [d], J.C. Milder [f, g], E. Wollenberg [h], A. Agrawal [a]

[a] International Forestry Resources and Institutions (IFRI) Research Network, School for Environment and Sustainability, University of Michigan, 440 Church Street, Ann Arbor, MI 48103, USA
[b] Forest Ecosystems and Society, Oregon State University, 321 Richardson Hall, Corvallis, OR 97331, USA
[c] Environmental Studies Program, Sustainability, Energy and Environment Community, University of Colorado Boulder, 4001 Discovery Drive, Boulder, CO 80303, USA
[d] Environmental Change Institute, School of Geography and the Environment, University of Oxford, Oxford, OX1 3QY, UK
[e] Instituto de Manejo e Certificação Florestal e Agrícola – Imaflora, Estrada Chico Mendes 185, Piracicaba, SP, 13426 420, Brazil
[f] Rainforest Alliance, Evaluation & Research Program, New York, NY 10279, USA
[g] Cornell University, Department of Natural Resources, Ithaca, NY 14853, USA
[h] CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Gund Institute for Environment, University of Vermont, 617 Main Street, Burlington, VT 05405, USA

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ABSTRACT

A number of governance mechanisms address socio-environmental challenges associated with commodity agriculture in tropical forested countries. Governance mechanisms that prove effective in one agricultural sector are often applied to other sectors as well. For example, voluntary certification programs have been adopted by producers of commodities as diverse as beef, coffee, palm oil, and soy. However, there are substantial differences in the extent to which governance mechanisms scale up and achieve impact in different sectors. This paper analyzes how the potential for scaling up a particular governance mechanism is influenced by environmental, market, and social geographies that differ between sectors. Through stakeholder interviews, farm-level surveys, and a literature review, we examine two types of voluntary governance mechanisms (third-party certification, and sustainable intensification programs) in the coffee and cattle sectors in Brazil, to understand why the two governance mechanisms have scaled differently between these two sectors. We find that third-party certification programs have scaled up relatively well in Brazil's coffee sector, more so than its cattle sector, in part owing to differences in sustainability priorities, market orientations, supply chain traceability, and social networks between the two sectors. We also find that pilot sustainable intensification programs in the cattle sector have had more success than certification in engaging farmers, in part because they involve less investment from participating farmers. We conclude that the distribution and quality of environmental resources, markets, knowledge, actors, and networks can play an important role in the ability of a governance mechanism to effectively take root.

1. Introduction

Commodity agriculture is a significant contributor to the economies of many countries that export beef, coffee, palm oil, and soy to meet growing global demand (FAOStat, 2017). At the same time, commodity agriculture in many countries is associated with environmental and social challenges that need to be addressed to enhance agricultural sustainability. For example, cattle and palm oil production are both associated with high rates of land use change,

* Corresponding author. Forest Ecosystems and Society, Oregon State University, 321 Richardson Hall, Corvallis, OR 97331, USA.
E-mail addresses: reem.hajjar@oregonstate.edu (R. Hajjar), peter.newton@colorado.edu (P. Newton), daniel.adshead@ouce.ox.ac.uk (D. Adshead), megkb@umich.edu (M. Bogaerts), victoria.maguirerajpaul@ouce.ox.ac.uk (V.A. Maguire-Rajpaul), luisfernando@imaflora.org (L.F.G. Pinto), constance.mcdermott@ouce.ox.ac.uk (C.L. McDermott), jmilder@ra.org (J.C. Milder), lini.wollenberg@uvm.edu (E. Wollenberg), arunagra@umich.edu (A. Agrawal).
[1] contributed equally to work.

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deforestation (Barona et al., 2010; Bowman et al., 2012), greenhouse gas emissions (Bustamante et al., 2012; Cederberg et al., 2011), encroachment into indigenous lands, and labor rights violations (Phillips and Sakamoto, 2012).

In many tropical forested countries, governments, corporations, and civil society organizations have attempted to implement a number of regulatory policies, voluntary programs, and other sustainability interventions and initiatives (collectively described in this paper hereafter as *governance mechanisms*) at local to global scales in an effort to achieve greater commodity agriculture sustainability (Newton et al., 2013; Agrawal et al., 2014). In recent decades, concerns about the effectiveness of regulatory approaches have led to a growing prominence of civil society and voluntary governance mechanisms. Such voluntary mechanisms include sustainable commodity roundtables, payments for environmental services programs, and third-party certification programs.

Voluntary governance mechanisms have found differing degrees of receptiveness across agricultural commodity producers and sectors. Governance mechanisms perceived to be effective in one sector have found application in other sectors, with the assumption that at least some of the elements driving successful outcomes are transferable. For example, moratoria on the production of soy and cattle have been established in Brazil, in each case to exclude supply chain actors that source from deforested properties in the Amazon biome (Gibbs et al., 2015, 2016). Similarly, voluntary zero-deforestation commitments have been made by numerous multinational companies in an attempt to sustainably source beef, palm oil, wood pulp, timber, and soy, by developing improved supply chain traceability and management systems (Lambin et al., 2018). Roundtables have been developed for commodities including beef, palm oil, and soy, taking a multi-stakeholder governance approach to defining and recognizing sustainability (Brassett et al., 2011). Finally, voluntary certification programs have been adopted by producers of commodities as diverse as black pepper, cattle, coffee, fish, palm oil, tea, timber, and soy (Tayleur et al., 2016). Certification programs are market-based systems that defineenvironmental and social sustainability standards, establish independent third-party verification of these standards, and recognize producers and products that comply with the standards.

