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Paths forward for sustainability

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Photo by Kate Evans/CIFOR
Aerial view of a landscape showing pasture lands near Rio Branco, Acre, Brazil.

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Executive summary

A historical overview shows that Brazil's land-use patterns have been closely intertwined with the shifting policy landscape. Industrialization and colonization policies in the 1960s and 1970s spurred waves of migration and brought about sweeping changes in the rural landscape. The development of agricultural technologies through publically funded research enabled the expansion of croplands onto the poor soils in the vast new frontiers of the Cerrados and Amazon forests from the 1970s onwards. Financial incentives through fiscal and credit policies have since played an important role in promoting the expansion of agribusiness and family farming, although the scales are heavily tipped in favor of the former.

From 1990 to 2001, annual crops expanded by 15.8 million ha, soybeans and sugarcane underwent net growth of 17.7 million ha, while the area used for staple food crops such as rice, beans and cassava tended to contract during the same period. Largely as a result of technological development, productivity increased enormously for all these crops, most notably for soybeans, sugarcane, corn and rice. Energy and industrial policies during the late 1990s and early 2000s and climate change policies in the mid-2000s were instrumental in the development of the sugarcane–ethanol industry and biodiesel policies, stimulating the expansion of soybean and sugarcane onto the new agricultural frontiers of Brazil's central savannahs known as the Cerrados.

As the country developed its climate change policy framework, ethanol derived from sugarcane became a key component of the country's mitigation strategy and a series of associated policy incentives drove the expansion of sugarcane as a "clean green" fuel. More recently, subsidies for gasoline that have kept prices artificially low at the pump have been a key factor in thwarting further expansion of the sugarcane–ethanol complex. Meanwhile, the government has provided substantial incentives for expanding agriculture through tax expenditures, i.e. tax reduction or exemptions, as well as credit incentives through low-interest loans worth over USD 50 billion. Similar tax incentives to the energy sector rose by 68% per year from 2003 to 2013. In contrast to sugarcane–ethanol policies, which were geared towards medium to large landholdings, the biodiesel sector policies were developed with the aim of including smallholders in feedstock production.

The expansion of mining and agricultural activities over the past 10 years has fueled the demand for charcoal and fuelwood. As a result, charcoal has increasingly become a driver of deforestation in the Cerrado and Caatinga biomes and around mining centers in the Amazon. One of the main land-use trends in recent decades was the expansion of pasturelands by 2.7 million ha from 1996 to 2006. The same period was characterized by a shift from natural to planted pastures and intensification in the ranching sector. As emissions from land-use change dropped drastically due to lower deforestation rates, cattle ranching became the leading source of source of greenhouse gas (GHG) emissions. The federal government responded by developing a set of policies aimed at reducing the pressures of cattle ranching on native forests.

Meanwhile, investments in large-scale transport and energy projects have more than doubled in just 4 years, rising from 1.6% of GDP in 2006 to 3.27% in 2010, mainly through the Growth Acceleration project. Likewise, financing for agriculture has also grown substantially through low-interest credit lines, with USD 51 billion going to agribusiness compared to USD 7.08 billion for family farming in 2013. Moreover, smallholder access to credit nationwide is on average still very low, with only 18% receiving any sort of financing. This suggests an imbalance in light of the importance of family farming, which accounts for 38% of the total value of production and over 70% of food production in Brazil. Additionally, direct subsidies for agriculture that have been growing steadily since 2003, when President Lula took office for his first term, include tax breaks for fertilizers, sales taxes and import duties and low-interest loans for farm machinery, amounting to about USD 5.83 billion in 2013.

Land tenure insecurity is a major obstacle to more sustainable land use, especially in the Amazon, where about 94 million ha are still considered to have unclear tenure status. The land tenure regularization program Arco Verde Terra Legal, which also focuses

on the Amazon, is considered key to addressing this situation but the gargantuan undertaking of regularizing lands in the Amazon still faces an uphill battle due to the sheer scale of the problem and low capacity of local government institutions. Protected areas, including conservation units and indigenous lands, have grown steadily over recent years, covering 47% of the Amazon, but only 8.1% of the Cerrado forests. Currently, the creation of protected areas has tended to stop.

The new Forest Code, which stands as the main policy attempting to regulate land use, kept provisions from the old law obliging all rural properties to set aside a part of their land for conservation purposes, which varies according to biome: 80% in the Amazon, 35% in patches of Cerrado vegetation within the Legal Amazon and 20% throughout the rest of the country. It also grants amnesty to landowners who cleared their land before 2008 beyond this quota as long as they implement restoration plans. The new law is also more flexible as it reduces the size of Permanent Preservation Areas (areas considered critical for ecosystem functions including riparian zones, steep hillsides, areas around springs, etc.) and exempts family farmers from the obligation of recovering these areas. The main challenge for enforcing the new Forest Code is implementing the Rural Environmental Registry – CAR, which will be required of all rural properties by 2015 as the main mechanism for monitoring compliance with these environmental regulations. Despite considerable progress in States (i.e. Pará, Mato Grosso), which have their own systems in place, implementation in most States is still limited due to low capacity and difficulties in coordination between state, federal and municipal governments, among other factors.

The national climate change policy set up a cross-agency program known as PPCDAm aimed at reducing deforestation rates in the Amazon. Coordinated initially at the highest levels of the federal government, the program was considered extremely successful in light of the 70% drop in deforestation rates in 2013 compared to the average over the previous 10 years. Declining deforestation can be attributed to a series of policy measures led by the federal government including: the implementation of a real-time satellite monitoring system called DETER, bolstering of enforcement involving several agencies and restricting credit to the municipalities with critical deforestation rates. Maintaining these low deforestation rates over the long run will hinge on maintaining and scaling up these policies. Other key factors that contributed to this decline were market-based initiatives such as the Soybean Moratorium and the expansion of Protected Areas, as well as falling commodity prices.

The Low Carbon Agriculture Program — the ABC Program — emerged in 2010 as the main solution for reducing GHG emissions in the agricultural sector by promoting the adoption of sustainable farming and grazing practices including no-till farming, crop–livestock–forestry integration systems, pasture restoration, cattle intensification and biological nitrogen fixation. The program provides low-interest loans and capacity building for farmers wishing to implement these systems. While ABC faced several hurdles that led to low levels of adoption in its first 2 years, funding has been increasing steadily, reaching USD1.41 billion in 2012/13. Although it is too early to ascertain its success, the program is pioneering in providing direct financial incentives for integrated production systems and soil conservation practices as opposed to value chains. As with other flagship programs such as CAR, one of the main constraints to implementing ABC is coordination among the federal, state and municipal agencies and low uptake in some states. Slow adoption of these technologies by ranchers is also seen as a key hurdle to scaling up this program.

One example of a policy where effective coordination among key stakeholders proved instrumental is the Green Municipalities program, which began initially in two counties in the Amazon States of Pará and Mato Grosso. This initiative created an enabling environment for local governments, farmers, ranchers, loggers and NGOs to pool resources in order to increase compliance with the Forest Code by helping to implement CAR and land regularization and improve cropping and ranching management practices through technical assistance.

Overall, our analysis of the policy framework concludes that the last two decades have been characterized by a marked shift from previous decades towards more conservation and climate change-oriented policies. A key factor to the success of new environmental governance policies has been coordination at the highest levels of government in both wielding sticks and offering carrots. Nonetheless, wide gaps still remain between economic development-oriented policies and climate change mitigation and conservation-oriented policies. On the one hand, the government has

provided hefty financial incentives for large-scale infrastructure, energy and agribusiness projects. On the other, it has set up innovative environmental governance programs that have successfully thwarted deforestation in the Amazon. At a wider level, the new Forest Code, coupled with rural development policies, has favored the expansion of large-scale monocrop systems onto other sensitive ecosystems that have received much less attention than the Amazon, especially the Cerrado forests, leading to a series of social and environmental impacts. Thus, the interactions and trade-offs between these various drivers of land-use change across biomes and regions need to be better understood and taken into account in policy-making processes. Despite Brazil's impressive progress on several fronts, the overarching challenge moving forward is mainstreaming key aspects of climate change and conservation-oriented policies into wider rural development and economic policies.

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1 Introduction

Over the last decade, Brazil has earned praise worldwide as the country that achieved the highest contribution to reducing greenhouse gas emissions (GHG) as a direct result of its rapidly declining deforestation rates. While much of this decline has been attributed to command and control policies, other factors such as market forces and industry-led initiatives have also played a significant role (Nepstad et al. 2014; Soares-Filho et al. 2014). Meanwhile, the strategic importance of the agricultural sector for the national economy has continued to rise (Martha and Ferreira Filho 2012).

Although Brazil initially managed to weather the global economic crisis relatively unscathed, the country is currently facing a stagnant economy, with GDP growth nearing 0% in 2014 (Banco Central do Brasil 2014) One of the few sectors that has continued to prop up the economy through these hard times is agriculture, particularly commodities such as soybean, beef, corn and sugarcane, which continue to expand across the vast frontiers of the Cerrado and transition zones to the Amazon forest (IBGE 2012a).

In the last four decades, the Brazilian agricultural sector was catapulted from being a net importer of foodstuffs to a top exporter of key agricultural commodities. While evidently fueled by market forces, the expansion of key crops such as soybeans, corn, sugarcane, as well as cattle grazing, has also been spurred by public policies. These policies range from colonization and land reform programs, economic incentives for agribusiness development and investments in technology, infrastructure and bioenergy development (Nepstad et al. 2014). Although the underlying doctrines behind these policies have shifted heavily, perhaps the one constant factor over time has been their central role in both promoting and thwarting land-use change.

For two decades, the military dictatorship's colonization and regional development policies were arguably the main driving force behind deforestation in the Amazon. In the three decades since democratization, environmental governance and rural development policies have been pivotal in hampering the conversion of Amazon forests, while at the same time stimulating deforestation in other Brazilian biomes.

Consequentially, the country's emissions profile has shifted, as agricultural and grazing activities are currently the top source of GHG emissions given the dwindling role of land-use change. As a response, the federal government instituted a series of programs under its national climate change policy aimed at reducing emissions. Similarly, some state and municipal governments have adopted programs geared towards implementing more sustainable environmental governance at the local level, including payment for environmental services and other innovative programs based on a mix of policies and market-based measures (Nepstad et al. 2014). Meanwhile, large-scale infrastructure and energy projects, buoyed by financial incentives such as low-interest loans through federal banks and hefty investments, coupled with uncertainties surrounding the new Forest Code, have contributed to a new increase in deforestation rates in the Amazon, albeit at much lower absolute levels compared to the past (Santos et al. 2013; ISA, IPAM and IMAZON 2014; Nepstad et al. 2014).

In the last decade, the federal government implemented a series of command and control policies to bolster enforcement of environmental regulations in the Amazon by monitoring changes in the forest cover on a real-time basis, while also putting in place economic mechanisms such as banning credit to farming and grazing activities in municipalities with the highest deforestation rates (Börner et al. 2014; Nepstad et al. 2014; Soares-Filho et al. 2014). Economic development-oriented and agricultural policies have favored the expansion of agriculture on the vast hinterlands of the Cerrado in the Central-West, Southeast and Northeast (Correa 2013; Sparovek et al. 2013). While illegal deforestation in the Amazon has been on a clear downward trend, the agro-industrial complex has occupied swaths of the Cerrado for large-scale mono crop systems, bringing about deep-seated impacts on landscapes and livelihoods.

This mosaic of policies affecting the rural landscape evidently reflects the myriad of interests championed by different government agencies and other stakeholders shaping policies with influence on land-use change, economic development and benefits distribution. Understanding these interests and how they play out on the ground gets even more complex when the state

and municipal institutions are taken into account. The latter institutions are in charge of decentralized implementation of social and environmental policies formulated mostly in the federal capital, Brasilia.

This paper aims to shed light on the role of Brazilian policies in stimulating and/or curtailing land-use change in its various forms across the country. To achieve this aim, we draw from a wide range of sources in the literature, analyses of statistical and spatial data, as well as perceptions put forth in interviews of experts and stakeholders from academia, the private sector, nongovernmental organizations (NGOs) and key government agencies.[1]

This document is organized into five parts including this introduction. The second part presents a historical overview of the role of policies in shaping rural development and environmental governance processes. The third part characterizes the main drivers of land-use change and the trends observed over the last few decades. The fourth part assesses the effectiveness and constraints of key policies in order to draw out lessons for scaling up or replicating successful programs and reconciling seemingly disparate policy pathways. The fifth part discusses some of the key findings from the previous sectors and draws together the main conclusions.

1 A total of 25 interviews were carried out in November 2013 in Sao Paulo and Brasilia with representatives from federal government ministries, the private sector, academia and NGOs.

2 Historical background

Over the centuries, Brazilian rural society has been shaped by a dualistic and dynamic tension between cycles of farming for commodities such as sugarcane, coffee, rubber and soybeans, among others and smallholders whose livelihoods rely on a combination of small-scale farming, livestock and extractive economies. This dualism persists to this day in the realm of policies and institutional frameworks and plays out on the ground, throughout the country, especially on the vast agricultural frontiers sweeping across the Central-West, North and Northeast regions.

Historically, the most striking features in Brazil's wider policy landscape are the marked contradictions within a mosaic of shifting policy priorities and the strong role of government on both extremes of the development–conservation policy spectrum. Since the mid-twentieth century, mainstream economic policies have been generally aimed at economic growth associated with goals of achieving a positive trade balance and, since the 1970s, at thwarting inflation. Based on similar objectives, energy and infrastructure policies have been geared towards meeting the rising demands of large-scale agriculture, mining, urbanization and transformation industries. Nonetheless, increasing national and international concerns have highlighted the social and environmental impacts of this development over time, especially when it has been associated with the conversion of forests to agricultural land uses. These pressures have led to shifting priorities in policy goals, including important efforts to mainstream biodiversity and climate change goals within the country's prevailing development policy framework.

As a result, the last few decades were characterized by the creation of the national system of conservation units (SNUC), which has significantly expanded the area of threatened ecosystems and the emergence of a series of rural development policies targeting smallholders and traditional communities and associated with natural resources conservation concerns. Simultaneously, development policies aimed at promoting agribusiness and agro-energy have continued to occupy the mainstream of government initiatives, driven mainly by objectives of economic growth (although also championed for their climate change mitigation benefits as in the case of sugarcane ethanol and biodiesel). Historically, fiscal, trade and development policies, and investments in research and technology, laid the foundations for the rise of national industries and a robust energy sector and drove the expansion of agro-industrial complexes.

2.1 Demographic, economic and development trends

Throughout Brazil's history, economic, migratory and social development patterns have been intertwined with policies fueling agricultural cycles and natural resource extraction. The first wave began with Brazil wood (*Caesalpinia echinata*) extraction, followed by sugarcane, coffee and rubber plantations, extensive cattle ranching, mining and, over the last century, agricultural commodities and bioenergy production. Over time, policies aimed at industrialization and rural development underpinned by a high dependency on just a few commodities for export left in their wake social and economic disparities in terms of income distribution, access to land and natural resources, leaving ripple effects that persist to this day. Up until the 1930s, Brazil was an essentially rural society and its economy was largely dependent on the export of commodities such as coffee, rubber and sugar that developed in the regions of southern and eastern Brazil (Martha and Ferreira Filho 2012). From the 1930s onwards, a succession of governments began promoting a series of policies aimed at industrialization, largely as a reaction to the global recession, which greatly reduced the demand for these agricultural commodities, but also buoyed by nationalist sentiments (Plá 2013).

Industrialization, in its turn, led to intense migratory processes whereby the rural poor flocked to cities such as São Paulo and Rio de Janeiro in search of jobs and higher wages as of the 1950s (Martha and Ferreira Filho 2012). Urban centers in the Southeast mushroomed as migrants from the more rural Northeast flocked to the cities in droves seeking higher paying wages and fleeing from poverty and droughts. These processes were rooted in protectionist measures such as import tariffs and subsidies for national manufacturing as part of Brazil's "import substitution"

policy, which aimed to reduce dependency on imported manufactured goods (Plá 2013).

In the early 1950s, the Vargas administration began promoting a colonization program known as "March to the West" under the National Settlement Department, which redistributed public lands and encouraged migration to the country's sparsely populated hinterlands of the Central-West and later extending to the North (Andrade 2006). Mechanization in agriculture further contributed to rural exodus and swelling of urban populations, while at the same time freeing up more labor for the next wave of industrialization that began in the early 1950s (Andrade 2006).

As industries sprang up throughout the Southeast of Brazil, concentrated mainly in Rio de Janeiro, São Paulo and Minas Gerais states, the Brazilian industrial revolution greatly increased the demand for raw materials, ranging from basic agricultural products for the food and textile industries to iron ore for the fledgling national automobile industry, as well as the demand for energy to fuel these industries and maintain rising urban populations (Correa 2013; Plá 2013). The rise of high-input and technology-intensive agriculture contributed to high rates of unemployment in rural areas, which kept rural wages low and spurred further investments in agricultural sectors (Martha and Ferreira Filho 2012).

While global and domestic market forces evidently played an important role in these economic cycles, understanding the meandering paths of economic, rural and social development requires shedding light on government policies and interventions. Driven primarily by government policies in the 1960s and 1970s, migratory flows to the Center West and North, especially from the South and Northeast ultimately reshaped the social and natural landscapes of these regions (Oliveira and Oliveira 2013).

Migration also has indirect impacts on extensive land-use patterns in the Cerrado, which has suffered important pressures as a result of agricultural expansion (IBGE 2012a). As the second largest biome in South America, the Cerrado occupies roughly 22% of the national territory (2,036,448 km^2) and spans across nine States in the Center West, Southeast and Northeast: Goiás, Tocantins, Mato Grosso, Mato Grosso do Sul, Minas Gerais, Bahia, Maranhão, Piauí, Rondônia, Paraná, São Paulo and Federal District and includes smaller pockets in three other Amazon States (Amapá, Roraima and Amazonas) (MMA 2013d) (Map 1). A major wave of rural-to-rural migration began mainly in the 1970s, when farmers from the south of Brazil flocked to the Central-Western Cerrados and northwards, driving the expansion of annual crops on the vast new agricultural frontier (Correa 2013). This process was greatly incentivized by the federal government through programs such as PRODECER (Program for Nipo-Brazilian Cooperation in Agricultural Development in the Cerrados Region), which played a key role in introducing soybean cultivation and attracting farmers from Southern Brazil to the central plateaus of the Cerrados (Heredia et al. 2010).

Throughout this period, the military dictatorship also played a decisive role in promoting colonization of the Cerrado and Amazon by offering large swaths of land to southerners at symbolic prices, or even for free, in an effort to occupy Brazil's vast and "empty" Central-western and Northern expanses (Correa 2013). These migratory patterns persisted until the 1980s, when skyrocketing public debts coupled with an economic recession dried up sources of public financing. Up to then, the Amazon was comprised mainly of isolated indigenous and traditional communities whose livelihoods depended on shifting agriculture, with the exception of a few large urban centers such as Manaus and Belém. Southern Brazil was already quite densely populated with European migrants (mostly Italians and Germans), who quickly took up farming in that region using modern techniques (Martha and Ferreira Filho 2012).

In order to link the agricultural frontiers with the main industrial and trade hubs in the southeast, the government made hefty investments in transport infrastructure (road and railways), as well electrical energy generation, which further stimulated migration of southern farmers in search of cheap land and generous financial incentives (Danni et al. 2004). As a result of massive rural-to-urban migration, rising food prices and Brazil's increasing dependence on importing foodstuffs, the federal government began investing heavily in technology aimed at bolstering domestic food production. Since 1964, the military regime has embarked on a mission to modernize Brazilian agriculture. In 1973, it founded Embrapa, the national agricultural research organization, which began developing varieties and technologies to enable food production and higher yields, especially on the highly acidic and nutrient-poor soils of Brazil's savannahs known as the Cerrado (Heredia et al. 2010; Martha and Ferreira Filho 2012).

Map 1. Biomes in Brazil, based on information provided by MMA.
Source: http://mapas.mma.gov.br/i3geo/datadownload.htm

Meanwhile, the rise of national industries coupled with the petroleum crisis in the early 1970s further increased the demand for domestic energy sources, prompting the government to seek alternative energy sources from biomass. To meet this demand, the federal government set up its flagship ethanol initiative known as Pro-Alcool, which led to the emergence of the country's sugarcane-based ethanol industry in São Paulo, later spreading to other states in the Southeast and Central-West (Andrade and Miccolis 2010b).

On the political front, the process of re-democratization that swept across the country in 1985 culminated in the new "Citizen's" Constitution of 1988. The new Constitution stimulated state modernization with broader social participation. For example, it granted a whole set of rights to indigenous and other traditional communities, including the right to their traditional lands, as well as the right to a healthy environment. Moreover, highly progressive environmental policies were put in place as the government set up the national system of conservation units and increased the percentage of areas to be set aside as protected on all private lands.

Over the last few decades, federal government policies have undergone a marked shift towards more conservation-oriented measures, although most of the national and international attention has been placed on the Amazon biome as vast areas of Cerrado have been increasingly occupied by large-scale farming of a few key commodities. As we shall see in the next section, wider economic and rural development polices have been instrumental in enabling this expansion of the agricultural frontier.

2.2 Policies and the expansion of the agricultural frontier

While the role of agricultural production in overall gross domestic product (GDP) has gradually diminished over the past few decades, only accounting for approximately 5.5% of GDP in 2012, it was the fastest growing economic sector

from 2001 to 2012 and the agro-industrial complex as a whole generates over 28% of GDP, most of which from the soybean sector. Furthermore, the expansion of agriculture in Brazil has been decisive for the country in keeping a positive trade balance. In 2011, the country's agricultural exports amounted to USD 81.4 billion, compared to USD 11.6 billion in imports, a trade surplus of USD 69.8 billion. Thus, the agricultural sector enabled offsetting the trade deficit of USD 39.7 billion accrued in all other sectors combined (MAPA 2012; MDIC 2013).

Brazil currently produces 31% of the world's soybean, 28% of the beef and is the world's top exporter of sugar, coffee, orange juice, beef, tobacco and broiler chickens (USDA 2013). Brazil's main international partners are the European Union, the United States and China. The country's exports totaled USD 201.9 billion in 2010 while imports totaled USD 181.6 billion — a surplus of USD 20.8 billion which was also made possible by exports of agricultural commodities (OGLOBO 2011). In 2013, the country is projected to reap a record harvest of 185 million tonnes of grains (CONAB 2013), which means 11.3% growth over 2012, with soybeans, sugarcane and corn accounting for 60% of the gross value of production.

The soybean agro-industrial complex alone accounts for roughly 5% of GDP and 25% of agricultural GDP when one takes into account the whole value chain, from agricultural production to processing, production and distribution of soybean meal, oil, feed and other by-products. This sector has become increasingly concentrated among a handful of national players such as the Maggi group and, increasingly, international companies, especially the so-called ABCD group (ADM, Bunge, Cargill and Dreyfus). One clear example of this trend is the increase of foreign capital in the soybean crushing industry, which jumped from 16% in 1995 to 57% in 2005 (Heredia et al. 2010).

The growth of the agro-industrial sector has been greatly aided by government financial incentives and technology development. In the early 1970s, the government offered new research and new technological advances such as irrigation and more efficient seeds and fertilizers, which made millions of hectares of land available on Brazil's Southeast, North–Northeast and Central Plateau that were previously considered unproductive. At the same time, the government also offered extremely attractive fiscal incentives for individuals to settle and companies to establish operations in the Cerrado and Amazon biomes, including: full income tax exemptions for companies investing in the region, especially in agriculture and cattle grazing; import and export tax exemptions; and subsidized credit and access to special funds (Walker et al. 2009).

Over the last 50 years, Brazil has made a transition from being a net importer of foodstuffs to being a major exporter. Currently, about 65% of national production is consumed domestically and 35% is exported to other nations; the country is self-sufficient in virtually all of the main agricultural products, with the notable exception of wheat. The production of agricultural commodities generated about USD 76.4 billion of export revenues in 2010 (MDIC 2013).

This reversal in a relatively short period of time was based on an expansion of farm and grazing land and, to a much larger extent, on gains in productivity. In 1960, 17.2 million tonnes of grains were harvested on 22 million ha, i.e. a productivity of 783 kg per ha, which pales in comparison to an average of 3173 kg per ha harvested in 2010, when an area of 47.5 million ha produced 150.8 million tonnes of grains (*Presidência da República* 2012).

A similar phenomenon occurred in cattle grazing, where the national stocking rate rose from 0.47 to 1.2 heads/ha during the same time period. In 1960, the Brazilian herd amounted to 58 million heads of cattle, compared to 204 million in 2010, although the expansion of pasture lands grew at a much slower pace: from 122.3 million to 170 million ha (*Presidência da República* 2012).

The expansion of agribusiness was largely policy-driven in the 1970s and early 1980s; in the decades since it has been driven mainly by private-sector players, including multinational trading companies (Heredia et al. 2010), with substantial government backing. Meanwhile, as we shall see in the next section, the role of government in land reform processes remained extremely vigorous and is very strong to this day.

2.2.1 Recent trends in the policy landscape

From the mid-1980s onwards, expansion of agriculture and cattle grazing in the Cerrado and Amazon have been driven mainly by private sector investments, both in the soybean and cattle ranching sectors, but continue receiving support from rural credit policies (Nepstad et al. 2013). Apart from

direct financial incentives, the indirect subsidies provided to large-scale farmers through government programs aimed at forgiving debts from unpaid farm loans have played a role in propping up the industry in hard times (Silva 2009). Large-scale farmers managed to secure many of these benefits by exerting considerable influence in national policy making through the rural caucus (Bancada Ruralista) in the National Congress (Silva 2009).

For the first time, the government also established rural development polices specifically targeting smallholders by establishing a category known as "family farmers" and programs such as PRONAF, the national program for strengthening family farmers (Andrade and Miccolis 2011).

As the Lula administration took office in 2002, the smallholder-oriented policies were strengthened through the Ministry for Agrarian Development but the government did not lose sight of the strategic importance of the agribusiness sector to the national economy and continued providing massive support through the Ministry of Agriculture programs and Embrapa research (Andrade and Miccolis 2011).

In the past 10 years, policies aimed at environmental protection have been led by the Ministry of the Environment (MMA) including, more recently, combating climate change and avoiding deforestation at a federal level. Wider agricultural policies, particularly those targeting the agribusiness sector, are spearheaded by the Ministry of Agriculture (MAPA). Smallholder-oriented and land-tenure policies are championed by a third institution, the Ministry of Agrarian Development (MDA). A similarly polarized pattern emerges in biofuels policies, as the general biodiesel coordination is located under the MDA, whereas ethanol policies are formulated under MAPA and the Ministry of Mines and Energy, MME. These government institutions often take opposite sides of key policy debates and champion different players in rural development and have varying levels of funding.

Despite its decisive contribution to maintaining a positive trade balance, the expansion of industrial farming in the Cerrado has displaced smallholder farming, thus aggravating rural-to-urban migration within regions (Andrade and Miccolis 2011). Moreover, the agribusiness sector has had a myriad of negative social and environmental impacts stemming from land concentration, contamination of water resources due to pesticide and fertilizer use, soil loss and deforestation of native Cerrado and Amazon vegetation types (Pignati et al. 2007). While technological advances enabling the adoption of technologies such as no-till farming and crop-livestock integration have successfully attenuated some of these impacts, social and environmental conflicts have been rising where the expansion of agribusiness meets smallholders, indigenous and other traditional communities. These conflicts and impacts have been documented by a series of studies (Fundação Oswaldo Cruz 2010; Rede Social de Justiça e Direitos Humanos 2011; CPT 2012; Fernandes et al. 2012).

2.2.2 Land reform and social conflicts

Brazil's basic legal foundations for land reform policies were laid during the early days of the military dictatorship, which in 1964 drafted the Land Statute. Initially supported by the US-backed Alliance for Progress, which aimed to redistribute lands to family farms and support the rural middle class, the drafting committee ultimately included and bowed to pressure from representatives of rural oligarchies, who pushed for large-scale agriculture and agro-industrial complexes, thus paving the way for the green revolution in Brazil (Fernandes et al. 2012). After the creation of INCRA (National Institute for Colonization and Agrarian Reform) in 1970, most of the attention was devoted to colonizing the Amazon by granting large tracts of land to migrants and fiscal incentives for companies to establish themselves in the region. This policy led to two decades of land-related conflicts as smallholders and traditional communities were pushed off their lands to give way to farming of commodities, beginning in Southern Brazil and then spreading northwards.

In an effort to quell these land-related conflicts, the democratically elected governments that took power after the new Constitution was passed in 1988 promoted an ambitious program to redistribute idle land to poor sectors of the population, known as the National Land Reform Program under the newly revamped INCRA. Created much earlier in 1970, INCRA has overseen the establishment of settlements of a total of 88.8 million ha, most of which began after 1994. According to official INCRA (2013) data, the vast majority of land-reform settlements are located in the North (76%), followed by the Northeast (12%) and the Central-West (9%), South (2%) and Southeast (1%).

In recent years, human rights watchdog groups have signaled a rise in socio-environmental and land-related conflicts throughout the country, affecting

indigenous and other traditional communities and smallholders disproportionately (Andrade and Miccolis 2011; CPT 2012). As these studies suggest, a high proportion of these conflicts has been directly associated with the large-scale monocrop agricultural systems and their ripple effects on access to land, water and natural resources.

Despite recent federal government efforts to stymie the purchase of large tracts of land by foreigners, land grabbing has also been singled out as a factor aggravating this situation. A recent survey conducted by IPEA (2012a), shows that the population groups most affected by such transformations in the Brazilian countryside over the past decades have been smallholders, family farmers, afro-descendants (*quilombolas*) and indigenous peoples. The Northeast has seen the highest number of conflicts, followed by the Southeast and North. A total of 65% of recorded conflicts involved land occupation and use, 45% stemmed from polluted water resources and 40% were due to gaps in demarcation of traditional (indigenous) territories. The main sources of these conflicts were attributed to the "actions of government agencies" (53%) and to monocrop farming projects (37%) (IPEA 2012a).

Several human rights groups and scholars have pointed to asymmetries in labor relations and grave labor violations as a main source of social conflicts between large-scale farmers and rural workers. According to the Ministry of Labor and Employment, between 1995 and 2010, nearly 29,000 farm workers were freed from conditions considered analogous to slavery (Movimento Nacional de Direitos Humanos et al. 2012) by their Mobile Enforcement Unit. In 2009, labor violations (which include forced labor and inhumane working conditions) in rural areas were most prevalent in the sugarcane sector (Andrade and Miccolis 2010b). In 2012, 2750 workers were freed from such conditions, a slight rise over the two previous years. The main sector was cattle grazing (497 workers), usually associated with clearing of new forests and charcoal production (452), mainly for steel mills. The North was the region with the highest number of cases (1100).

A survey conducted by Fundação Oswaldo Cruz (2010) mapped out 297 "environmental conflicts" throughout the country stemming from development projects, which include large-scale agriculture, dams, roadways and energy projects, concluding that over half of the affected population was comprised of indigenous and afro-descendent communities. Additionally, several studies have shown that the use of agricultural inputs such as chemical pesticides and fertilizers have had grave effects on soil, water and human health (Pignati et al. 2007; IBGE 2012a). The recent expansion of oil palm has also caused concern with regard to labor violations committed by large companies in Northeastern Pará (Reporter Brasil 2013).

The persistent and pervasive nature of these conflicts suggests that the country still faces structural inequalities deeply rooted in history that will be difficult to redress overnight. As farming for agricultural and energy commodities continues to expand across Brazil's vast agricultural frontiers, pressures on the livelihoods of smallholders and traditional communities will also tend to mount (Sawyer 2008; IBGE 2012a). Indeed, the negative impacts of the commodity-oriented approach to agricultural expansion reach far beyond local impacts, with negative feedback loops in climate change scenarios that might render them untenable in the future (Oliveira et al. 2013).

2.2.3 The role of energy policies

From the 1990s to 2000s, international debates on climate change took center stage and mounting pressure from environmental groups, which demanded cleaner sources of energy and fuel and from 'ruralist' groups (i.e. large landholdings), which demanded a stronger agriculture sector, prompted the Brazilian Government to launch the agro-energy plan in 2005 (Andrade and Miccolis 2011). The agro-energy plan aimed to develop the bioenergy sector based on a variety of agricultural products: soybeans, other oilseeds, beef tallow and sugarcane. For the first time, energy from sugarcane by-products surpassed hydropower energy in the energy mix and biodiesel blended into diesel mix reaped huge savings in diesel imports (EPE 2012).

The government bolstered research and funds to develop biomass production in an effort to wean the economy, especially the agriculture, electricity and transport sectors, off the dependence on hydropower generation and diesel imports (Andrade and Miccolis 2011). Thus, the development of this new energy policy was closely related, on the one hand, to the expansion of agribusiness of sugarcane ethanol, considered key to the country's trade balance; on the other hand, it was framed in the context of social inclusion under the new biodiesel program (Andrade and Miccolis 2010a). The National Program for Biodiesel Production (PNPB)

set up clear tax incentives through the social fuel seal aimed at including smallholders in feedstock production, ranging from soybeans in the South, castor beans in the Northeast and, more recently, oil palm in the North. Since 2010, the rapid expansion of oil palm in the Amazon has been associated with such incentives coupled with low interest credit programs (Miccolis et al. 2014).

2.2.4 Emerging concerns surrounding climate change, environmental protection and sustainable land use

In 2009, the Brazilian Government drafted the overarching policy on avoiding GHG emissions from deforestation and land-use change in Brazil, called the National Climate Change Policy (PNMC, in Portuguese). PNMC is divided up into the national climate change plan, sectoral plans at the state level and other land-use policies at the municipal level. The main plan for implementing this policy in the Amazon is the PPCDAM, comprised of three main components at the federal level: (1) land tenure and planning; (2) environmental monitoring and control; and (3) fostering sustainable production activities. At the state level, the plans for combating deforestation and the Rural Environmental Registry (CAR) are the main policy instrument and, at the municipal level, the key actions are related to the land-tenure program (Arco Verde). These actions are underpinned by a range of guidelines in the Sustainable Amazon Program (PAS). The main funding mechanism besides earmarked federal budget funds is the Amazon Fund, to which the Norwegian government has pledged USD 1 billion. Several plans have been developed to deal with mitigating and adaption to climate change.

2.3 Family farming, agribusiness and access to credit

The policy framework for agriculture is marked by a clearly cut dualism between the measures aimed at corporate farming, as described above and those targeting family farming, smallholders and traditional communities. According to the official definition, 'family farms' must meet specific criteria in order to have access to a range of benefits extended by social and agricultural policies, namely: maximum farm size, which varies greatly according to municipal indicators, from roughly 2 to 200 ha; maximum of two off-farm laborers; the income must be predominantly earned through farming activities; and the farm must be managed by the family (Brazil 2006; Law 11326; MDA 2013). In order to qualify for social programs such as low-interest loans through PRONAF, there is also a maximum allowable gross income per family, which was recently raised to approximately USD 156,000 per annum (MDA 2013).

While family farms make up a relatively small percentage of all land (24% nationwide), they play a fundamental role in the national economy and food production. From 1995 to 2005, family farming accounted for around 9% of GDP, compared to an average of approximately 19% for corporate farming over the same period. Family farming makes up 38% of the gross value of production and 32% of the national agricultural GDP, playing an even more significant role in the economy of the Northern region (40%) (MDA 2007). The share of family farming in food production is even greater. According to official analyses, approximately 70% of all foodstuffs consumed by Brazilians are produced on family farms, including 87% of cassava, 70% of beans, 59% of pork, 58% of milk, 50% of poultry meat, 46% of corn, 34% of rice and 30% of beef (França et al. 2009; Presidência da República 2012).

The main program targeting family farmers is the National Program for Strengthening Family Farming (PRONAF), which began in 1996 under the Cardoso administration, and expanded under Presidents Lula and Rousseff. PRONAF is currently the main mechanism for providing farm loans to smallholders and traditional communities throughout Brazil, while also providing other services such as rural extension and farm insurance (MDA 2013). Overall, PRONAF has helped to provide more access to subsidized loans for family farmers, over USD 7 billion (MDA 2013), as well as increasing access to extension services.