Some of the ways that the success of a governance mechanism can be assessed are by its rate and extent of adoption, and by its positive and negative impacts. Certification is an example of a governance mechanism that has reached significant scale in several key commodity crop sectors, and the proportion of agricultural production that is certified in these sectors has increased dramatically in the past two decades (Potts et al., 2017; Tayleur et al., 2016). Producers that become certified usually need to improve their management practices to comply with the program's standards. This creates additional costs, but also several possible benefits: for example, product price premiums, improved market access, or improved on-farm efficiency or productivity (Raynolds et al., 2007). An emerging body of evidence suggests that certification can significantly influence environmental outcomes at large scales (Hardt et al., 2015; Vanderhaegen et al., 2018). Organic coffee certification reduced chemical input use and increased adoption of some environmentally friendly management practices, including increasing tree cover and habitat conservation, in several countries (Blackman and Naranjo, 2012; Giulia et al., 2017; Hardt et al., 2015; Jurjonas et al., 2016). A global review of the literature on effects of Sustainable Agriculture Network/Rainforest Alliance certification found that certified farmers applied more sustainable farm practices and contributed more frequently to protecting local water resources, while also increasing productivity and profitability, than non-certified farmers (Milder and Newsom, 2015).

Although certification has gained traction, there is significant heterogeneity among agricultural sectors in the proportion of production that is certified. For example, in 2014, globally, 48 percent of coffee, 30 percent of cocoa, 20 percent of oil palm, 18 percent of tea, and 12 percent of bananas were standards compliant (Potts et al., 2017). In contrast, just a handful of cattle farms are standards compliant (Alves-Pinto et al., 2015). Variation in the uptake of certification in different sectors may partly reflect how long programs have existed for different commodities – for example, reflecting the relatively nascent nature of livestock certification relative to crop certification. At the same time, there may be important lessons to learn from sectors for which certification programs have been in place for longer, or in which certification has scaled up to a greater extent –i.e. adopted by a larger number of actors (e.g. producers), and/or across a larger proportion of a sector. Such lessons from past experiences may be useful in more rapidly or successfully scaling up certification in sectors for which certification is relatively nascent. On the other hand, variation in the extent to which certification has gained traction in different sectors may also indicate inherent differences between sectors that affect either the likely viability of certification as a tool for enhancing sustainability, or the most appropriate strategies for scaling up certification.

Many agencies engaged in socio-environmental governance are proposing comparable solutions across sectors. Their underlying assumption is that it would be valuable to scale up new sustainability solutions that maintain or improve positive environmental, social, and economic outcomes. It is worthwhile, therefore, to identify sectoral differences pertinent to scaling up strategies. This paper asks: Are there salient environmental, economic, and social factors that differ among sectors, and that enable or constrain transferability of voluntary mechanisms, their scalability, and their potential for positive impacts on sustainability? This question is addressed by examining the case of certification and other voluntary initiatives in the coffee and cattle sectors in Brazil. In this paper, initiatives that have emerged in two contrasting agricultural sectors are compared and contrasted, key factors that explain their differences are identified, and the implications of these differences are assessed for the future expansion of certification and other voluntary initiatives in each sector.

2. Research context: sustainability governance mechanisms in the cattle and coffee sectors in Brazil

The focus of this study is on two agricultural commodity sectors in Brazil: cattle and coffee. Although these two sectors are markedly different in many dimensions, these sectors were chosen based on the opportunity to draw useful lessons from contrasting cases. On the one hand, experience from the coffee sector, which has a decades-long history of certification and has experienced relatively rapid and widespread uptake of certification, may inform the incentives and mechanisms by which certification in the cattle sector might better achieve impact and scale. On the other hand, research on other sustainability initiatives in the cattle sector might help identify if, how, and when other approaches besides, or in addition to, certification might be appropriate.

In addition, Brazil is a world leading producer of both of these products, allowing the comparison of both sectors within a single, globally significant country context. Furthermore, the Sustainable Agriculture Network/Rainforest Alliance (SAN/RA) certification program has certified both cattle and coffee farmers in Brazil, enabling the comparison of the same certification program across two contrasting sectors.

2.1. Coffee

A number of voluntary environmental and social certification programs have been adopted within Brazil's coffee sector. These include UTZ Certified, Fairtrade, Organic, Nespresso AAA Sustainable Quality, 4C Association, and SAN/RA. The SAN/RA program first certified coffee in 1996 and has grown relatively rapidly in the coffee sector in Brazil and elsewhere in Latin America (Milder and Newsom, 2015). The SAN Sustainable Agriculture Standard for farm certification includes a set of sustainability principles and criteria that promotes social, economic, environmental, and ethical standards for certified farms and farmer groups (SAN, 2010b, 2017b). In Brazil, the first coffee farm was certified in 2003 and over 250 coffee farms and 169,000 ha of land planted with coffee were SAN/RA certified at the end of 2016 (SAN, 2017a), representing one third of the country's certified coffee, and 8 percent of the country's total coffee area.