Interest rates from PRONAF range from 0.5% to 2% per annum for most lines of credit targeting smallholders and 5% for a few specific lines of credit targeting relatively higher income farmers that still fall under the category of family farmers. These rates are highly subsidized by Brazilian standards, where the basic lending rate established by the central bank (SELIC), well below average market rates, is currently at 9% p.a. and has stayed above 20% p.a. for several years in the early 2000s (RFB 2013) As a comparison, market rates for bank loans in 2013 averaged 88.61% p.a. in 2013, which is nonetheless well below historical rates in the last 10 years (Folha de São Paulo 2013). Loans are classified according to two main types: costing and investments. Out of the total, 43% of all loans to family farmers, including both of these categories, went to livestock and 57% to crops, led by maize and soybeans.

While PRONAF loans to smallholders have been on the rise, they still pale in comparison to credit issued to large-scale or corporate farmers. In addition to the tax incentives mentioned above, from June 2012 to June 2013, large-scale farmers received a total of approximately almost USD 56 billion in direct credit through various programs, compared to USD 9 billion for family farmers through PRONAF (Banco Central do Brasil 2012).

Additionally, according to Fernandes and colleagues (2012), the country's agribusiness establishments receive 85% of agricultural credits, control 76% of the land area, produce 62% of gross output and employ 26% of farm labor. As they point out, "This means that a highly limited number of individuals on a major portion of the land control a majority of the sector's resources."

Despite a rise in rural credit programs targeting both corporate and family farms, access to credit among family farmers is still very low throughout the country, as 82% of family farms do not receive any sort of financing. Although these figures vary greatly depending on the region, even in the South, the region where the highest proportion of farmers have access to credit, a full 62.5% still receive no financing whatsoever. Here, it is worth noting that the amount of low-interest loans issued to family farmers through PRONAF (the main credit program aimed at smallholders) has increased steadily since the early years of the Lula administration and continued rising during the first years of the Rousseff administration (USD 2.3 billion in 2003/4 compared to USD 11.5 billion in 2010/11). On the other hand, rural credit scales in Brazil are tipped overwhelmingly in favor of agribusiness, which in 2010 received a sum total of over USD 56.8 billion in direct financing, compared to a total of USD 9 billion for family farming (Andrade and Miccolis 2011). A similar pattern remained in 2013, when family farming received USD 7 billion compared to USD 52 billion for corporate farmers. If one takes into account indirect subsidies and foregone debt payments, this ratio would be even more imbalanced.

A study by Graziano et al. (2006) (in Heredia et al. 2010) shows a concentration of 'debt forgiveness' whereby nationwide renegotiated contracts below BRL 50,000 accounted for 65% of all credit operations and 8% of all funding, whereas contracts above BRL 200,000 made up 14% of operations but 71% of total financing. Some years later, following the renegotiation of debts under the Special Program for Sanitizing Assets (PESA), the share of small contracts (up to BRL 50,000) had gone down to only 19% of all operations and roughly 2% of the overall debt. Large operations, on the other hand, accounted for 98% of overall debt.

With regard to access to direct credit, in Mato Grosso State, for example, where soybeans have spread most intensely, large-scale soybean farmers have been the main recipients of credit, with 50% to 75% of contracts and close to 95% of the overall amount of government financing. A similar pattern can be observed in Bahia State, which saw a trend towards large-scale contracts, where only 1% of credit operations amounted to over 50% of disbursements in 2004 (Heredia et al. 2010). Furthermore, the vast majority of these loans were concentrated in the west of the state, where large-scale soybean and cotton production have dominated the landscape.

3 Current land-use trends and drivers

3.1 Introduction to main trends

Land-use change results from a combination of pressures and drivers, which occur over different time and spatial scales and can happen permanently (e.g. land reform) or intermittently (e.g. droughts or economic crises). Combined effects of multiple drivers can be amplified or reduced by reciprocal or antagonistic actions and feedback (Geist and Lambin 2002). Changes in drivers that indirectly affect land-use change (LUC) and indirect land-use change (iLUC), such as agricultural policies and commodity prices, can lead to changes in the proximate causes directly affecting LUC and iLUC, such as agriculture and livestock expansion and food supply (Kaimowitz and Angelsen 1998; Angelsen and Kaimowitz 1999; Rudel et al. 2009). For example, a rise in the international demand for commodities (e.g. soybean, beef) may lead to a regional loss of forest cover, as well as credit policies that incentivize specific land uses, or improvements in technologies that lead to lower production costs of commodities whose expansion may have a direct influence on forest conversion.

Some studies in Brazil have examined the direct drivers of land-use change, especially in the Amazon biome and to a lesser extent in other biomes such as the Cerrado, including historical and spatial changes in those drivers (Barona et al. 2010; Arima et al. 2011; Barreto and Araújo 2012; IBGE 2012a; Sparovek et al. 2012; Andrade de Sá et al. 2013; Nasser and Moreira 2013).

Barona et al. (2010), among others, use spatially explicit analysis based on data at the municipality level on land use across the Brazilian Legal Amazon, between 2000 and 2006, to examine the spatial patterns and statistical relationships between deforestation and changes in pasture and soybean areas. Arima et al. (2011) present a spatial regression model, which attempts to capture the effects of iLUC. By incorporating spatial weights matrices, their model links the conversion of forest to pasture and successively to LUC elsewhere in the Legal Amazon. These authors link deforestation especially to the expansion of soybean production in a settled agricultural area via a land 'cascade' from the latter to the forest frontier. Deforestation between 2003 and 2008 is thus shown to be strongly related to soybean expansion elsewhere. Meanwhile Andrade de Sá et al. (2013) suggest a positive relationship between sugarcane expansion and deforestation in the Amazon.

Some other authors question the iLUC effect. According to Nasser and Moreira (2013), the iLUC effect is difficult to assess and wrought with uncertainties. These authors have argued that sugarcane ethanol is a biofuel with a low iLUC risk, at least in the short term. This argument is based on evidence that Brazilian agriculture is going through an intensification and efficiency gains process that reduces the need for new land conversion to accommodate crops that are expanding.

Another attempt to tackle the monumental challenge of tracking the dynamics of agricultural expansion and contraction at a national level and linking it to deforestation was made by the National Statistics Bureau (IBGE 2012a). IBGE published a wide-reaching study based on a series of new analyses of its own census data (Agricultural and Demographic), comparing 1996 to 2006 data as inputs for setting up sustainable development indicators, coupled with municipal production data from 2010 (IBGE 2012a) Table 1 and Figure 1 present some of the aggregated data since 1970, showing a trend of 90% increase on annual crops and 400% on planted pasture from 1970 until 2006, while a decrease on natural pasture.

Barreto and Araújo (2012) evaluated indirect drivers, such as 37 measures, bills of law and lawsuits initiated between 1992 and 2009, which aimed to change the status of 250,169 km^2 of protected areas. Up to July 2010, 49,506 km^2 were pulled from legal protection and 86,538 km^2 are threatened, due to the expansion of agribusiness and other development projects such as dams and mining. Similarly, a series of studies conducted by IMAZON have shown that the risk of land-use change in protected areas (indigenous lands and conservation units) is lower than in areas that are not protected, even taking into account the influence of other factors such as distance to roads (Barreto and Silva 2010; Barreto et al. 2013a). However, some protected areas have been more vulnerable to land-use change and deforestation since they were created closer to or within places where there is already some kind of informal or illegal occupation (Barreto and Araújo 2012).

Table 1. Land use in Brazil in selected years (million ha).

	1970	1975	1980	1985	1995	2006
Perennial crops	8.0	8.4	10.5	9.9	7.5	11.7
Annual crops	26.0	31.6	38.6	42.2	34.3	48.9
Natural pastures	124.4	126.0	113.9	105.1	78.0	57.6
Planted pastures	29.7	39.7	60.6	74.1	99.7	102.4
Natural vegetation	56.2	67.9	83.2	83.0	88.9	95.3
Planted forests	1.7	2.9	5.0	6.0	5.4	4.7
Total	246.0	276.4	311.8	320.3	313.8	320.7

Source: Adapted by authors based on IBGE agricultural census in several years with data obtained from IBGE: http://www.sidra.ibge.gov.br/

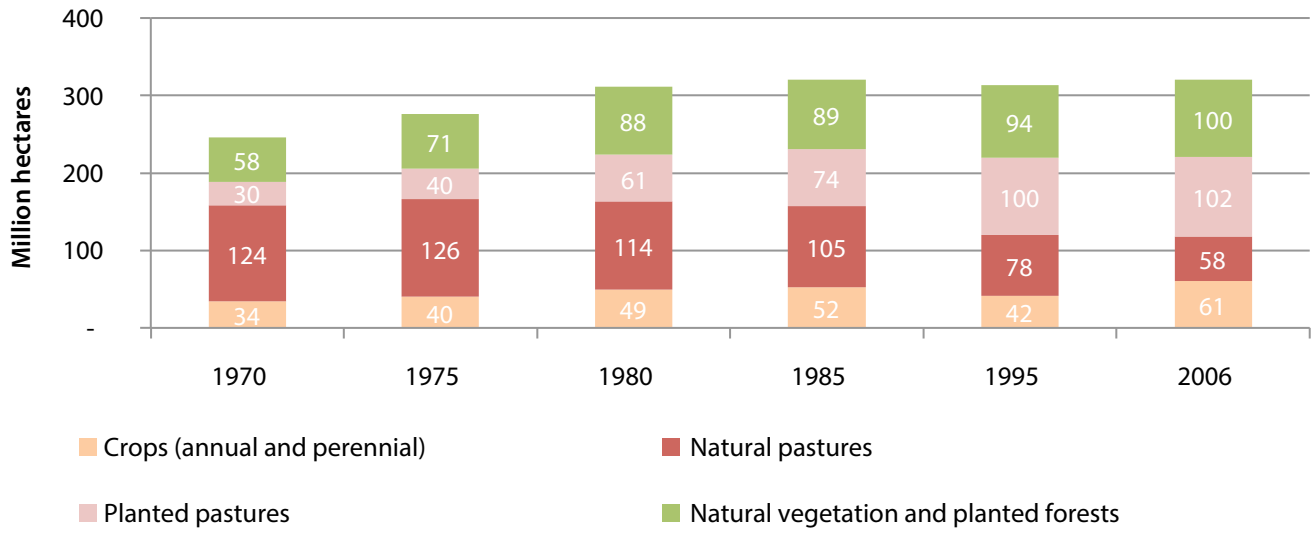

Figure 1. Land uses based on IBGE Agricultural Census.
Source: Based on data from IBGE 2012c

3.2 Overview of land use in Brazil

Brazil's vast territory is comprised of roughly 846 million ha, 61.2% of which (517 million ha) is covered by natural vegetation. About 170 million ha (20%) of these lands are located within federal and state protected areas and most of the remaining natural vegetation is in private hands (Sparovek et al. 2012).

According to FAO (2013), total agricultural land in Brazil amounted to 275 million ha in 2011 (Table 2), an increase of 4% since 1990, although other sources have put this estimate at 211 million ha (Sparovek et al. 2012). Based on FAO figures for 2011, the largest portion (about 71%) of agricultural land was comprised of pastures and meadows, followed by arable land used for crops (26.2%). From 1991 to 2011, while annual croplands rose by nearly 42% and pastures by 6.4%, forested areas fell by 10%. According to the Terra Class executive report, in 2010 cumulative land use, land-use change and forestry (LULUCF) in Brazil was 739.6 million ha, of which 458.9 million ha were converted into pastureland (including regenerated forest with pasture, dirty and clean pasture), up by 11.4 million ha in 2008; 39.9 million ha were converted into annual crops in 2010, an increase of 5 million ha since 2008; and 165 million ha were converted into secondary vegetation, an increase of 15 million ha since 2008. (EMBRAPA/INPE 2010)

Map 2 shows that the vast majority of croplands are located in the Central-West and South Central regions. While the cattle herds are also largest in these same regions, they are also found extensively in the Northern region where the Amazon is located.

Table 2. Land use in Brazil in selected years (in 1000 ha).

	1990	In%	2000	In%	2011	In%
Country area	851,488		851,488		851,488	
Land area	845,942	100.0	845,942	100.0	845,942	100.0
Agricultural area	241,608	28.6	261,406	30.9	275,030	32.5
• Arable land	50,681	6.0	57,776	6.8	71,930	8.5
• Permanent crops	6,727	0.8	7,424	0.9	7,100	0.8
• Meadows and pastures	184,200	21.8	196,206	23.2	196,000	23.2
Forest area	574,839	68.0	545,943	64.5	517,328	61.2
Other land	29,495	3.5	38,593	4.6	53,584	6.3
Inland water	5,546	0.7	5,546	0.7	5,546	0.7

Source: Adapted by authors with data from FAOSTAT (2013), http://faostat.fao.org/

Map 2. Land use in Brazil.
Source: Authors' mapping of data from GLOBCOVER 9 (2009) and ESA (2010)

3.2.1 Trends in the expansion of pasturelands

According to IBGE (2012c), from 1996 to 2006 there was a nationwide increase of 2.7 million ha of planted pastures, with a great deal of movement between states and expansion predominantly towards the North. An analysis disaggregated by regions and states shows an increase of 6.1 million ha (41.5%) in the North, led by Rondônia (1.9 million ha, 77.1%) and Pará (3.3 million ha, 58%). In all other regions, with the exception of the Northeast — which saw an increase of 2.4 million ha (20,4%) — the area of planted pastures dropped, most notably in the Southeast (–3.5 million ha, -17.5%). Planted pastures in São Paulo alone reduced by 42.2% (-2.9 million ha).

Moreover, the area used for natural pastures was reduced by 20.4 million ha (-26%) nationwide. Most of this decline occurred in the Southeast (6.4 million ha in São Paulo, -36,8% and 6.3 million ha in Minas Gerais, -36.8%.) where croplands increased substantially, especially sugarcane and corn. Natural pastures also shrunk in other states, including: Tocantins (2.9 million ha, -51.0%), Bahia (2.7 million ha, -34.5%), Rio Grande do Sul (2.2 million ha, -21.4%), Goiás (1.9 million ha, -38.7%) and Mato Grosso (1.8 million ha, -28.8%). This overall reduction in natural pastures at the same time as increases in planted pastures suggests intensification in the South and Southeast and the overall data on pasture sizes per state suggests displacement of herds from the South and Southeast to the North (IBGE 2012a). This combination of data suggests the increasing role of pastures in land-use change, mainly in the North.

As seen in Figure 2 and Table 3, cattle in the mid-1970s was mainly concentrated in the Southeast of Brazil, followed by the Central-West, compared to very small herds in the North. While cattle herds in the South and Northeast remained largely unchanged, numbers increased substantially in the Central-West, from about 24.8 in 1975 to 57.5 million heads in 2006. A similar trend took place in the North, where cattle herds began to expand since the early 1990s, reaching a total of 31.3 million heads in 2006, thus surpassing the herds found in the South (IBGE 2012b).

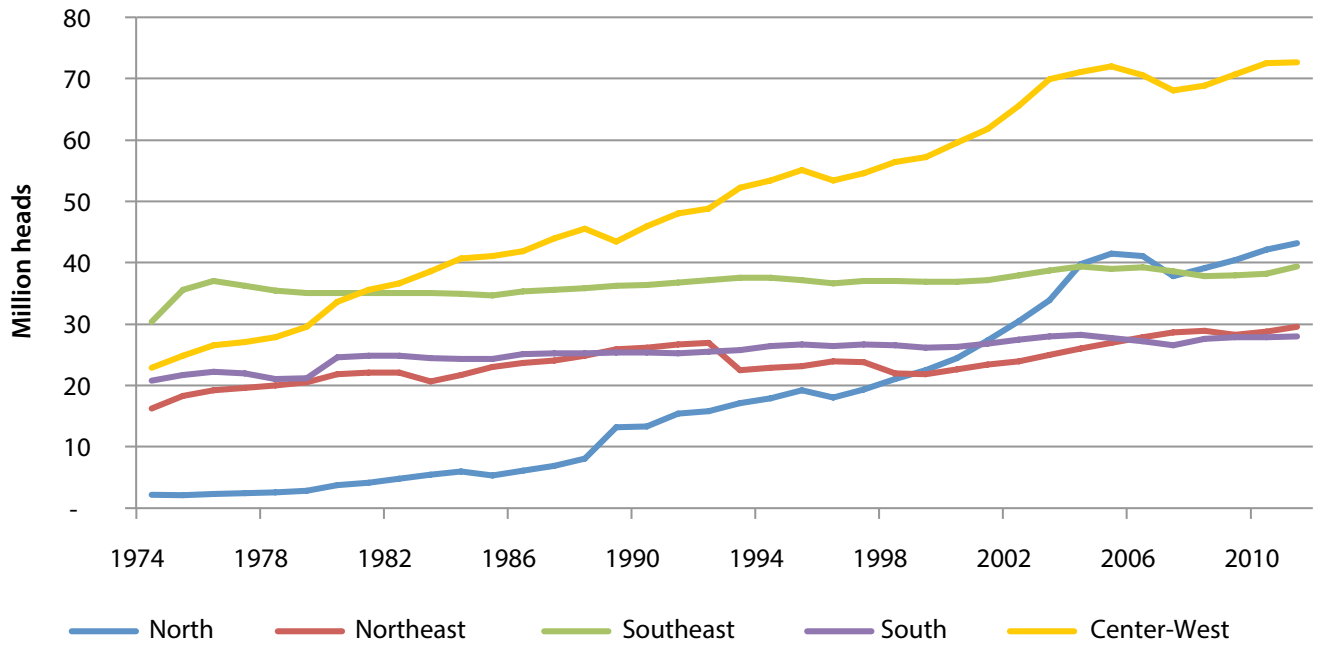

Figure 2. Cattle population by region in Brazil in the period from 1974 to 2011.
Source: Based on information provided by the IBGE Livestock Municipal Survey (2012a)

Table 3. Cattle density (head of cattle/hectare) by region.