2.2. Cattle

The SAN Standard for Sustainable Cattle Production Systems for cattle farm certification is the world's first and main voluntary, third-party certification program in the cattle sector (Alves-Pinto et al., 2015; SAN, 2010a). It builds on the SAN standards for certifying agricultural crops with additional cattle-specific requirements. The program first certified a cattle farm in Costa Rica in 2012 and is thus relatively nascent. Only four cattle farms in Brazil have been certified as of July 2018; only two were certified at the time data were collected for this study.

In addition to certification, a number of other sustainability initiatives are underway, led by state, private sector, and NGO actors to reduce deforestation and enhance sustainability in the cattle sector in Brazil (Alves-Pinto et al., 2015; Nepstad et al., 2014). These include sustainable-intensification pilot projects, which aim to increase stocking density through improved pasture management (Bogaerts et al., 2017) (see Table S2 for descriptions of initiatives included in this study).

3. Methods

This paper synthesizes the results of research undertaken between 2014 and 2016 by a multi-institutional team of researchers as part of an interdisciplinary project on certification and sustainability in the coffee and cattle sectors in Brazil (Guedes Pinto et al., 2016). In this exploratory study, both primary data collected during a field season (June–August 2015) (Section 3.1) and current literature are used to describe and analyze environmental, economic, and social factors affecting scalability of voluntary governance mechanisms in both sectors.

3.1. Primary data collection

Data were collected and analyzed from 1) surveys with farmers, and 2) semi-structured interviews with non-farmer stakeholders including representatives of NGOs, government agencies, and the private sector. These different data collection strategies served to answer different parts of the research question. The farm-level surveys quantified the characteristics of the system according to the perspective of the participants and the data provided by those participants; the stakeholder interviews provided greater insights into the broader processes that explain those characteristics.

3.1.1. Farm-level surveys

A total of 104 coffee and cattle farmers were interviewed across five Brazilian states: Amazonas, Mato Grosso, Minas Gerais, Pará, and Rondônia. Interviews were based on a survey instrument developed with the aim of collecting similar information from both coffee and cattle farmers. The data collected include information on farmer motivations and barriers related to joining certification and sustainability programs, the social networks from which farmers received advice related to farming, and factors influencing participation.

In the coffee sector, 60 farmers were surveyed: 29 certified and 31 non-certified farms in the Triângulo Mineiro region of the state of Minas Gerais (Figure S1), known for its coffee production. There is a high concentration of certified farms in this area. Interviewees were selected with the help of coffee cooperative representatives, with the aim of having a relatively balanced sample across all farm size groups within the region (Table S1; Adshead, 2015).

In the cattle sector, 44 farmers were interviewed (Table S2, Figure S1): one owner of two SAN/RA-certified farms; 22 farmers participating in sustainable-intensification programs identified by research collaborators; and 21 otherwise-similar farmers not participating in any sustainability program (non-program farms were qualitatively assessed to be comparable to program farms at each study site based on size of operation, geographic proximity, and type of operation (Bogaerts et al., 2017)).

3.1.2. Stakeholder interviews

Semi-structured interviews were completed with twenty key stakeholder informants. Purposive sampling was used to include representatives of, or experts in, sustainable cattle interventions, including: agricultural banks, the beef industry, federal and municipal government agencies, rancher associations, certification bodies, beef roundtables, environmental NGOs, and the sustainability initiatives included in the sample. Interviewees were located in the states of São Paulo, Mato Grosso, Rondônia, Rio de Janiero, Amazonas, and Pará, and in the Federal District of Brasília (refer to Maguire-Rajpaul et al., 2016 for more details). The goal of these discussions was to elicit interviewees' perspectives on Brazil's sustainable cattle initiatives. Semi-structured interviews were deemed appropriate since Brazil's sustainable cattle initiatives are nascent with fast-changing sustainability goals, so too many predetermined interview questions could have been restrictive (Ferris, 2015).

3.2. Analysis

While starting with the premise of examining the sectors' social, environmental and economic dimensions that may play a role in scaling up sustainability, the iterative process of examining the different components of this research led to an emergent analytical framework where the study of environmental, market, and social geographies centers on place and space: environmental resources and related conservation priorities, market locations and extensiveness of supply chains, and social structures and relations, all interact in ways that are shaped by physical, socio-political, and economic spaces. The analysis spans multiple scales. First, a focus on the sectoral and regional scales: stakeholder interviews were used, in addition to relevant secondary literature, to examine the environmental and market geographies (sections 4.1 and 4.2, respectively), and the farm-level surveys to examine the social geographies (section 4.3) of the coffee and cattle sectors. Second, a focus on the scale of the producer: the farm-level surveys were used to characterize how certification and other sustainability initiatives were perceived by farmers (section 4.4). The semi-structured interviews were analyzed question by question, with responses being categorized into emergent categories. Using an

iterative process, these categories were grouped into broader thematic groupings (see Ferris, 2015; Maguire-Rajpaul et al., 2016). To enhance internal validity, responses were triangulated with available literature, researchers liaised with interviewees after the interview process for clarifications, and final results were shared with all interviewees (Yin, 2003). The survey data were analyzed using descriptive statistical methods in SPSS. Social network analyses were conducted in UCINET.