	Cattle population (million heads)			Pasture (million ha)			Stocking rate (AU/ha)		
	1975	1996	2006	1975	1996	2006	1975	1996	2006
North	2.1	17.3	31.3	5.3	24.4	26.5	0.5	0.8	1.2
Northeast	18.0	22.8	25.3	30.6	32.1	30.5	0.8	0.9	1.0
Southeast	35.2	36.0	34.1	47.3	37.8	27.6	0.8	1.0	1.3
South	21.5	26.2	23.4	21.2	20.7	15.6	1.2	1.4	1.6
Center-West	24.8	50.8	57.5	61.3	62.8	58.5	0.4	0.8	1.0
Brazil	101.7	153.1	171.6	165.7	177.7	158.8	0.7	0.9	1.2

Source: Adapted from Barreto et al. (2013b) with data taken from www.ipeadata.gov.br

At the same time, cattle ranching underwent intensification in the Southeast and South regions, where there is a higher stocking rate, in the order of 1.3 and 1.5 AU/ha, respectively. The density of cattle has also increased in other regions, mainly in the northern region, where the stocking rate equates 1.2 AU/ha. This data suggests that pastures have tended to shrink or remain stable in regions where higher cattle ranching intensification is visible, whereas it has expanded mainly in the North, mainly taking over forest land. It is noteworthy that this region has simultaneously undergone processes of intensification and extensification. Cattle tends to intensify in areas of older occupation, while it expands through more extensive cattle production systems in the areas where the new frontiers are evolving (Pacheco and Poccard-Chapuis 2012).

3.2.2 Intensification as a path forward for more sustainable cattle grazing

On the one hand, there is a clear perception that the country is moving towards a period of greater compliance with environmental legislation as both ranchers and growers are bowing to national policies and pressures from consumers and environmental watchdog groups (Barreto et al. 2013b). A key example of such national policies is the 'blacklist' of municipalities with high deforestation rates, which has restricted access to credit for farmers and ranchers (Barreto et al. 2013b). At the same time, current trends clearly point to intensification as a means for reducing pressures on the native vegetation as the key players in the cattle industry have set up voluntary initiatives aimed at rendering the supply chain more sustainable through intensification of production and increasing transparency and accountability in the supply chain (Barreto et al. 2008; Nepstad et al. 2014).

As a direct result of increased command and control policies, current trends point to decreases in illegal deforestation in the Amazon, despite a recent spike announced in late 2013 and it is likely that illegal deforestation related to cattle will continue to drop because of both government policies and market-based initiatives (Nepstad et al. 2014). At the same time, legal deforestation is bound to continue rising, especially in the Cerrados, partially as a result of greater compliance with environmental restrictions in the Amazon. These land-use interactions are still not well studied.

It is likely that cattle intensification is increasing in the Cerrados as a result of incentives such as the ABC program and other lines of credit currently being developed such as *Intensifica Pecuária*. This process of cattle intensification has the potential of making available 60 million ha of pasturelands to be converted to agriculture without having to fell any trees (see Section 4). The current situation is still not conducive to intensification on marginal lands, however, due to poor infrastructure, logistics and low access to markets near these lands (FIESP 2013). Additionally, more policies need to be put in place to reconcile agriculture and cattle with conservation in the Cerrados (Rada 2013).

Indeed, the underlying premise of Brazilian policies for reducing conversion of native vegetation on private lands is that there is enough marginal land available to avoid this conversion (Heredia et al. 2010; MAPA 2012). The question, however, is the extent to which growers will choose to use these lands instead of simply deforesting legally in the vast new frontiers of the Cerrado regions. Again, the solution lies in the creation and scaling up of economic incentives for ranchers to occupy these lands more sustainably. Just as policy interventions in the past have favored the indiscriminate expansion of pasturelands onto sensitive ecosystems, as the policy pendulum swings in the other direction, they may now have the opposite effect.

The other burning question is the degree to which ranchers will be able to intensify in the outreaches of the Amazon, where infrastructure is extremely poor and farmers tend to adopt low tech and low-capital management practices. On the governance front, a key constraint for intensification in the ranching sector is the high degree of informality and thus underreported production in slaughterhouses, which makes traceability and accountability very difficult. Moreover, regulating the beef sector is politically quite expensive because more control would tend to increase prices. Since most of the herd sizes in Brazil are relatively small, such regulations would also have a high social cost on the livelihoods of small-scale ranchers. Increasingly, deforestation stemming from ranching in the Amazon is becoming a social issue (Godar et al. 2014).

To address some of these finance-related constraints, the federal government is in the process of setting up a new line of credit known as "*Intensifica Pecuária*" (Intensify Cattle), which will loan at lower interest rates than other lines of funding for ranchers who intensify cattle production and thus reduce pressures on standing forests.

In short, the government is increasingly focusing its strategy to reduce GHG emissions from land-use change by supporting intensification in the ranching sector. According to recent studies, this goal can only be achieved through a combination of command and control measures, economic incentives and market-based approaches (Böner et al. 2014; Nepstad et al. 2014). Clearly, intensification will also require other policy-related conditions such as improved infrastructure, technical assistance and extension services. Additionally, ranchers, which in Brazil are on average small-scale, generally do not have access to capital in order to make investments in better management practices needed for intensification. As first users of recently converted forest, they use the land as much as possible until it reaches a point of depletion.

Another constraint for intensification is the lack of adequate technical assistance to ranchers, who are by nature averse to risk and have little access to new technologies (Interview MAPA/MDA 2013). Here, it is noteworthy to make a distinction between — and target technology transfer actions at — ranchers working at different stages of the beef value chain: those raising calves and cattle at early growing stages, which are generally smallholders, who then sell their cattle to medium and large-sized ranchers focusing on the fattening or finishing stages. Ultimately, with seemingly limitless expanses of land, the average rancher has very few incentives to be more efficient. Soybean and corn farmers tend to be larger in scale and more capital and technology intensive, so they are able to purchase more suitable lands and invest in soil recovery. These farmers also exercise greater influence over policy makers so they ultimately will invest in and subsidize infrastructure improvements that are essential for rendering expansion economically more attractive (i.e. roads, ports, storage). Intensification requires providing conditions (technological and logistic) for ranchers to stay on their land and improve soil quality rather than clearing new lands.

3.2.3 Expansion of key crops

As pastures have continued to expand on the vast frontiers of the Amazon and Cerrado biomes, crop area during the same period increased by 10.4 million ha (20.9%), throughout all regions, with the largest increases seen in the Central-West (5.09 million ha, 68.4%), South (1.7 million ha, 12.6%) and Southeast (1.7 million ha, 15%). The states with the largest expansion of crop areas were in the Central-West: Mato Grosso (2.98 million ha, 86.4%) and Goiás (1.3 million ha, 55.6%). In the South and Southeast, crop expansion seemingly replaced pasturelands, whereas in the Central-West and Northeast, forested areas were generally replaced by pastures and crops (IBGE 2012a).

An analysis of agricultural census data shows several land-use patterns, in terms of trends over time and significant shifts within and across regions. The first pattern is that the total area of establishments increased over time until 1985, after which it remained steady until 2006. The second is that lands under annual crops tended to grow over time, until reaching a total of 61 million ha in 2006 and the third is that natural pastures have tended to contract and planted pastures to expand. Meanwhile, natural vegetation, which amounted to about 95 million ha in 2006, actually increased, which might be attributed to the fact that a greater number of agricultural establishments covering a larger area were surveyed in the 2006 census.

The most important crops in Brazil in terms of area are: soybeans, corn, sugarcane, beans, cassava, rice and wheat. The cultivation of these crops occupied 82% of the cropland area in Brazil in 2006, when the last agricultural census was undertaken (IBGE 2013). According to the municipal agricultural survey (IBGE 2012c), the total cultivated area in Brazil has continued growing over the last two decades, by about 15.8 million ha between 1990 and 2011, although most of this increase is due to the accumulated net growth of two crops, soybeans and sugarcane, which expanded by about 17.7 million ha. In contrast, crops such as beans, rice, wheat and cassava tended to contract (Figure 3 and Table 4). In all cases, production in 2011 surpassed the levels reached in 1990. This was due to increases in productivity, which were higher in soybean, sugarcane and corn.

Geographically, the expansion of croplands by region suggests a trend that has been documented widely: that agricultural growth took place from the South and Southeast regions in Brazil, moving northward to the Central-West and then to the northern region. As illustrated by Figure 4, most of the sugarcane cultivation has taken place in the Southeast region, mainly in the state of Sao Paulo and most of the soybean expansion has taken place in the South, Northeast and especially Central-West, mainly in the state of Mato Grosso, where corn has also begun expanding. In the last 2 years, sugarcane has also expanded significantly in the Central-West despite decreased demand.

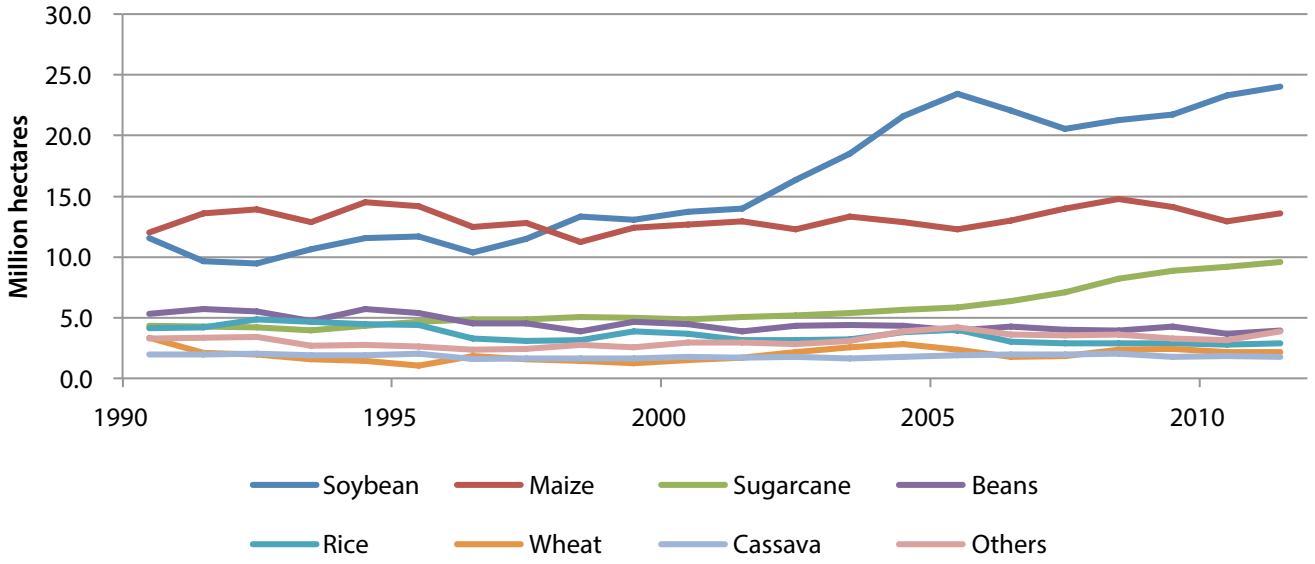

Figure 3. Total planted area.
Source: Based on IBGE municipal agricultural survey (2012c)

Table 4. Planted area, production and yields in Brazil in 1990 and 2011.

	Area in million ha			Production in TM			Yields (TM/ha)		
	1990	2011	Annual growth (in%)	1990	2011	Annual growth (in%)	1990	2011	Annual growth (in%)
Soybean	11.6	24.0	3.5	19.9	74.8	6.3	1.7	3.1	2.8
Corn	12.0	13.6	0.6	21.3	55.7	4.6	1.8	4.1	4.0
Sugarcane	4.3	9.6	3.8	262.7	734.0	4.9	60.8	76.3	1.1
Beans	5.3	3.9	(1.5)	2.2	3.4	2.0	0.4	0.9	3.5
Rice	4.2	2.9	(1.8)	7.4	13.5	2.8	1.8	4.7	4.6
Wheat	3.3	2.2	(2.1)	3.1	5.7	2.9	0.9	2.6	5.0
Cassava	2.0	1.8	(0.6)	24.3	25.3	0.2	12.3	14.4	0.8
Others	3.3	3.9	0.8						
Total	46.0	61.8	1.4						

Source: Adapted by authors based on IBGE Municipal Agricultural Survey (2012c)

Table 5 presents IBGE data from 1990 and 2011 of seven crops for the five regions in Brazil. Soybean is the only crop that expanded in all the regions since 1990 and sugarcane expanded in all the regions except in the Northeast. Meanwhile, all the other crops had their areas reduced in one or more regions, especially rice, beans and wheat. This overall pattern suggests a replacement of staple crops (rice, beans, cassava) with commodity crops (soybean and corn).

The figure presented above suggest that the land expansion of soybeans and sugarcane has been coupled with an increase in yields and that there is a significant correlation between pasture area and stocking rate, suggesting that pasture intensification has historically been correlated with a reduction in pasture area, although there are some variations across regions. Barreto et al. (2013a) conducted an analysis of agricultural intensification in Brazil and its effects on land-use patterns, suggesting that, in South and Southeast Brazil, regions in which agriculture is greatly consolidated, land-use intensification (both on cropland and pastures) coincided with either contraction of both cropland and pasture areas, or cropland expansion at the expense of pastures. In contrast, in what could be defined as agricultural frontier areas in the Central-West and North, land-use intensification coincided with expansion of agricultural lands. These observations suggest that land-use intensification takes place through different

pathways and can also occur at different intensities through time and depends on the stage of agricultural frontier development.

A recent study evaluating total factor productivity (TFP) growth in the Cerrado has concluded that the bulk of productivity growth in this biome over recent years has stemmed from the use of more inputs, especially fertilizer and pesticides and not from greater efficiency per se (Rada 2013). Increasingly, social movements and environmental groups have pointed to the grave environmental effects fertilizer and pesticide use, such as contamination of aquifers and streams (IPEA 2012a), as well as human health hazards (Fundação Oswaldo Cruz 2010). One study shows that reports of ailments stemming from pesticides have greatly increased in municipalities where large-scale agriculture has also increased in the Cerrado (Soares and Porto 2007).

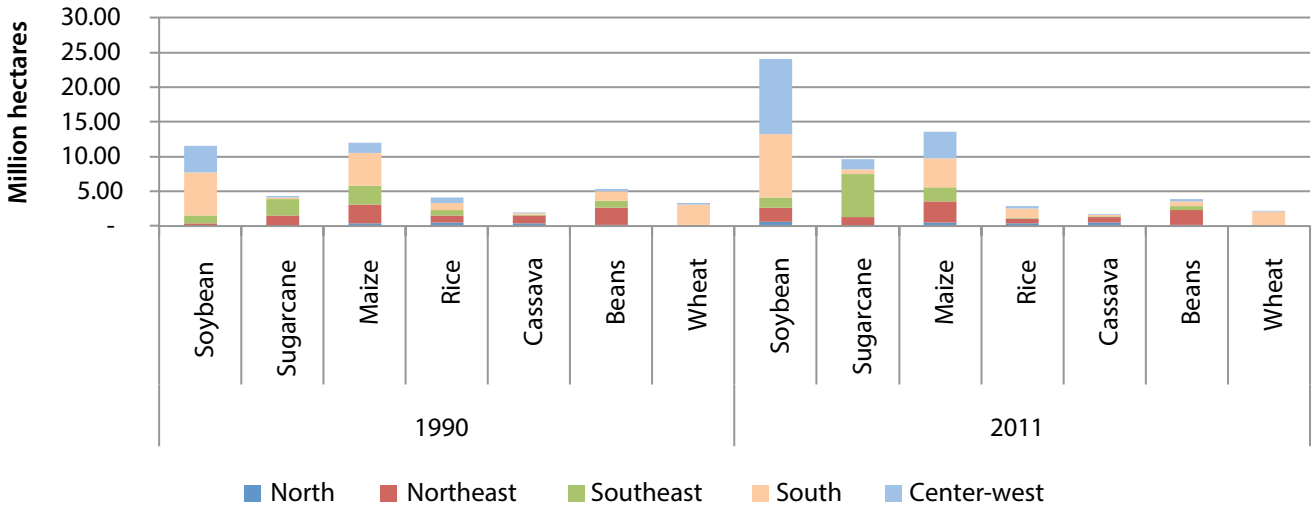

Figure 4. Total planted area of seven selected crops by regions in Brazil in 1990 and 2011.
Source: Based on information from IBGE Municipal Agricultural Survey (2012c)

Table 5. Planted area in 2011 and differences compared to 1990.

	Soybean	Sugarcane	Maize	Rice	Cassava	Beans	Wheat
Planted area in 2011 (in million ha)							
North	0.64	0.05	0.52	0.44	0.51	0.16	-
Northeast	1.96	1.23	3.01	0.68	0.74	2.14	-
Southeast	1.51	6.23	2.04	0.07	0.14	0.55	0.06
South	9.09	0.69	4.11	1.36	0.29	0.72	2.07
Center-West	10.84	1.42	3.92	0.31	0.07	0.34	0.04
Brazilian Legal Amazon	7.62	0.33	0.16	0.16	0.03	0.06	-
Planted area in 2011 – Planted area in 1990 (in million ha)							
North	0.60	0.03	0.11	(0.03)	0.17	(0.04)	-
Northeast	1.58	(0.26)	0.35	(0.41)	(0.39)	(0.34)	-
Southeast	0.39	3.87	(0.70)	(0.65)	(0.00)	(0.45)	(0.15)
South	2.93	0.48	(0.64)	0.35	0.00	(0.57)	(0.85)
Center-West	6.94	1.18	2.45	(0.57)	0.00	0.00	(0.18)
Total BLA	6.02	0.21	(1.02)	(1.38)	(0.57)	(0.32)	(0.00)

Source: Adapted by authors based on IBGE Municipal Agricultural Survey (2012c)

Additionally, the expansion of the agro-industrial complex in the Cerrado has sparked criticism for deforestation of the native Cerrado vegetation given its importance for biodiversity and livelihoods of traditional populations. While the expansion of extensive farming and grazing in the Cerrado is relatively recent, beginning mainly in the 1970s, approximately 50% of the native vegetation has already been deforested (Garcia et al. 2011; IBGE 2012b), compared to only 20% of the Amazon biome. The main vectors of deforestation have been large-scale farming for commodities, especially soybeans and corn, in addition to extensive cattle grazing.