4. Results and discussion

4.1. Environmental geographies

Different spatial contexts can lead to variation in the adoption of more sustainable agricultural practices (Choi, 2016). The cattle and coffee centers of Brazil are situated in two different regions, with variations in environmental resources and conditions, making the principal environmental challenges differ markedly between the two. This in turn affects the foci of sustainability interventions in these regions.

4.1.1. Environmental sustainability priorities in different biomes

Sustainability priorities vary between actors, sectors, regions, biomes, and over time. These priorities shape the governance of a sector in terms of which programs receive the most effort and attention.

Coffee production in Brazil is concentrated mostly in the Atlantic Forest and Cerrado biomes, which are among the 10 global biodiversity hotspots and prime targets for conservation attention (Myers et al., 2000). The Cerrado has faced high deforestation rates in recent years owing to agricultural expansion, particularly for soy (Strassburg et al., 2017). The Atlantic Forest had been heavily deforested in the 19th and 20th centuries, now reduced to 20 percent of its original forest cover. Rates of deforestation are much lower than historically, in part due to the introduction of stringent environmental laws (e.g. the Forest Code, law 12.651/2012) and improved monitoring capabilities, and in part because such a large proportion of the original forest extent has already been removed. As such, deforestation is no longer a foremost environmental concern in Brazil's main coffee-producing regions. Rather, sustainability concerns in regions where the coffee sector is concentrated center around environmental and social issues such as: environmental degradation, including biodiversity loss, ecosystem fragmentation, and water and soil pollution caused by coffee monocropping; the health implications of chemical residues used in farming; and the social inequalities associated with the international coffee trade (Raynolds et al., 2007). Environmental objectives in the coffee-growing regions of Brazil are thus more focused on reducing environmental degradation that has resulted from landscape fragmentation, biodiversity losses, and pollution from farming additives.

Cattle production in Brazil is concentrated mostly in the Amazon and Cerrado biomes. Prevalent at the frontier of deforestation in the Brazilian Amazon, cattle farming is associated with more than 80 percent of Brazil's deforestation (De Sy et al., 2015). Further, the cattle sector is associated with a large proportion of Brazil's greenhouse gas emissions from the land-use change associated with deforestation (which represented approximately 22 percent of the country's total greenhouse gas emissions in 2010 (MCTI, 2013)) and from emissions associated with cattle production, including enteric fermentation and manure management (Bustamante et al., 2012). Land conversions are the primary focus of policy makers and NGOs addressing environmental issues in these biomes (Strassburg et al., 2014). In contrast to the coffee sector, then, the recent foci of sustainability efforts that target the cattle sector in Brazil have been reducing deforestation, and greenhouse emissions from land use change and enteric fermentation.

4.1.2. Governance mechanisms for sustainability in the Brazilian coffee and cattle sectors

A range of governance mechanisms has been implemented to enhance sustainability in both the cattle and coffee sectors. Some are not sector-specific, such as the Forest Code, which requires that at least 80 percent of forested land be retained as forest on private properties in the forest regions of the Amazon. However, the governance mechanisms that have received greatest attention and recruited the largest number of participants in these two sectors in recent years may, at least in part, reflect the differing sustainability priorities described above. For example, sustainability governance mechanisms in the Brazilian coffee sector include certification schemes such as UTZ and SAN/RA, as well as technical assistance. These focus on minimizing environmental degradation from crop production, in addition to implementing social safeguards. On the other hand, sustainability governance mechanisms in the Brazilian cattle sector continue to focus principally on the problem of deforestation. These include: i) the Cattle Agreement, signed by four of Brazil's largest meatpackers, not to buy cattle from ranches in the Amazon biome that have participated in deforestation after 2009; ii) NGO- and government-backed sustainable intensification programs in the Amazon biome that aim to increase the amount of beef produced per hectare, hoping to offset increased demand for beef with increased production without having to expand pasture land into forested areas; and iii) the SAN/RA certification program. The aggregate 'sustainability governance landscape', which characterizes the two sectors in their respective regions, varies in part as a consequence of differentiated sustainability priorities.

4.1.3. Implications of differences in environmental geographies and sustainability priorities

These differences in environmental sustainability contexts, priorities, and governance mechanisms between the two sectors in different regions of Brazil inform several points of discussion.

First, governance mechanisms variously focus on enhancing sustainability by reducing the worst, undesired practices or by promoting better practices. For example, successfully implementing the Cattle Agreement involves eliminating worst practices, such as illegal deforestation, labor violations, and encroachment on indigenous lands. In contrast, successfully implementing sustainable intensification programs entails the promotion and adoption of a set of accepted 'best practices', including improved pasture management, and increasing stocking densities. Finally, successfully implementing the SAN/RA certification program involves the promotion and adoption of a larger number of best practices, across a range of environmental and social criteria articulated in the certification standards. Which of these actions – reducing worst practices or promoting best practices – is of greatest priority may influence actors' decisions in which governance mechanisms to focus effort upon.