3.2.4 Sugarcane and ethanol

For several years, sugarcane ethanol, touted as the "clean green fuel", was a flagship of the country's climate change mitigation strategy. In recent years, however, mounting evidence that cattle herds are being displaced from the Cerrados northwards to the Amazon as a result of expanding sugarcane has somewhat put this view in check, although uncertainties abound in the methodologies attempting to calculate this indirect land-use change. According to Gouvello et al. (2011), about two-thirds of the area into which sugarcane expanded came from converting pastureland and the remainder from replacing other crops (32%) and from converting natural vegetation (2%). While zoning policies for sugarcane have successfully impeded its encroachment onto the sensitive ecosystems of the Amazon and Pantanal Wetlands, the same cannot be said of the Central South, comprised mainly of Cerrado, where much of the expansion of this crop has been concentrated over recent years.

In a recent development worth monitoring, a bill of law seeking to authorize the planting of sugarcane in the Amazon biome is being discussed in the national congress and has already been approved in one of two main Senate committees. If approved, this new law might have huge implications for sugarcane as a driver of land-use change in northern Brazil despite provisions in the bill aimed at restricting plantations to 'degraded lands' (Andrade and Miccolis 2010a; Reporter Brasil 2013). As seen in the case of the national Sustainable Oil Palm Production Program, which put in place guidelines that restrict conversion of native forests, the definition of degraded lands is still fuzzy and subject to interpretation, so enforcement of this provision in the proposed law might be very difficult (Andrade and Miccolis 2010a).

Another trend in this sector is that discussions about the impacts of expanding sugarcane have taken a back seat to other drivers of land-use change (cattle and annual crops) as the demand for ethanol plummeted and major companies have frozen investments in new plantations. This trend has been due, above all, to direct and indirect subsidies (such as the CIDE fuel tax and price controls) that have kept gasoline prices artificially low and thus rendered ethanol much less attractive to consumers at the pump. The crisis in the Brazilian sugarcane sector began around the same time of the 2008 financial crisis, as traditional investors (mostly family-owned mills) faced shortages in credit from the financial sector and borrowing became more expensive (Assad et al. 2012). At the same time, big companies bought up existing assets and postponed investments in new areas and renewing current plantations. Since then, the sector has been facing a 15–20% idle capacity due to the lack of feedstock to supply mills (Assad et al. 2012). As a result of declining investments, productivity, which had been rising steadily for several years, also dropped significantly in recent years. Meanwhile, as Petrobras kept gas and diesel prices artificially low to keep inflationary pressures at bay, ethanol consumption at the pump has continued to drop (Andrade and Miccolis 2011).

Box 1. Zoning policies for sugarcane expansion

The Agroecological Zoning for Sugarcane (ZAE Cana), which limits the expansion of sugarcane in the Amazon region, may potentially be displacing other agricultural activities to the Cerrado, although this pattern is extremely difficult to prove on the ground. Andrade de Sá et al. (2013) show that a necessary condition for displacement is that the output of the displaced activity faces a relatively inelastic demand, which might be the case, for instance, if the displaced crop is a staple food produced and consumed locally, or if the country is a major producer and exporter such that its supply affects international prices.

Another relevant zoning instrument is the Ecological–Economic Zoning, aimed at ordering the economic behavior of a wide range of stakeholders. Certain agro-ecological conditions, infrastructure and zoning rules may result in a concentration of crops in some regions. This result has led to a general increase in the use of spatial methods that can control for spatial auto-correlation in forest conversion decisions, for example in the soybean expansion in the Cerrado region, other biodiesel crop expansion and logging zones (Barreto et al. 2013a).

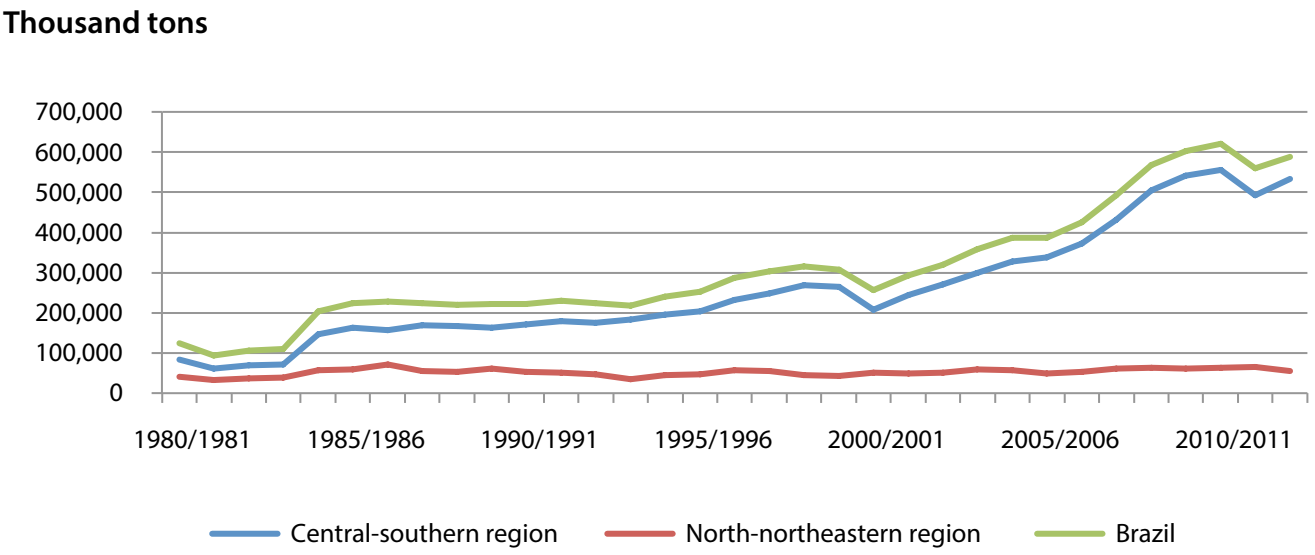

Figure 5. Evolution of sugarcane production by region in Brazil from 1980–2013.
Source: Adapted by the authors from MAPA (2013)

Currently, the Central Southern region of Brazil produces approximately 90% of Brazilian sugarcane and the North — Northeast produces the remaining 10%. As shown in Figure 5, this current distribution began around 1985 and, most notably, as of 2003, when the flex fuel car production boom began.

Some of the main questions with regard to the sugarcane–ethanol sector are the extent to which expansion patterns will resume as predicted previously, whether yields will also reach previous levels and the timescale for commercial production of second-generation biofuels from sugarcane and other feedstock. Another major lingering question is the speed at which second generation biofuels, particularly from sugarcane residues, will be competitive. Despite hefty investments by several energy sector players in Brazil, including Petrobras and research institutions such as Embrapa and CTC (Sugarcane Technology Center). It is likely that second generation will take anywhere between 5 and 10 years, possibly more, to become a feasible alternative to first generation ethanol production. In addition, Brazilian producers will undoubtedly need to adopt integrated first- and second-generation solutions for sugarcane on the same site and that it will probably take another 5 years before productivity can be recovered to previous levels of 8 tonnes/ha (interview with MAPA staff, 2013).

Recovering productivity in the Cerrados of the Central-West and Northeast, where sugarcane has most expanded in recent years, will also entail making investments in developing new varieties and irrigation, which may be a constraint for growth as water resources become scarcer in this region due to land use, climate change and overexploitation. So the extent to which sugarcane will resume its previous expansion trend hinges mainly on domestic demand, which is directly proportional to the price of gasoline compared to ethanol. This, in turn, will depend on how long the country manages to keep prices artificially low, but also on exogenous factors such as international oil prices and market conditions. Recently, low rainfall levels have increased the country's need to use thermal power plants to fill the gap left by low reservoir levels in hydropower plants. In this scenario, greater numbers of sugarcane producers will tend to turn to co-generation as a means to supplement their income streams. Hence, while market conditions are key to determining the expansion of sugarcane, government policies regulating the price of gasoline as well as fiscal policies such as the elimination of the CIDE fuel tax have have had a decisive effect on both the expansion and contraction of the sugarcane–ethanol sector.

Furthermore, over the last decade the federal government has also provided substantial fiscal incentives for agriculture by reducing or waiving federal taxes on agricultural inputs, including fertilizers, pesticides and machinery (Lima et al. 2014). The value added tax (ICMS) collected by states is also lower for such products. Indeed, of all the sectors listed in the Brazilian revenue service's statement of tax expenditures (i.e. tax cuts) (DGT 2006–2013), agriculture has received the highest volume of incentives, totaling about BRL 13 billion

(USD 6.03 billion) in 2013 (Lima et al. 2014). Incentives for this sector have risen steadily since they were first created in 2003. While lower in total volume, fiscal incentives for the energy sector have also undergone a steady rise over the last 10 years, on average 69% per year, compared to 38% in agriculture and 18% in the automotive sector. (Lima et al. 2014)

3.2.5 Soybeans and biodiesel

Besides the incentives provided to the agricultural sector in general, specific measures have been set up to promote the production of biodiesel, particularly with the aim of including smallholders. Biodiesel is a fuel produced from vegetable oils or animal fats. Dozens of plant species present in Brazil have been researched and used for producing biodiesel, such as: soybeans (*Glycine max*), oil palm (*Elaeis guineensis*), sunflower (*Helianthus annuus*), babassu nut (*Attalea speciosa*), peanuts (*Arachis hipogaea*), castor beans (*Ricinus communis*), jatropha (*Jatropha curcas*), Macaúba palm (*Acrocomia aculeata*) and Brazil nuts (*Bertholletia excelsa*), in addition to beef tallow and spent cooking oil (Andrade and Miccolis 2010a).

Biodiesel production has continued to rise steadily over recent years to over 2.9 million m^3 in 2013 (ANP 2013).[2] Major companies seeking the social fuel seal have purchased increasing amounts of castor bean oil from smallholders, especially in the Northeast, but over 90% of all feedstock bought from smallholders still comes from soybeans, the vast majority of which from southern Brazil. Castor bean oil is generally being sold to the vegetable oil market, however, rather than being used for biodiesel due mainly to its high opportunity costs in non-fuel markets. To overcome this hurdle, the MDA is currently considering extending the benefits granted by the social fuel seal to vegetable oils in general. If successful, this measure will greatly boost the demand for oilseed production among smallholders and companies. (Miccolis et al. 2014)

As shown in Figure 6, soybean oil has been the predominant feedstock over the past 6 years. In 2012, biodiesel production from soybean oil was 2.06 billion liters, a little higher than that of 2011, 2.05 billion liters. According to ABIOVE (2013) data on feedstock used until June 2013, soybean oil accounted for 74% of all biodiesel produced in Brazil in that year, followed by beef tallow (19%) and cottonseed oil (2%) Other sources together accounted for 5% of national production, including spent cooking oil (over 1%).

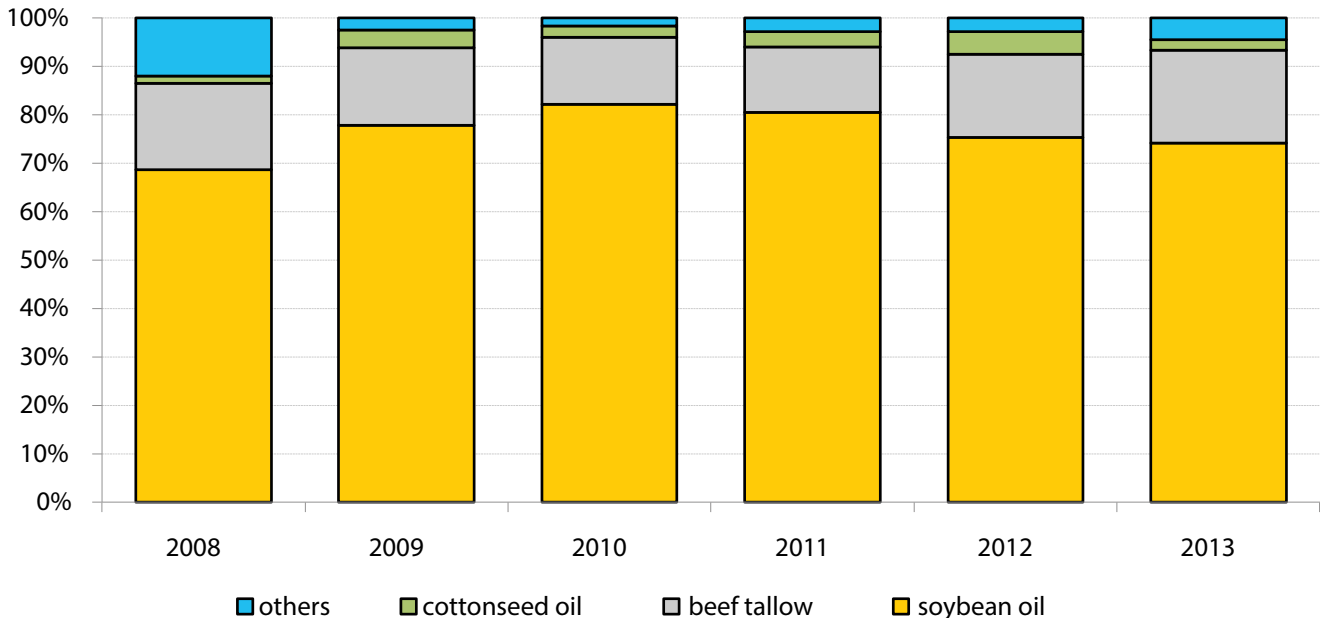

Figure 6. Main feedstock for biodiesel in 2012.
Source: Based on data from ANP (2013)

2 www.anp.gov.br/?dw=8740

To date, the hegemony of soybeans in biodiesel production can be attributed largely to major investments in the sector and to the highly developed links across the soybean complex value chain (grain, meal and oil), including farming, storage, transport/distribution and processing infrastructure. The expansion of soybean area in Brazil in the past years was somewhat stymied by the soybean moratorium in the Amazon region in 2006, after which expansion was mostly concentrated in the Cerrado region, where technological innovation increased yields considerably.

Indeed, soybeans have been expanding mostly in the Central Western Cerrados, especially in Mato Grosso State, but more recently in MATOPIBA (a region including parts of the States of Maranhão, Tocantins, Piaui and Bahia). According to some experts consulted, this geographic trend is due partly to the lower environmental requirements for setting aside protected areas on private lands in this biome. Besides massive investments in technological improvements that have enabled transitioning to the highly acidic and nutrient poor soils, another main factor underlying this expansion is the clearer land tenure situation in the Cerrados compared to the Amazon.

While double cropping soybean with corn has also enabled productivity gains and soil conservation in mostly no-till systems and therefore more efficient land use, it is unlikely that this practice will be able to take hold in the drier regions of MATOPIBA because of the shorter growing season. The adoption of double cropping in this region, which is economically more attractive to farmers who take advantage of the same fixed costs and infrastructure, will thus require wider use of irrigation and exert greater pressures on water resources, which are already scarce in the region. This expansion is also much more likely to benefit large landholdings, as smallholders in this region still have scant access to irrigation and other agricultural technologies (Miccolis et al. 2014).

Regardless of these constraints in MATOPIBA, soybeans are likely to continue being the main feedstock for biodiesel production in the coming years. So in the business-as-usual scenario, the expansion of soybeans is likely to continue in the Cerrados. As shown in Figure 7, the 2011/2012 harvest fell from the previous year for climate-related reasons, longer and severe droughts. One of the limiting factors for this expansion to continue in the future, then, will be water availability, especially if climate change scenarios for the region predicting lower overall rainfall levels come to fruition.

As seen in the previous sections, Brazil has been undergoing an important expansion of croplands, mainly as a result of growth in soybean and sugarcane. Though it is difficult to quantify the extent to which this growth has been spurred by policies, a complex combination of carrots and sticks undoubtedly played an important role: a series of policies tax and infrastructure policies providing incentives to farmers, on the one hand, and on different levels of environmental regulations for different regions, on the other.

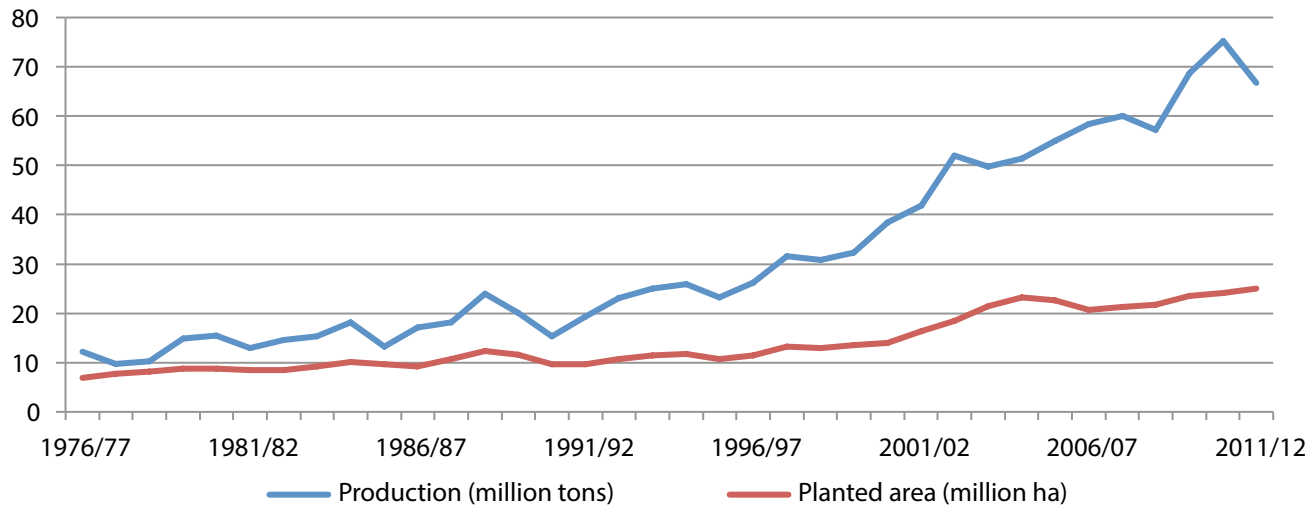

Figure 7. Soybean expansion in Brazil.
Source: Based on data from CONAB (2013)

3.3 Charcoal, fuelwood and planted forests

The expansion of mining operations throughout the Cerrado and portions of the southern Amazon, such as in southern Pará, has greatly increased the demand for bioenergy from charcoal, both from native timber and planted forests. One key characteristic of the charcoal sector in Brazil vis-à-vis command and control policies is that enforcement mechanisms are not considered as effective as they are for other sectors, such as logging and agriculture, for example, since licensing processes are easier to forge or bypass.

3.3.1 Fuelwood production

Extractive fuelwood production in 2011 amounted to 37,574,207 m^3, 1.7% lower than in 2010. Bahia is by far the top producer (9,171,091 m^3), followed by Ceará (4,809,238 m^3), Pará (3,347,942 m^3), Maranhão (2,735,794 m^3), Mato Grosso (2,084,086 m^3) and Pernambuco (2,043,995 m^3). Together, these six states produced 64% of the total fuelwood recorded (IBGE 2012a). Eight out of the top ten fuelwood-producing municipalities are located on the fringe of soybean and cattle expansion in Southwestern Bahia, in the Cerrado biome (IBGE 2012a).

3.3.2 Charcoal

One of the problems associated with the governance of charcoal production in Brazil is tracking the origin of raw materials. Charcoal production from planted forests has been insufficient to meet the rising demand, which has meant greater pressure on remaining forests, especially in many parts of the Cerrado and Caatinga biomes and in some parts of the Amazon (Miccolis et al. 2014). In 2011, eight states located in the Cerrado together produced 95% of the total extractive charcoal, equivalent to 1.35 million tonnes in 2011. The State of Mato Grosso do Sul was the largest producer, with 359,300 tonnes, followed by Maranhão, with 339,700 tonnes, then Minas Gerais, with 156,500 tonnes and Piauí, with 137,700 tonnes. The other four States are Bahia (115,300 tonnes), Pará (73,500 tonnes), Goiás (52,040 tonnes) and Mato Grosso (51,300 tonnes) (IBGE 2012a).

Pará State is the largest producer of charcoal from forests in the Amazon region. Not coincidentally, the main charcoal producers are located in the municipalities in Southeastern Pará, where intense in-migration was spurred by development policies for the Amazon, such as the opening of major highways (Belém–Brasília, Trans, PA-070 and PA-150) and the construction of a major hydroelectric plant, Tucuruí. This expanding charcoal production has also been fueled by the implementation of the Grande Carajás (PGC) mining project (and associated steel production), as well as tax incentives for agriculture, grazing, mining and logging activities, which all led to the opening of the agricultural frontier in this region and to the consolidation of a pattern of natural resource use based on the removal of native forests (MDA 2010).

In the municipalities of Marabá and Itupiranga, pig iron activities have been expanding for the production of rolled steel. Despite this growth, increased enforcement and pressure from environmental protection agencies against the use of illegal charcoal have led to the closure of several charcoal plants and consequently a drop in extractive charcoal production in the last 3 years (Santos et al. 2013). Charcoal from planted forests, mostly comprised of eucalyptus, is beginning to fill this local demand gap (MDA 2010).

3.3.3 Planted forests

Eucalyptus currently occupies roughly 9 million ha in Brazil (IBGE 2012a), which is similar to the area sugarcane occupies, and this area is likely to continue growing, given the rising demand for bioenergy in the mining and paper and pulp sectors. The other characteristic that sets eucalyptus apart from other sources of planted biofuels such as sugarcane and soybean is that it can be planted on much more marginal and climate-constrained lands with physical limitations, which are by definition cheaper. Thus, eucalyptus plantations continue to expand in the Cerrado onto lands otherwise overlooked by soybean and sugarcane farmers because of its capacity to adapt to marginal lands, characterized by low fertility or topographic conditions unsuitable for soybean, corn and sugarcane (interview ESALQ, 2013). As a result, this expansion tends to have a higher social cost since it often occurs on micro-regions with higher concentrations of smallholders (interview ESALQ, 2013). The complexities of the eucalyptus markets as well as the long timespan of production and high degree of informality in the charcoal sector, however, make both of these sectors very difficult to track and model.

The share of planted and native forests in timber production in Brazil has changed since 2000, when

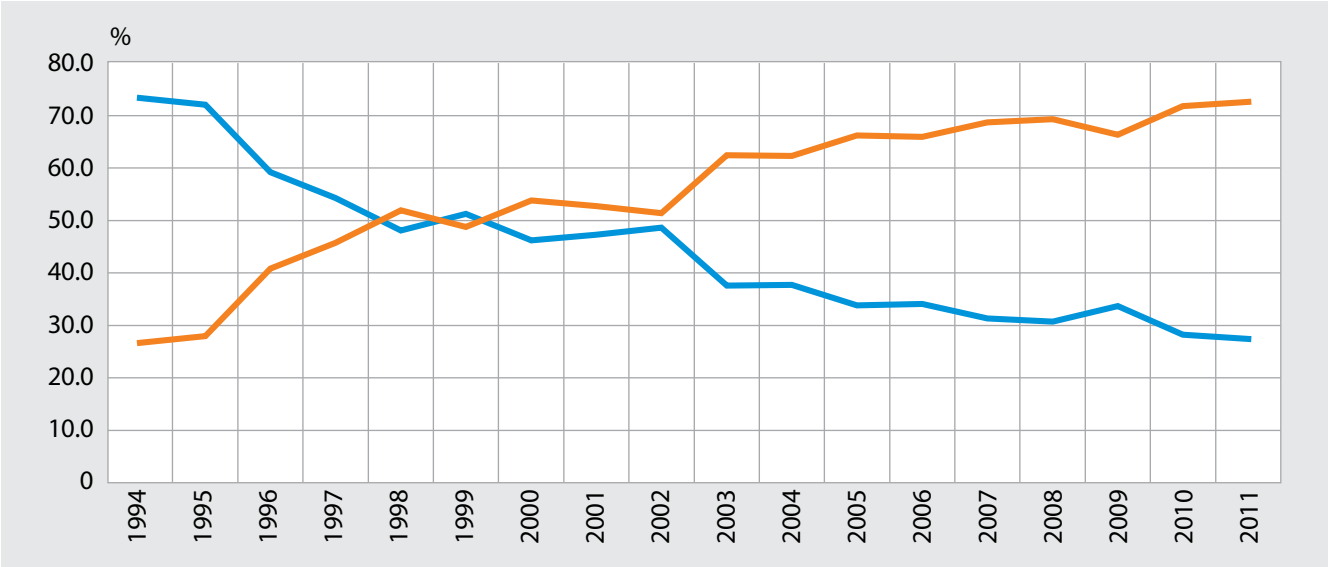

Figure 8. Share of planted (orange line) and native (blue line) forests in timber production.
Source: IBGE (2012a)

the production and share of planted forests in overall production greatly increased (Figure 8).

The need to meet the demand for steel and various sectors that use charcoal as an energy source resulted in a 19.7% rise in production compared to 2010 (in 2011 it produced 4.1 million tonnes). The main producing State was Minas Gerais (3.3 million tonnes, 81% of national production), followed by the states of Maranhão (353,000 tonnes) and Bahia (161,000 tonnes). Renewable energy sources account for 45.8% of total domestic energy production in Brazil, 10.3% of which relies on fuelwood (EPE 2012).

With an increase of 7.6% over the previous year, the amount of firewood in 2011 reached 51.7 million m^3. The States of Rio Grande do Sul (14.3 million m^3), Paraná (13.0 million m^3), Santa Catarina (8.3 million m^3), São Paulo (6.7 million m^3) and Minas Gerais (4.6 million m^3) are leading producers and together account for 91.2% of the national total (IBGE 2012a).

4 Key policies, their effectiveness and constraints

In this section, we describe and analyze three main sets of policies with direct impacts on land use in Brazil in terms of their effectiveness and constraints. First, we look at the mainstream, development-oriented policies, which include fiscal incentives for public investments in infrastructure and development projects, including the Growth Acceleration Program (PAC), rural development programs, tax incentives for the agricultural and energy sector and rural finance mechanisms. Second, we highlight social inclusion and conservation-oriented policies such as family farming, the Forest Code and those aimed at the establishment and management of conservation units. Lastly, we discuss environmental governance and climate change policies that have a potential for up-scaling or replication, including CAR, *Municípios Verdes* (Green Municipalities), *Bolsa Verde* (Green Grant), REDD+ mechanisms, and industry-led initiatives.

4.1 Mainstream development-oriented policies

In this section we present the main government policies aimed at spurring economic growth throughout the country: first, economic development, energy and infrastructure policies, including the Growth Acceleration Program (PAC, in Portuguese), which was set up in 2007 under the Lula administration and greatly expanded under the administration of Dilma Rousseff. Second, we examine biofuels policies and, third, the rural development policies implemented in the country.

4.1.1 Social and economic development

Over the last few decades, a series of social and rural development policies have played a pivotal role in reducing undernourishment to meet the World Food Summit goal of alleviating poverty and inequality throughout the country. Brazil has met its goal, by reducing undernourishment by 40% according to the World Food Summit, which dropped from about 22.8 million people in the period 1990–1992 to 13.6 million people in the period 2011–2013. (FAO 2013) Moreover, several authors have argued that agricultural modernization in Brazil, particularly technological innovation promoted by Embrapa based on increasing yields through plant breeding, mechanization and chemical inputs, has played a key role in reducing hunger worldwide and food-related inflationary pressures nationally (Pereira et al. 2013).

On the economic front, the BNDES (National Social Economic Development Bank), which has more funds to lend than the World Bank, greatly expanded investments in infrastructure (mainly hydropower plants, highways, petroleum and gas), up from USD 11.05 billion in 2003 to USD 79.8 billion in 2012. More specifically, from 2006 to 2011, BNDES promoted a massive increase in financing for several sectors of the economy, raising its portfolio from USD 309 million to USD1.2 billion in the mining sector, USD 698 million to USD 3.4 billion in agriculture and USD 1.9 billion to USD 12.3 billion in transport (BNDES 2013).

4.1.2 Growth Acceleration Program (PAC)

Over the last decade, besides keeping in place the basic macroeconomic foundations laid by their predecessor, the two administrations under the Worker's Party (Presidents Lula and Dilma Rousseff) have been steadily increasing investments, especially in transportation infrastructure and energy. The PAC has pledged investments in the order of BRL 1 trillion (roughly USD 434 billion) in infrastructure to these sectors, which are deemed strategic to sustaining economic growth and overcoming the crippling bottlenecks in the logistics needed for transporting and exporting agricultural and mining commodities (FIESP 2013).

Throughout this period, public sector investments have risen from 2.6% of GDP in 2003 to 4.4% in 2012. Under the Rousseff administration, the government has also fostered BRL 470 billion (roughly USD 240 billion) of private sector investments through new concessions for large infrastructure projects in 2012 alone, of which 242 were in the transport sector, 148 in electrical energy and 80 in the petroleum and gas sectors (MF/SPE 2012).

In its first 4 years, the PAC was the main factor in doubling public investments in infrastructure (up from 1.62% of GDP in 2006 to 3.27% in 2010) and helped to prop up employment figures during the peak of the economic recession. (MP 2013) Besides

providing direct investments through federal funding, one of PAC's key economic measures has been to provide tax incentives aimed at spurring private sector investments, especially in the following sectors: energy, semi-conductors, digital TV equipment, computers, inputs and services used in infrastructure works and steel framing (Lima et al. 2014).

More importantly, the government adopted a series of measures aimed at increasing access to credit, such as lowering interest rates and setting up funds for long-term loans through the Caixa Economica Federal and BNDES, including the Fund for Investment in Infrastructure that draws from a payroll tax, with an initial input of BRL 5 billion (USD 2 billion) plus BRL 12 billion (USD 5 billion) in the near future. Overall, such government projects will leverage a total of BRL 56 billion (USD 23 billion) in infrastructure investments in energy, railways, roadways, ports and sanitation (MF/SPE 2012).

An additional measure was the reduction of long-term interest rates from 9.75% per annum in 2005 to 6.5% in 2007. Moreover, the country's main development bank (BNDES) reduced its spreads on loans in infrastructure, urban development and logistics (i.e. railways, roads, airports, ports and terminals) (MF/SPE 2012).

Major infrastructure and energy projects are also seen as being underpinned by mainstream development policies benefitting corporate farming, mining and industrial interests, often at the expense of conservation and livelihoods of smallholders and traditional communities. Historically, transport infrastructure, particularly roadways, has been a key driver of deforestation and evidence suggests that the recent rise in deforestation has been linked to new highways being built in the southern amazon. Additionally, civil society groups have claimed that many of the infrastructure and energy projects under development in the Amazon basin have been pushing forth without adopting recommended social and environmental safeguards, often bypassing judicial rulings, such as in the case of the Belo Monte hydroelectric power plant (ISA, IPAM and IMAZON 2014).

4.1.3 Biofuels policies

The main arguments and policies supporting biofuels production in Brazil are grounded on notions of the country's aspirations to become a world leader in biofuel production, trade and technology, in addition to energy independence and territorial security, social and agrarian sustainability, and a solid environmental regulatory framework (Andrade and Miccolis 2010b). Indeed, energy security is one of the key arguments driving the expansion of ethanol and biodiesel production in Brazil, which favors domestic feedstock production to substitute fossil fuel derivatives. Preliminary data from Brazil's 2008 National Energy Balance indicates that sugarcane ethanol accounted for a historical high of 16% of the Brazilian energy mix in Brazil (EPE 2013).

Biofuel policy formulation is coordinated and drafted at the highest levels of the Brazilian Government: under the President's Office (CC/PR), through an advisory body (CNPE) and by two separate inter-ministerial councils, CIMA and CEIB, dealing with sugarcane ethanol and biodiesel, respectively. CIMA, the much smaller sugarcane ethanol council is led by the Agriculture Ministry and comprised of three other ministries: Development, Industry and Trade (MDIC), Mines and Energy (MME) and Finance (MF). Biodiesel policy making, on the other hand, is formulated and implemented by CEIB, an unlikely assemblage of government agencies led by the President's Chief of Staff Ministry, comprised of a wide range of ministries cutting across sectors and coordinated through the National Biodiesel Production and Use Program (PNPB). While regulated by the petroleum, gas and biofuels agency (ANP) and coordinated by the Presidency and the Ministry of Mines and Energy, biodiesel policies and programs are closely associated with agencies working on the other side of the spectrum, such as the Ministry for Agrarian Development (MDA), which coordinates policies aimed at smallholders and traditional communities, including land tenure and reform, family farming and technical assistance (Andrade and Miccolis 2011).

So while ethanol's long trajectory has been interwoven with sugar and agricultural policies, agencies and farmers, the much more recent biodiesel policies drafted in 2005 and nestled in the heart of the executive branch, have been coordinated and regulated by energy sector agencies (MME and ANP) but implemented and supported largely through agencies tackling rural poverty and social exclusion.

Additionally, the use of cellulosic subproducts of ethanol and biodiesel has been taking on increasing prominence in energy production thanks to Law 10438/2002, the National Program of Incentives for

Alternative Electricity Sources (PROINFA –*Programa de Incentivo a Fontes Alternativas de Energia Elétrica*). PROINFA supports the use of sugarcane bagasse as a renewable energy source for electricity production through co-generation. The first stage of this policy promoted the use of renewable technologies (specifically wind, biomass (co-generation) and small hydro) through incentives and subsidies. Once the first phase objectives were achieved, the second phase was aimed at increasing the share of renewables to 10% of annual energy consumption. Also in this phase, participating plants were required to issue Renewable Energy Certificates annually in proportion to the amount of clean energy they produced (Andrade and Miccolis 2011).

The first phase subsidies were funded through the Energy Development Account. Consumers pay into this account through higher energy bills (from which low-income sectors are exempt). To support this program, the Banco Nacional de Desenvolvimento Econômico e Social (BNDES, the Brazilian National Development Bank) has special financing available for these renewable projects as well (up to 70% of capital costs, excluding site acquisition and imported goods and services) at the basic national interest rates plus 2% of basic spread and up to 1.5% of risk spread, although no interest is charged during construction. PROINFA introduced 3300 MW of renewable energy by 2007, including wind, biomass cogeneration and micro-hydropower. By early 2005, the first phase was finished and 3300 MW were completed (1266 MW micro-hydropower, 655 MW Biomass, 1379 MW wind) (MME 2009).

Furthermore, government advocates for the expansion of sugarcane–ethanol have consistently cited scientific evidence attesting to the sustainability of sugarcane–ethanol with regard to environmental and energy benefits and job creation (Dolzan et al. 2006; MAPA 2006; Macedo 2007; BNDES and CGEE 2008; Walter et al. 2008). Backed by these studies, the Brazilian Government laid out policies through the Ministry of Agriculture, Ministry of Science and Technology and Ministry of Mines and Energy aimed at increasing the role of bioenergy in the energy mix and developing national and international markets for "clean fuels".

4.1.4 Socio-environmental impacts and land conflicts

In recent decades, economic and energy policies across different administrations in response to exogenous market forces and endogenous social and environmental dynamics were also instrumental in shaping the country's economic trends as well as its social and environmental landscapes. Indeed, over the past 30 years, the expansion of large-scale agriculture has played a decisive role in the national economy and, according to some studies, in local economies as well. A seminal study conducted by Mueller and Martha in 2008, which examined the socioeconomic impacts in regions where agribusiness most expanded in the Cerrados up to 2005, found that micro-regions with more dynamic agricultural expansion experienced much higher per capita GDP growth than others with lower levels of agricultural expansion, as well as significantly higher HDI indexes. Yet, the authors note that the considerable wealth generated was not evenly distributed, judging from their analysis of land concentration and demographic growth and opportunities in non-agricultural sectors, while also raising concerns about environmental impact.