Second, whether a governance mechanism addresses worst practices, promotes best practices, or both, there is variation both in the comprehensiveness with which it frames sustainability (breadth), and in the extent of change that it aspires to produce in any one dimension (depth). In terms of breadth, some governance mechanisms define sustainability more broadly and holistically than others; they vary from those focused on a narrow set of metrics to those focused on a more comprehensive set of environmental and social conditions. In terms of depth, some mechanisms demand greater, or more difficult, changes from their participants than others.

This variation in breadth and depth has implications for how

easily a farmer might comply with the expectations or demands of a program. One might expect that a program may face challenges in recruitment and implementation if the governance mechanism's breadth and/or depth present seemingly insurmountable obstacles for farmers to transform their practices. However, strategies that are broad and deep may ultimately achieve land use and agricultural practices that are more sustainable.

Governance mechanisms in the coffee sector in the Atlantic Forest and Cerrado biomes, such as certification, tend to seek to affect sustainability more holistically, while initiatives in cattle sector in the Amazon and Cerrado biomes, particularly in the frontier regions, are more focused on the narrowly defined issues of deforestation and greenhouse gas emissions. The few cattle sector programs that do take a more holistic approach to sustainability tend to be located away from deforestation frontiers. For example, most – though not all – cattle farms participating in sustainable intensification and certification programs, including those that were sampled, while located in states that have high deforestation rates, were not located on farms at the very frontiers of deforestation.

This difference in conditions suggests that more effective outcomes may be reached if differentiated strategies are used to optimally target the sustainability goals at hand. If the goal of sustainability efforts in one sector and region (e.g. coffee in the Atlantic Forest and southern Cerrado) is to reduce environmental degradation, applying those same sorts of efforts in another sector in a different region where different sustainability objectives prevail (e.g. cattle in the Amazonian frontier) may be less effective.

In the studied cases, sustainable intensification programs in the cattle sector focused on improving agronomic practices, while the SAN/RA certification program additionally incorporated environmental and social practices, and animal welfare considerations (Alves-Pinto et al., 2015). However, if reducing deforestation and related greenhouse gas emissions remain as the sustainability priorities in deforestation frontiers in the Amazon and Cerrado biomes, where much of the cattle sector is concentrated, other governance mechanisms may be more effective. The more holistic approach to sustainability offered by SAN/RA certification, may effectively be 'overkill', relative to the contextualized priority of curtailing deforestation, by requiring compliance with a great deal of additional, and potentially burdensome, environmental and social criteria. Ultimately, though, it may not be the breadth of the SAN/RA certification program that best explains its limited rates of adoption by ranchers, but perhaps rather its zero tolerance for recent deforestation and its requirement for compliance with the Forest Code – two criteria that quickly exclude a large number of ranchers from even contemplating participation. Indeed, voluntary mechanisms more broadly may be unlikely to halt illegal deforestation in the Amazon, since they are unlikely to be able to engage those actors and land units most closely implicated in clearing forests to create pasture.

The sustainability focus of the cattle sector in these regions may eventually evolve to include other concerns. The more holistic approach to sustainability represented by the development of the SAN/RA cattle certification program, and – to some degree – by the Brazilian Roundtable for Sustainable Livestock (GTPS) may be early indicators of such an evolution, but, at least for SAN/RA, this approach may have slower uptake than other strategies.

4.2. Market geographies: market orientations and supply chains

In this section, evidence is presented that suggests that the characteristics and spatial variations of the respective market orientations and supply chains of coffee and beef also affect the likelihood of a particular initiative scaling up and achieving impact.

4.2.1. Differing market orientations

Brazil is the largest coffee producer, and top coffee exporter, in the world, with 32 percent of global coffee production (International Coffee Organization, 2014; Potts et al., 2017). While it is also a main coffee consumer, the coffee sector is more dependent on, and attuned to changes in, international demand for certified coffee. In 2016, 68 percent (34 of 49.6 million bags) of Brazil's harvest was exported to 129 countries, with 17 percent (5.9 million bags) of this export having a special quality or sustainability certification seal.

Brazil is also the world's largest exporter of beef (Index Mundi, 2017). However, just 20 percent of beef produced in the country is exported (Walker et al., 2013). Most of the SAN/RA-certified beef produced in Brazil to date has been sold domestically; there has thus been limited visibility of certified beef in international markets. However, the percentage of Brazil's beef production that is exported is growing; this may represent a growth in opportunities to scale up sustainability programs, such as certification, that appeal to international markets. Nevertheless, while large volumes of Brazilian coffee are exported to rich countries where sustainability and consumer awareness are high, most of Brazilian beef is exported to developing countries where there is little demand for "sustainable" products.

Another important difference between the coffee and cattle sector relates to how brands connect consumers, companies, and producers throughout the value chain. A high proportion of coffee is marketed to consumers under established brands that are easily identified in domestic and global markets (Panhuysen and van Reenen, 2012). Companies that own these brands place considerable value in them, and have established sustainable sourcing commitments to help protect these brands and to meet other objectives, such as sustained quality and reliability of supply. By comparison, a smaller proportion of beef is marketed to consumers under a recognized brand and, when it is, this brand may be associated with a retailer (e.g., McDonald's) and not with a supermarket product. As a consequence, the brand-driven reputational risk pressure to address potentially unacceptable environmental and social impacts in beef supply chains is both far less widespread and more indirect (i.e., further removed from production units of origin) than it is in the coffee sector. Furthermore, sustainability consciousness related to coffee supply chains has been building for two decades, whereas it is much more recent for beef supply chains. Taken together, these differences help explain the current sustainability status of each sector: the beef sector is still dealing with eliminating the worst practices, while the coffee industry is more focused on promoting, and branding, best practices.

4.2.2. Supply chain length and traceability

As a market-based sustainability governance mechanism, certification may be easier to implement in the coffee supply chain than in the cattle one due to length and location of their respective chains.

The coffee supply chain is relatively short, simple, and spatially contained. It involves relatively few stages, locations, and actors, and is comparatively easy to trace. In many cases, production and trade are organized by cooperatives, allowing for easier transmission of market signals. If the export market demands certified coffee, the cooperatives that sell directly to that export market can pass that demand signal on to the farmers that sell directly to those cooperatives and assist those farmers in achieving certification status.

In contrast, the cattle supply chain can be long, complex, and fragmented, involving multiple farms, producers, processors, and traders at different cattle life stages, from birth, fattening, and slaughtering of the cattle, to processing of the beef and final sale,

with different social and environmental impacts at each stage. The supply chain can cover thousands of kilometers across different biomes before reaching the domestic market alone. This makes clear traceability of the beef, from calving farm to supermarket shelf, extremely challenging. Poor traceability enables illegal deforestation to be 'hidden' in the supply chain, as slaughterhouses may be separated from calving operations by two or three intermediaries, whose transactions are difficult to track and in some cases may be deliberately managed to 'launder' animals originating from ranches with active or recent deforestation (Gibbs et al., 2015). The SAN/RA standards and associated chain of custody systems require that all certified producers and downstream links in the supply chain are monitored at least to a basic degree, but the absence of a national traceability system creates hurdles to comply with this requirement. Such traceability has been implemented on a national scale in Uruguay, where all cattle are ear-tagged, but Brazil's cattle herd is significantly larger and no large-scale effort to achieve full traceability has yet been attempted. Such a lengthy and fragmented supply chain not only diffuses market signals throughout the chain; it also limits potential benefits from reaching the early cattle rearing stages that are most associated with deforestation. As such, non-market based mechanisms, such as NGO- or state-led assistance programs, coupled with increased enforcement where appropriate, may be able to more purposively target early stage ranchers or particular components of the supply chain that are most problematic. Such 'indirect suppliers' are the focus of several NGO- and roundtable-led efforts to reduce deforestation in the cattle supply chain (e.g. led by National Wildlife Federation, The Nature Conservancy, and the GTPS).

4.3. Social geographies: social networks of advice and influence

Social networks can influence land use behavior, and social ties that convey information can influence the adoption of better agricultural practices (Isaac and Matous, 2017). In this section, market geographies in both sectors are explored to explain how these geographies mediate social structures and interactions among producers and other actors within a sector, to better understand how knowledge and adoption of sustainability interventions can take hold among a network of farmers and ranchers.

4.3.1. Social network structures of the sectors follow market geographies

Advice and influence networks – from whom they sought advice, and who influenced their decision to join a certification or sustainability program (Guedes Pinto et al., 2016) – were compared among the surveyed farmers and ranchers.

For coffee farmers, technicians from the cooperatives to which they sold most of their coffee, were the main sources of information for both certified and non-certified farmers, and were the most influential relationships for certified farmers. Of the total ties in the sampled network (176), ties from the surveyed farmers to cooperative technicians numbered 83, or almost 50 percent of all ties. Seventy-two percent of influential ties (defined as those who influenced them to join a certification or sustainability program) for certified farmers were to cooperative technicians (Guedes Pinto et al., 2016). Given that their principal source of advice and influence were the principal buyers of their coffee, a demand for certified coffee from the buyer (the cooperative) could likely more easily filter down to the producer through the extension services already provided by the cooperative. Certification and sustainability programs can also take advantage of the strong technician-farmer information flows that characterize the coffee sector, as technicians can help farmers navigate complicated standards and auditing requirements. Results also show that small coffee farms were no less likely to be certified than larger farms: the collective association of prominent cooperatives and their accompanying extension services, as well as subsidies and cost savings associated with cooperative membership and group certification, may have alleviated some of the challenges that prevent smaller farms from becoming certified (Adshead, 2015).