Despite its undeniable impacts in bolstering local economies, others authors have also argued that the growth of agribusiness has had a myriad of negative social and environmental impacts stemming from land concentration, contamination of water resources due to pesticide and fertilizer use (Pignati et al. 2007), as well as soil loss and deforestation of native Cerrado and Amazon vegetation (Sawyer 2008; IBGE 2012).

While the last three federal government administrations have set up a range of programs aimed at alleviating poverty and targeting family farmers, social and environmental conflicts have also been rising where the expansion of agribusiness meets smallholders, indigenous and other traditional communities. These conflicts are seen by social movements, human rights groups and some scholars as an inheritance of the history of inequality and insecurity over land rights and tenure and as the main obstacles to more sustainable land use and equitable development (Fundação Oswaldo Cruz 2010; Rede Social de Justiça e Direitos Humanos 2011; CPT 2012; Fernandes et al. 2012).

A clear example of fiscal policies aimed at spurring development of the agricultural sector are tax incentives on imports and sales of chemical fertilizers (Lima et al. 2014). Although the increased use of fertilizers coupled with the development of new crop varieties and management techniques was instrumental to increasing productivity in the Cerrado regions, these finance mechanisms do not stimulate efficiency and proper management in

fertilizer use, the leading cause of GHG emissions in the agricultural sector. From 2005 to 2010, the use of chemical fertilizers was one of the causes of GHG emissions that most grew (35%) (MCTI 2013).

While the government has provided substantial subsidies to expanding agriculture, currently the main driver behind the conversion of native vegetation, it has also put in place over the years a series of measures aimed at regulating land use and conserving forests, as we shall see in the next section.

4.2 Land use and conservation-oriented policies

This section describes main land use and conservation-oriented policies, such as Terra Legal, CAR, the Forest Code and National System of Conservation Units (SNUC).

4.2.1 Land tenure policies

A basic tenet of land tenure rights in Brazil that has a great deal of influence on land-use patterns is that the law rewards farmers for direct land-use change by more readily granting titles to those who can show they are "farming the land", based on the basic principle enshrined in the Constitution and the Forest Code of the "social function" of land. The underlying logic of land tenure therefore poses a series of challenges for sustainable land use as it clearly provides direct incentives for farmers and land speculators to convert vegetation to pasture or other uses.

Increasingly, deforestation in the Amazon has become "a social issue" involving shifting cultivation, oftentimes on land under questionable tenure status. The new forest concession law is bound to help clean up the land tenure situation by granting ownership to large amounts of *terras devolutas* (lands with undefined ownership) through a step-by-step approach beginning with smallholders and ending in the creation of National Forests (FLONAS) aimed at sustainable logging concessions.

While private ownership of forests is permitted in Brazil, in practice, the complicated governance system surrounding land tenure has led to insecure tenure and disputes over land ownership, so much so that non-titled landowners can be evicted by more powerful players associated with regional oligarchies. Thus, insecure tenure makes people vulnerable to being dispossessed, giving them less leverage in relations with government and the private sector (Costenbader 2009). Insecurity in land and forest ownership has also undermined sound forest management since. Without secure rights, forest users have few incentives to invest in protecting forest resources over the long run, leading to higher rates of deforestation. The links between deforestation and land tenure status are undeniable as about three-quarters of rural properties in the Amazon region do not meet the requirements of the Rural Environmental Registry (CAR) because of non-titled land. (Barreto and Araújo 2010)

Under Law 11952 of 2009, the Ministry of Agrarian Development set up an initiative aimed at legalizing land tenure known as Arco Verde Terra Legal (Green Arc Legal Land), which drew together several ministries and federal agencies focusing initially on the 43 municipalities with highest deforestation rates in the States of Amazonas, Maranhão, Mato Grosso, Pará, Rondônia and Roraima. This initiative spun off into a wider program called Terra Legal Amazônia (Amazon Legal Land), also coordinated by the Ministry of Agrarian Development (MDA).

The main goal of this program is to provide land tenure security as a basic building block for enabling sustainable production models in the Legal Amazon. The target is to deliver land titles to 150,000 occupants (*posseiros*) of federal lands with undefined tenure status, i.e. excluding indigenous reserves, public forests, conservation units, marine reserves and military lands (MDA 2013). The program prioritized providing land tenure to legitimate occupants, especially smallholders and local communities, while at the same time avoiding lands considered to be occupied by speculators (*grileiros*) through an online and public-access registration system. However, the TERRA LEGAL program has faced a series of constraints leading to a slow pace of implementation, with over 94 million ha in the northern region still in this unclear tenure situation, although there is still an enormous gap in data on untitled land. While the Rural Environmental Registry (CAR) is intended to help fill this gap, implementation of CAR faces even greater challenges.

4.2.2 The Forest Code

In order to protect forests and their biodiversity and conserve water resources in different Brazilian biomes, the Brazilian Forest Code sets out two main types of mandatory protected areas on all private rural lands: Permanent Preservation Areas (PPAs) and Legal Reserves (LRs). PPAs are aimed at protecting water resources, soils and biodiversity, while also

serving as ecological corridors in the wider landscape. They are comprised of riparian zones along all water bodies, steep slopes, high altitude areas and hilltops with the sole purpose of conservation and must therefore be covered predominantly by natural vegetation. LRs are required on a portion of all private rural land and their exact location is suggested by the landowner and approved by an official environmental agency, where natural vegetation should also be kept for biodiversity conservation and ecosystem services. Some productive uses are permissible in these areas, provided they can be combined with natural vegetation preservation. In the Legal Amazon Region, the LR requirement varies. Currently, the percentage of legal reserve requirement varies per eco-region in Brazil: 80% in the Amazon biome, 35% in stretches of Cerrado located within the Legal Amazon and 20% throughout the rest of the country. With the revamped Forest Code passed in 2012, the federal government forgave part of the illegal deforestation carried out up to July of 2008, thus encouraging farmers to continue illegal deforestation in the future as they await for new amnesties.

Upon issuing new land titles, landowners are obliged to map out and commit to preserving — and recovering in the case of degraded lands — these two parts of their land (Brazil 1981). The principles and provisions established in 1981 under the National Environmental Policy and regulated through a series of National Environmental Council (CONAMA) resolutions oblige projects expected to have substantial environmental impacts (such as agribusiness and biofuels) to obtain environmental licenses through a cumbersome set of procedures, which are considered inaccessible for smallholders due to their high expense and technical complexity (Wilkinson and Herrera 2008). Deforestation and the use of fire as a management practice also require official authorization under the environmental legislation.

While these provisions in the law are extremely difficult to enforce in vast swaths of hard-to-reach lands, especially in the Amazon region, they do stand as substantial constraints to expanding agribusiness and biofuels, especially for small-scale farmers and traditional communities (Andrade and Miccolis 2010a). In order to enforce the Forest Code, some command and control mechanisms using satellite imagery tools, such as the Project for Conservation and Use of the Brazilian Biological Diversity (PROBIO) and Program of Amazon Forest Monitoring by Satellite Imagery (PRODES), which monitors deforestation in the Amazon biome, have proven to be quite effective (MMA 2013b).

By all accounts, it is likely that the new Forest Code will ultimately protect less native vegetation in private lands than the old code, mainly because it has lifted the requirement for family farmers to restore their legal reserves, while also providing amnesty for landowners who cleared their land before 2008 as long as they commit to restoration plans (SFB 2013). Here, one must highlight the distinction between the Amazon, where the main issue is enabling compliance with existing policies and the Cerrado, where new measures need to be put in place to increase protection of native vegetation.

The lower level of protection for the Cerrado also applies to the semi-arid region known as the Caatinga, which comprises most of the northeastern region and parts of MATOPIBA. So as the federal government has been ratcheting up efforts to stop illegal deforestation in the Amazon, vast swaths of Cerrado can be legally deforested to clear land for soybean, sugarcane, cattle or eucalyptus. Indeed, the lion's share of agricultural expansion is occurring precisely in this eco-region and in MATOPIBA (Macedo et al. 2012; CONAB 2013; IBGE 2013).

It is likely that growers will face enormous challenges to comply with the new Forest Code. One of the main constraints for compliance is lack of knowledge and varying interpretations about its various provisions and implementation mechanisms. Thus, the Federal Government and other local level government agencies must provide accurate information to farmers about how to improve management practices. The other key challenge is providing the government agencies at both a state and federal level the necessary resources to expedite implementation.

4.2.3 Environmental Rural Registry (CAR)

The key mechanism for enforcing the new code is The Environmental Rural Registry (CAR), comprised of an electronic registration system drawing together information on protected areas on private lands as required by law, namely PPAs and LRs, data on forests and native vegetation, as well as human occupation and activities. Rural properties have until 2015 to be registered in this geo-referenced system, which will be required for issuing any environmental licenses, while also allowing state and federal environmental agencies to compare stated vs. actual land use through satellite images. The CAR is thus a flagship of the new

Forest Code since it seeks to finally get a handle on the land use situation in order to promote compliance with environmental legislation on millions of hectares throughout the country.

CAR implementation will require building sizeable and sustained efforts to strengthen the capacity of States and federal agencies, since most state and even federal agencies charged with this gargantuan undertaking do not have the capacity (both in terms of staffing and basic infrastructure) to do so effectively (CI 2014). According to a study on the implementation of CAR conducted in April of 2014, only three States, Acre, Rondônia and Tocantins, have adapted their forest regulations to the new code laws until April of 2014 and only Acre and Rondônia instituted their Environmental Regularization Programs (PRA in Portuguese) through specific laws, which does not mean they are being implemented (CI 2014). With regard to funding of CAR, this study shows that only the States of Amazônia, Pará and Rondônia have earmarked funding from state budgets and none stated having staff working on CAR on a full-time basis, although most States intend on hiring service providers to analyze and validate CAR applications. Moreover, the States lack a wide-reaching training programs, which when they do exist are isolated initiatives mostly restricted to State environment secretariats (CI 2014).

The top state with regard to number of CAR applications in the system is Pará, with anywhere between 36% and 49% of all rural properties, followed by Mato Grosso, which has roughly 30% of all properties enrolled and Rondônia, with just over 9%. The other six Amazonian states are all still lagging behind and have yet to enroll a single property in their systems. Overall, validation of the CARs, which requires on-site inspections, is even further behind, with merely 17% validated in Mato Groso and only around 1% in Pará, although they are the two leading states in this regard (CI 2014). The study also concludes that the federal and state governments still lack a clear strategy for implementing the new regulations of the Forest Code.

The likely delays in the implementation of CAR call for setting up economic incentives for restoring degraded lands, which currently does not reap any economic returns for farmers. The new Forest Code actually establishes that such incentives need to be created but so far they have not, with the notable exception of an *ex-situ* compensation mechanism that is already being operated by the Bolsa Verde do Rio de Janeiro (BVRIO). This mechanism enables farmers who have exceeded their own LR requirements to sell Environmental Reserve Quotas to other landowners in the same biome who are unable or unwilling to do so. As suggested by Soares-Filho (2013), this mechanism, once fully operational throughout the country, may help to offset a significant portion of the environmental liability left by the new Forest Code.

4.2.4 The National System of Conservation Units (UCs)

In 2000, landmark legislation (Law No. 9.985 of July 07, 2000) established the National System of Conservation Unit (SNUC, in Portuguese). In Brazil, protected areas are regulated by the SNUC, which encompasses all federal, state and municipal protected areas. As the main strategy for the conservation of forests and other natural resources, Conservation Units (UCs, in Portuguese), which are considered a separate category of land in Brazil, can include both public and private lands, although the vast majority lie on public lands. The system includes 12 categories of protected areas divided into two groups according to land use and management strategies: those under full protection and those allowing sustainable use of natural resources (MMA 2007) (Map 3).

It is important to highlight that use rights for forest resources in some public areas are granted to communities, as is the case of indigenous lands, extractive reserves, sustainable development reserves, agrarian reform settlements and some national forests. In the case of private forests, the landowner holds the right to explore the forest resources, with some exceptions, although communities may also hold the right to explore non-timber forest products in private areas under specific laws such as Babaçu nuts in Maranhão State, for instance. However, forest management must always be licensed by the government, even in privately owned forests.

Additionally, the SNUC establishes a specific governance mechanism aimed at facilitating the complex task of coordinating disparate stakeholder interests and viewpoints on environmental conservation. Known as the Management Council, this mechanism is mandatory on UCs and provides a forum at the local level for bringing together sectoral and community representatives for consensus-building on conservation goals and exploring management alternatives.

Map 3. Conservation Units in Brazil. Biomes in Brazil.
Source: Based on information provided by MMA http://mapas.mma.gov.br/i3geo/datadownload.htm

Nationwide, forest areas under protected and "sustainable forest estate" areas have increased and reached a total of about 750,000 ha in 2010. Additionally, the number of UCs as well as their total area has also increased to a total of roughly 300, in the same year. In the Amazon, from 2004 to 2012, protected areas in UCs and indigenous lands expanded by 68%, encompassing 47% of the entire Brazilian Amazon region (Nepstad et al. 2014). As noted above, however, despite this national trend, some protected areas in the Amazon have been reduced to make way for large infrastructure projects and only 8.1% of the Cerrado is covered by protected areas, with only 3.1% in the strict protection category (MMA 2014b).

Despite their overall effectiveness in conserving sensitive ecosystems compared to other areas, overall, UCs face a series of constraints, including understaffing and underfunding for surveillance, enforcement and maintenance, lack of management plans or difficulties implementing them and encroachment by many of the drivers mentioned above, including ranching, farming, mining, poaching and logging (WWF 2014). Similarly, indigenous lands, which are a separate category apart from Conservation Units, are deemed quite effective at conserving native forests and grapple with many of the same threats from outside their lands as UCs. Many indigenous territories still face lengthy processes for legally recognizing their lands and expropriating occupants (ISA 2014).

4.3 Climate change and environmental governance policies

This section provides an overview of key climate change and environmental governance policies: the National Climate Change Policy and its several programs including PPCDAm, PPCerrado, state-level plans and the ABC program. Then it analyzes CAR, a municipal-level environmental governance initiative called Green Municipalities and a payment for environmental services program known as *Bolsa Verde* (Green Grant).

4.3.1 The National Climate Change Policy

The PNMC was established in 2009 under Law 12.187/2009. This policy laid out Brazil's voluntary commitment of reducing GHG emissions by 36.1–38.9% compared to projected emissions by 2020, according to the baseline of 3236 GtCO2-eq. This means absolute emissions reductions between 1168 GtCO2-eq and 1259 GtCO2-eq (Brasil 2010). Spearheaded by an interministerial committee on climate change and its executive group, the PNMC is implemented through the national climate change plan and the national climate change fund, as per the Brazilian communication to the UNFCCC (Brazil 2010).

Table 6 summarizes Brazil's Climate Change Policy commitments aimed at reducing emissions from deforestation and land-use change (through PPCDAm and PPCerrado) and from the agriculture sector (ABC).

Box 2. National climate change plan: Targets

Among the chief targets set forth in the national climate change plan, one might highlight:

- Reducing annual deforestation rates in the Amazon biome by 80% by 2020 (as per Decree no. 7390/2010) and by 40% in the Cerrado biome;
- Increasing domestic ethanol consumption by 11% over the next 10 years;
- Doubling the area of planted forests to 11 million ha in 2020, including 2 million ha planted with native species;
- Increasing the supply of electric energy through co-generation, especially from sugarcane bagasse, to 11.4% of the total supply of electricity in the country by 2030;
- Replacing 1 million old refrigerators per year with new, more efficient ones over 10 years;
- Increased recycling of solid urban waste by 20% by 2015;
- Reducing non-technical losses in electrical energy distribution at the rate of 1000 GWh per annum over 10 years.

Table 6. PNMC commitments to reduce emissions from land-use change and agriculture.

Issue	Goal and target	Strategy or action plan	Status of implementation
Land-use change: Deforestation rate in the Amazon	80% reduction in deforestation rate in the Amazon compared to the annual average in 1995–2006	PNMC – 2009 PPCDAm – 2009 REDD+ Amazon Fund CAR	In the Amazon region, some command and control tools such as PRODES and DEGRAD/INPE led to a visible reduction in the deforestation rate since 2008.
Land-use change: Deforestation rate in the Cerrado	40% reduction in deforestation rate in the Cerrado between 2008-2020, compared to the deforestation average in 1999–2008	PNMC – 2009 PPCerrado – 2009	In the Cerrado region, implementation of command and control tools such as PMDBBS/IBAMA
Land-use change: Recovering of degraded pasture	15 million ha from 2008 until 2020	ABC	77% of funding (3.4 billion overall) spent on this component but no results on implementation published yet
Crop–livestock integration. Crop–livestock–forestry integration. Agroforestry systems	4 million ha from 2008 until 2020	ABC	No results on implementation published yet
No-till planting	Adding 8 million ha	ABC	Since it started it has already added 6 million ha.
Biological nitrogen fixation instead of use of chemical fertilizers	5.5 million ha	ABC	Still needs improvement in the substitution, demand, research
Planted forests	3 million ha	ABC	Not measured yet

Source: Adapted by the authors from MMA (2013d)

In order to gauge the effectiveness of the national climate change policy, in the next section we analyze the main programs aimed at reducing emissions in the agricultural and forestry sector: PPCDAM, PPCerrado and ABC.

Program for Combating Deforestation in the Amazon (PPCDAm)

Following alarming deforestation rates in the Amazon during the 1980s–1990s, in 2003, the Federal Government set up a Permanent Interministerial Working Group (GPTI, in Portuguese) comprised of seventeen ministries to propose and coordinate actions aimed at reducing deforestation in the Amazon through the PPCDAm, which cut across several other programs. Until March of 2013, the *Casa Civil* (Chief of Staff Ministry under the Presidency of the Republic) led the group, after which the Ministry of Environment took over coordination. The new model of governance adopted for Phase 3 (2012–2015) is divided up into main three branches: (1) executive (2) consultative and (3) transparency. This governance structure was built on the demand for continued monitoring of implementation so as to enable changing course, decision-making by the Ministry of Environment and resolving conflicts that may arise among federal agencies and between federal and state agencies (MMA 2013e).