The widespread presence of cooperatives and extension services in the coffee sector is not matched in the cattle sector, making a mechanism such as certification, which requires compliance with detailed and stringent standards, less accessible to ranchers. Furthermore, the social network analysis of the cattle sector showed that ranchers' advice was sought principally from other farmers and NGO technicians. Almost two thirds of ranchers' advice ties were from other farmers; almost two thirds of these were located within 20 km of the farmer. Ties with NGO technicians were mostly with those promoting sustainability programs in their local area. These represented 30 percent of program participants' advice ties, but only 17 percent of non-program participants' ties. Farmers received much less advice and influence from private sector actors.

Thus, farmers' advice and influence networks in the two sectors were comprised of different sets of actors. Most importantly, the results show that social and advice ties for coffee producers were largely with actors who could indicate the market demand for sustainability, and could assist producers in attaining the standards demanded. In contrast, social and advice ties for cattle producers were largely with neighboring farmers, who were less likely to fulfill these functions. Consequently, unlike coffee producers, cattle ranchers were not receiving advice or influence from those buying their cattle, perhaps making it more difficult for a market-based mechanism to take hold in the sector in the same way that it has with coffee.

4.4. Producers' motivations for joining sustainability programs: which environmental, economic, and/or social factors matter?

This section turns to the producers themselves: what motivated them to join a sustainability initiative, or what barriers prevented them from doing so?

For sampled coffee farmers, the primary motivating factors in becoming SAN/RA-certified were economic. When certified farmers were asked what motivated them to get certified, and when non-certified farmers were asked what would motivate them to get certified, both groups ranked the possibility of a price premium, access to new markets for certified products, and requests from buyers in the top four (out of 13) motivating factors (Fig. S2). In practice, these economic motivations were less often realized than other benefits, such as improvements in agricultural or labor practices (Fig. S3). Indeed, recent economic analysis of 78 coffee-producing farms in the Cerrado region of the state of Minas Gerais showed that certified farms performed better, economically, than non-certified farms, but that this was a consequence of greater efficiency and productivity, and higher revenues, and not a consequence of prices, which were not significantly different between certified and non-certified farms (Bini et al., 2016).

For cattle farmers, the biggest motivating (program farmers) or potentially motivating (non-program farmers) factors to participate in a certification or sustainable intensification program were the opportunities to increase production, reduce production costs, and learn new practices or technologies (Fig. S4). Interests in sustainability tied for third rank in importance for program farms. Further, increased production and increased production efficiency accounted for 47 percent of responses to the open question on their primary motivating factor for joining a program; 79 percent of those not in a program believed that the primary benefit of being in a program would be increased production or production efficiency.

Most of the program farms reported that while several benefits had been realized since joining the program, economic considerations such as access to new markets, increased demand for sustainable beef, and obtaining a price premium were least often realized (Fig. S5). The potential of obtaining a price premium for their beef was ranked very low as a motivating factor for those who had joined a sustainability program, presumably because the information that they received about the programs emphasized increased production over any potential price premiums. However, many of those who had not yet joined a program cited price premiums as something that would motivate them to join, should program-compliant beef in the future fetch a market price premium. The one SAN/RA-certified farmer interviewed stated that the promise of a price premium had been somewhat motivating in his choice to get certified, and that he had seen a 1–2 percent increase in his beef prices because of it.

This study shows that economic motivations were paramount in the decision of both coffee and cattle farmers to seek certification, and that price premiums were often expected; yet they are less often realized, while other non-monetary benefits are. Given that the main economic advantages of certification may accrue to farms as a result of better management and efficiency (Milder and Newsom, 2015), the adoption of certification may thus be economically justified independently of expectations of market benefits (Bini et al., 2016). For cattle sustainable intensification programs, farmers who joined were mostly motivated by the promise of increased production. Since sustainability price premiums are uncommon in the sector, narratives around the benefits of certification or sustainability programs may be more productively and realistically reframed around multiple other, more attainable benefits. For example, farmers participating in the Novo Campo sustainable-intensification project will sell beef to McDonalds as part of the corporation's commitments to more sustainable sourcing; such assured markets may represent a significant benefit to producers.

In terms of barriers in the coffee sector, certified farmers reported navigating certification procedures and paperwork as the principal challenge to getting certified (Fig. S6). Non-certified farmers did not report this challenge to be the principal anticipated barrier – perhaps underestimating the challenge that the procedural dimension of certification poses – but rather indicated that not seeing a market advantage to certification was their principal disincentive for certification. Perceived challenges (by those who were not certified) of changing social and environmental practices and the costs of audits were on average higher than reported as experienced challenges (by those who were certified). In open responses, over half the non-certified respondents stated that the main reasons they weren't certified were that it was too much work or that it was too expensive. Given that a large proportion of interviewed certified farmers had received a substantial subsidy from the cooperative to become certified, this perceived challenge may transpire to be less of a barrier in practice.

In terms of barriers to joining sustainable intensification programs in the cattle sector, the main challenges reported by farmers participating in sustainability programs that they experienced in joining those programs were the costs of changing management practices, the challenge of building sufficient technical capacity, and the challenge of following legal requirements such as complying with the Forest Code (Fig. S7). Non-program farmers did not cite the need for sufficient technical capacity as being a barrier to join; rather, they anticipated obtaining financing to be a more important challenge. The difference in perceived challenges and experienced challenges shows that costs and financing are perceived to be a higher barrier than they were by those who actually joined sustainability programs. Some farmers not in a program simply perceived it to be too much work for too little benefit (five of 18 responses). But a key restricting factor reported by those not in a program was that there were no opportunities for them to be in one (six of 18 responses); all the programs were still operating in pilot phases, and could only accommodate a limited number of farmers at this early stage. The program of Instituto Centro de Vida (ICV) had plans to grow from 15 farms to 300 in the years following this study's fieldwork, but the other programs did not report similar plans.

5. Conclusions

Governance mechanisms aimed at promoting the sustainable production of tropical commodities need to have expanded impacts to effectively address the pace and scale of environmental and social change in tropical forested regions. Yet governance mechanisms may not be highly transferable from one sector to another, given the heterogeneity of factors and conditions affecting different commodities. The distribution and quality of environmental resources, markets, knowledge, actors, and networks, this study argues, can play an important role in the ability of a governance mechanism to effectively emerge, scale up, and deliver greater sustainability outcomes across different agricultural sectors. Yet, the environmental, economic, and social geographies of these different sectors are dynamic and evolving.

This study argues that certification in Brazil's coffee sector has scaled up relatively well due to the sector's sustainability priorities, market orientation, supply chain traceability, and social networks. First, the holistic approach of certification standards lends itself well to a sector concentrated in a region focused on reducing environmental degradation and improving social and labor conditions. Second, an international market orientation feeds international certified coffee demand, while better-structured and short supply chains are readily responsive to increasing demands for certified coffee. Finally, social networks within Brazil's coffee sector enable efficient transfer of market information and technical assistance based on those short and responsive supply chains. This greatly aids in the uptake of complex and demanding standards associated with certification.

In contrast, the environmental, market, and social geographies of the cattle sector in Brazil have constrained the extent to which certification has been able to enhance sustainability within the sector to date. The more stringent demands of certification may be too burdensome for readily upscaling recruitment, while the objective of eliminating deforestation may not be well met by a voluntary program for which participants have relatively little to lose by not participating. This proposition is supported by the observed relative success of the Cattle Agreement, which, although also voluntary, carries a higher penalty (i.e. effective exclusion from several key markets) of non-participation. Further, the market for certified Brazilian beef remains extremely small compared to certified coffee. Longer, more complex supply chains also make traceability more challenging than for coffee. Finally, cattle ranchers' non-market based advice networks make it difficult for information related to a market mechanism to reach them.

In contrast, sustainable intensification programs promoted by NGOs in the cattle sector in Brazil have been able to spread information and provide technical assistance in targeted regions. Relative to certification, these pilot projects implemented to date have required less investment in capital and process from the farmers, and do not place demands on legal compliance with deforestation laws. The farms participating in the studied sustainable intensification programs were located within states that have recently experienced high rates of deforestation (e.g. Mato Grosso and Pará).

But the properties themselves generally had relatively little forest remaining, or were located where there was little threat of imminent further deforestation. This was the case for all sampled farms, except those in Amazonas state, which is a state with lower deforestation rates. Therefore, it is difficult to judge how effective these programs will be at curbing deforestation at scale beyond the program pilot stages. For the moment, effects on deforestation remain theoretical – with the proposition that intensification programs will meet increasing demand for beef and thus relieve pressure for expansion into existing forests elsewhere in the country. However, evidence from crop intensification programs in some locations has shown that increased production can result in more natural habitat being converted to agriculture (e.g. De Fries and Rosenzweig, 2010), pointing to the need for additional governance mechanisms to disincentive further deforestation.

Governance mechanisms that are both market-based (e.g. the Cattle Agreement) and non-market based (e.g. sustainable intensification programs) have achieved some success in attracting participation of producers to tackle socio-environmental challenges within the cattle sector. However, third-party certification differs from both of these governance mechanisms. In contrast to the Cattle Agreement, certification promotes a suite of best practices. And in contrast to sustainable intensification programs, certification requires more substantial investment from farmers. The simpler, cheaper governance mechanisms may therefore *currently* be better able to scale up by recruiting more participants. But under future scenarios, it may also be possible to scale up certification – particularly if markets for sustainably-produced cattle products expand.

Certification and associated product labelling in the coffee sector is older than in the cattle sector, and institutions and markets that support certified cattle products may develop over time. However, even in a nascent form certification may fulfil important roles (Newton et al., 2015). For example, the holistic definition of sustainability adopted by most certification programs reminds us that sustainability is not one-dimensional, and that –for example– addressing avoided deforestation is a necessary but not sufficient action in the pursuit of sustainability. The commitment of certification programs to continuous improvement is also a strong characteristic (SAN, 2017a, p.10; RSPO, 2013, Principle 8) that may favor greater long-term sustainability gains than more modestly-ambitious mechanisms. There is thus a trade-off between ease of scaling-up sustainability initiatives, and addressing sustainability more comprehensively (Winters et al., 2015). Non-voluntary governance mechanisms are likely needed to stem deforestation at forest frontiers in the short- to medium-term, but these will need to be accompanied by increased investment in small farmer support so as not to disproportionately negatively affect the welfare of small producers.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jclepro.2018.09.102.

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