While acknowledging that the PPCDAm was a pivotal conservation policy, some studies found that the decline in Amazon deforestation coincided with fluctuations in commodity markets and the implementation of market-based initiatives, besides the command and control improving monitoring and enforcement, finance policies aimed at restricting credit for deforesters and excluding them from supply chains. (Macedo et al. 2012; Rosa et al. 2012; Assunção et al. 2013; Nepstad et al. 2014).

Judging by deforestation rates, which fell by 77% from 2004 to 2010, PPCDAm might be considered extremely effective. Two main driving forces behind this astonishing drop were: the implementation of a real-time monitoring system called DETER coupled with beefed-up enforcement activities, on the one hand and lower commodity prices on the other (Soares-Filho et al. 2010; MMA 2013d; Nepstad et al. 2014). Prior to the activation of DETER, Amazon monitoring depended on voluntary reports of threatened areas, making it difficult for the federal environmental enforcement agency IBAMA to locate and access deforestation hotspots in a timely manner (Assunção et al. 2013). With the adoption of the new remote sensing system, however, IBAMA was able to better identify, more closely monitor and more quickly act upon areas with illegal deforestation activity. As a result, an increase in the number of fines applied in a given year tended to reduce forest clearings the following year (Soares-Filho et al. 2010).

Overall, after the adoption of DETER-based monitoring, an increased IBAMA presence helped avoid approximately 59,500 km^2 of forest clearings in the Amazon from 2007 to 2011. Based on deforestation actually observed during this period, which totaled 41,500 km^2, recorded deforestation was 59% lower than it would have been in the absence of the policy (Rosa et al. 2012). In this case, observed deforestation was 75% lower than total estimated deforestation for the same period. These results indicate that near real-time monitoring and law enforcement activities have a substantial deterrent effect on deforestation (Nepstad et al. 2014).

PPCDAM's component on territorial ordering and land tenure made significant progress in recent years, including the creation of 25 million ha of new municipal, federal and state-level conservation units at the federal level located on the deforestation frontier. Other measures included fencing and proper identification of units around the indirect area of influence of the BR-319 highway, regularization of 10 million ha of indigenous lands, drafting of ecological economic zoning for the Legal Amazon and mapping of 25,628 rural properties in the land tenure program known as Arco Verde Terra Legal.

Under its Environmental Monitoring and Control Component, the program established DETER, with deforestation alerts and improvement of the PRODES satellite system. Enforcement was bolstered by drawing together the army, federal police, federal highway police and public security national force in partnership with IBAMA in the planning and implementation of the surveillance operations in the region, resulting in 649 surveillance operations, total fines of BRL 7.2 billion and seizing of 864,000 m^3 of timber (Assunção et al. 2013). Additionally, about 600,000 ha of areas had operations shut down due to infractions, with restriction of public credit to projects linked to illegal deforestation under Brazilian Central Bank Resolution No. 3.545/2008 (Assunção et al. 2013).

Despite these gains, after four consecutive years of declining deforestation rates, in late 2013 the

environment ministry released new figures showing a 27.8% rise in deforestation in the Amazon from August 2012 to July 2013, compared to the same months in the previous year. According to a recent report, some of the causes of this recent spike are: a rise in illegal deforestation, the effect of major infrastructure projects without the necessary environmental safeguards and land speculation (ISA, IPAM and IMAZON 2014). An underlying cause is also the new Forest Code and associated uncertainties with regard to its regulations and the amnesty granted to landowners who deforested up until 2008, both of which tended to spur new land clearings (Assunção et al. 2013; Nepstad et al. 2014).

So while the federal government has clearly made very impressive progress in reducing deforestation by ratcheting up command and control policies in the context of the Amazon through real-time satellite monitoring systems and associated enforcement activities, there are still lingering questions about the extent to which the effectiveness of these measures will be maintained as deforestation has shifted from large-scale to small-scale farmers (Godar et al. 2014).

Program for Combating Deforestation and Forest Fires in the Cerrado (PPCerrado)

Although much more attention has been paid to the Amazon biome internationally, the Cerrado (also known as the Brazilian central savannahs) is also considered a biodiversity hotspot due to its abundance of wildlife and phenomenal biological diversity, with 11,627 native plant, 199 mammal, 837 birds, over 1200 fish, 180 reptile and 150 amphibian species (MMA 2011, 2013d). Moreover, it is home to the headwaters of three of South America's major river basins (Prata, Tocantins/Araguaia, São Francisco), thus it is often dubbed Brazil's "water tank" due to its importance for water resources (MMA 2013d). As large-scale agriculture has expanded throughout the country, the main new frontiers of growth have been in the Central-Western region, home to most of the Cerrado, as well as in the transition zones between the Cerrado and Amazon biomes and between the Amazon/Cerrado and dryland forests of the Northeast (MATOPIBA).

As mentioned earlier, while Brazil has made outstanding progress over recent years in reducing deforestation in the Amazon by stepping up command and control, among other climate change and forestry policy measures, a growing body of scientific evidence shows direct and indirect linkages between the expansion of agribusiness, especially sugarcane and soybeans in the Cerrado and deforestation associated with displaced cattle herds, among other factors. (Lapola et al. 2010; Arima et al. 2011; Andrade de Sá et al. 2013; Correa 2013). Other studies have pointed to recent deforestation in the Cerrado biome due to soybean and pasture expansion farther east and northeast in the biome, particularly in the States of Bahia, Maranhão, Piauí and Tocantins (Brannstrom 2009; IBGE 2013), although it is unclear whether these trends reflect iLUC from the southern Amazon. Cumulative deforestation left only 51.5% of the original Cerrado biome, 1,036,877 km^2 (MMA 2010) compared to roughly 80% in the Amazon.

The PPCerrado was created in 2010 as the main instrument for coordinating federal and state government actions aimed at preventing and controlling deforestation in the Cerrado biome. The plan is implemented through institutional arrangements involving federal and state agencies working in the biome and high-level representatives of civil society organizations. A key part of PPCerrado is the component on protected areas and environmental and territorial ordering (land-use planning), which aims to promote sustainable land occupation and use, including the creation and strengthening of protected areas, the demarcation of indigenous lands, water resources planning and development of the ecological–economic macrozoning. Up until recently, the ecological–economic zoning has been performed at a state level or agroecological zoning has been aimed at one specific crop. In this zoning for the Cerrado, the strategic areas targeted as initial priorities are the existing remnants of Cerrado vegetation in Southwestern Bahia, Maranhão, Piauí and Tocantins. GIS tools enabled selecting areas of high importance that indicated priority areas for the creation of protected areas and environmental inspection actions (MMA 2011).

PPCerrado has another component on fostering sustainable development activities, which aims to support a transition from the current model of land-use development based on deforestation and conventional agricultural practices to one that incorporates principles of sustainability, soil conservation, maintenance and improvement of organic matter in the soil and the diversification of economic activities on the property. Here, "sectoral pacts" are being established with the productive sector, such as the agricultural and mining/steel pact (MMA 2011). Despite such promising initiatives, there is still insufficient data to ascertain its effectiveness.

Low-carbon agriculture plan (ABC)

The analyses of the Brazilian emissions profile conducted in the Second National Communication (Brazil 2010) and preliminary data launched in 2013 (MCTI 2013) showed a trend whereby agricultural and ranching activities have surpassed land-use change as the main source of emissions, prompting the federal government to search for technological solutions for curbing emissions in this sector. In 2010, the Ministry of Agriculture established the sectoral plan for climate change mitigation and adaptation for solidifying a low-carbon emission economy in agriculture, known as the ABC program through Decree No. 7.390/2010 with the aim of organizing and planning measures to increase the adoption of low carbon production techniques (MAPA 2013).

Spanning from 2010 to 2020, the plan is supposed to be updated biannually. The federal government has forecasted funding in the order of BRL 197 billion (roughly USD 90 billion) to implement the ABC plan over this 10-year period, including grants and lines of credit, which will amount to the lion's share of the program (around BRL 157 billion, about USD 65 billion and entail approximately BRL 33 billion (USD 13.75 billion) in subsidies through lower interest rates, known as 'equalization', around 5% per year through federal funding (MAPA 2013). The maximum amount per loan is BRL 1 million (USD 400,000) (MAPA 2013). In 2010/2011, when the ABC's actions began operating on the ground, it funded approximately BRL 2 billion, reaching BRL 3.15 billion in 2011/12 and BRL 3.4 billion in 2012/13 (Assad 2013).

Initially, the main thrusts of the program were reducing deforestation stemming from livestock (mainly cattle), especially in the Amazon biome, recovering degraded pastures throughout the country, increasing adoption of no-till farming and enhancing biological nitrogen fixation. The main criteria for adopting these measures were scale, economic importance and high degree of efficiency in reducing GHG emissions, most notably methane, carbon dioxide and nitrous oxide. The ABC program established finance mechanisms that innovated by providing loans for production systems per se as opposed to just targeting credits for products or value chains (Assad 2013).

While implementation of ABC is still insufficient to measure impacts and ascertain whether goals will be met, the first major evaluation drew out some important lessons (Assad 2013). Among the key constraints to the implementation of ABC, Assad (2013) highlights difficulties in political coordination between the Agriculture Ministry (MAPA) and State agriculture secretariats (SEDRAF) in managing the funds. In Mato Grosso State, where the main champion of ABC should be the state government, the Embrapa Agrosilvapastoral Center has actually played an important role in implementation (Assad 2013).

Another major issue is that the plan is not reaching the regions that most need it, the North and Northeast, due largely to a lower capacity for implementation among state and local agencies in these regions. The fact that many of the borrowing

Box 3. ABC implementation barriers

According to Assad (2013), who coordinated the most comprehensive assessment of this program to date, the main barriers to expedite the implementation of the ABC plan are:

- lack of economic, financial and managerial structure for farmers to adopt sustainable production systems;
- lack of public and private skilled technical assistance services with high capillarity for farmers (municipal level);
- difficulties in accessing rural credit due to many regulatory requirements by the banking sector, as in the case of the ABC program;
- insufficient knowledge and poor dissemination of the ABC plan and program;
- ABC is not a high enough priority and there is lack of commitment from state governments for implementation at the state level, which is reflected in the low inclusion of the ABC plan within state climate change policies;
- there are other more advantageous credit lines, particularly for family farmers and regions with specific constitutional funds;
- lack of facilities, especially in the private sector, to conduct soil analyses, especially in the measurement of total carbon. There is a need to create special credit lines to purchase equipment for such analyses to abide by the plan's standards;
- the financial agents and others responsible for implementing the ABC plan are still not sufficiently onboard;
- increasing the adoption of the technologies outlined in the ABC plan also depends on increasing the participation of NGOs due to their important role in development processes in Brazil.

companies are headquartered in the South but actually operate in the North might disguise the reality on the ground and lead to a somewhat erroneous impression about the disproportionate geographic distribution of implementation (interview MAPA staff, 2014) Overall, though, it is clear that the available data is still insufficient to make a precise assessment of ABC's implementation. This is partly due, according to MAPA (interview, 2014), to the need to harmonize — and gain more detailed access to — the data detained by lending institutions.

Furthermore, while the ABC approach is groundbreaking for financing more sustainable production systems as opposed to single crops or their value chains, the program is still highly production-oriented and does not provide direct incentives for maintaining or restoring native ecosystems. Although funding increased substantially in recent years, ABC still occupies a marginal role in the overall agricultural financing landscape and uptake of funding through ABC is still low because the economic incentives provided are still not as attractive as some other lines of finance aimed at more conventional farming methods. Low uptake can also be attributed to the governance mechanism established for implementation whereby the State governments should play a key role but are sometimes hesitant to do so.

4.3.2 The Amazon Fund

The main national financing mechanism for Reducing Emissions from Deforestation and Degradation (REDD) is the Amazon Fund, with roughly USD 1 billion pledged largely by the Norwegian government and much smaller contributions by the German government and Petrobrás and is restricted to the Amazon biome. While pioneering in its scope and ambitious in targets for reducing emissions, it is still too early to ascertain the extent to which the Amazon Fund will meet its targets, especially given the slow pace of project approval and implementation (BNDES 2012).

It is also uncertain to what extent its project-based approach will have meaningful impacts on reducing emissions given the scale of deforestation that still persists in the Amazon and considering that the vast majority of deforestation (around 80%) is currently concentrated on plots smaller than 25 ha (BNDES 2012). A study by Godar and colleagues also suggests that smallholders contributed "less in both relative and absolute terms to the deforestation slowdown" in Brazil (Godar et al. 2014). Smallholders seldom have access to such mechanisms due to their unclear land tenure status and lack of access to environmental licensing procedures, which is a minimum requirement for projects to be funded through the Amazon Fund. Acknowledging this reality, the fund managers have amended guidelines to encourage new projects to target more on-the-ground projects seeking alternatives to deforestation among smallholders (BNDES 2012).

Nonetheless, the federal government has yet to establish a national REDD agency and generally seems averse to market-based approaches to REDD, preferring a centralized national model. In light of the constraints for implementing compliance with the new Forest Code mentioned above, a REDD-type mechanism for compensation, such as *Bolsa Verde do Rio* – BVRIO (Rio's Green Stock Exchange), the federal *Bolsa Verde* (Green Grant) program and other PES initiatives, as discussed below, may be a more effective means for compliance with the Forest Code through *ex-situ* restoration.

4.3.3 Green municipalities

In 2007 and 2008, the federal government issued a series of decrees and norms (Presidency of the Republic 2007, Decree 6321/2008, Portaria MMA 28/2008, Portaria MMA 102/2009, Portaria MMA 138/2011, Resolução Bacen 3, 545/2008) aimed at combating deforestation in the Amazon by restricting credit to activities associated with illegal deforestation, holding entire value chains accountable for illegal deforestation, especially logging and cattle, issuing hefty fines and shutting down illegal operations, while also setting up a blacklist of perpetrators of deforestation and municipalities (initially 43) with critical levels of deforestation (Guimarães et al. 2011). This list of municipalities has been used as a key input for resource allocation through the Amazon Fund and prioritization of enforcement activities under PPCDAm.

These command and control and regulatory initiatives prompted two municipalities, Paragominas, Pará State and Lucas do Rio Verde in Mato Grosso, to develop a program called "Green Municipality", which aimed initially to get the municipalities off the blacklist and recover their tarnished reputation, but ended up going much further (Guimarães et al. 2011). In both cases, the program was enabled through partnerships and agreements between NGOs (TNC and IMAZON), the municipal government, farmers, ranchers and other stakeholders at the local level.

In a nutshell, this program is an innovative governance mechanism aimed at reducing deforestation and promoting more sustainable value chains at the municipal level by bringing stakeholders together to establish natural resource and land use management pacts and by providing technical assistance for the adoption of more sustainable production techniques, coupled with land tenure and environmental regularization. Such a co-management natural resource governance mechanism is enabled by pooling public and private resources to implement existing provisions for environmental protection under the Forest Code, such as legal reserve and permanent preservation areas and leveraging licensing mechanisms such as the Rural Environmental Registry - CAR, for instance, but also by increasing adoption of sustainable forest management, agricultural and grazing practices (Guimarães et al. 2011).

4.3.4 *Bolsa Verde* (Green Grant)

Known officially as the Program for Supporting Environmental Conservation, *Bolsa Verde* was launched by the federal government in 2011 based on a similar state-level program first implemented in Amazonas State, housed under the *Brasil Sem Miséria* (Brazil Without Extreme Poverty) program, which is coordinated by the Ministry of Social Development, *Bolsa Verde* targets families considered extremely poor (earning less than BRL 70 per month (approximately USD 30) per capita who live in national forests, extractive reserves or sustainable development reserves, indigenous lands and land reform settlements or on lands occupied by riverine, traditional or maroon communities. Initially, the program was restricted to the Legal Amazon but it is recently being adopted nationwide.

Beneficiary families receive 300 BRL (USD 125) on a quarterly basis as a payment for environmental service for a 2-year period that can be extended provided they continue conserving forests, which is monitored through satellite and remote sensing (DETER and SIPAM) and periodic visits to a sample of families (MMA 2013d). By March of 2013, the program had benefitted 36,844 families, of which 11,214 were in sustainable development conservation units (30.4%), 23,954 in land reform settlements (65%) and 1,676 in riverine areas (4.5%) (MMA 2013c).

According to recent data (December of 2013), the Bolsa Verde program has spent approximately USD 30 million since it began in 2011, including 51,200 families in 65 conservation units, 767 land reform settlements and 57 municipalities. The majority (75%) of these beneficiaries are located in the north of Brazil, mostly in Pará State and more than 70% in land-reform settlements (Guimarães et al. 2011; MMA 2014).

4.3.5 Market-based initiatives

Several initiatives led by the private sector are also worth noting as ways forward for more sustainable land use and bioenergy production. In addition to the soybean moratorium and soja plus, which aims to promote a sustainable supply chain in the soybean sector through social–environmental assessments and compliance with basic sustainability guidelines, major companies have also joined hands in the wider Working Group on Sustainability in Agribusiness (*Grupo de Trabalho de Sustentabilidade no Agronegócio*). Such initiatives are attempts to assuage pressures from environmental NGOs and consumers, both in Brazil and abroad.

A similar trend is occurring in the country's burgeoning oil palm sector, where major companies setting up shop in Pará State are seeking means to quiet voices of critics who claim the expansion of oil palm is having deleterious social and environmental impacts by implementing standards such as RSPO. ADM, for instance, has claimed that all of its plantations and outgrowers will be RSPO-certified.

In the ranching sector, major companies set up the Working Group on sustainable Ranching (GTPS). In a recent development, some companies have been taking concrete steps to clean up the reputation of Brazilian cattle. One example of this trend is a recently launched initiative led by the country's three largest beef companies, JBS, Marfrig and Minerva, which opened their books to external audits examining their supply chains for suppliers causing deforestation and compliance with the so-called "Cattle Agreements" (Acordo de Gado) (Greenpeace 2014; GTPS 2014).

The soybean moratorium

The initiative was launched in 2006 by the country's two main industry associations, ABIOVE, the Brazilian Association of Vegetable Oil Industries and ANEC, the Brazilian Association of Grain Exporters, which together represent 94% of the soybean produced in the country. They then invited key environmental NGOs, Greenpeace, WWF, IPAM and TNC and established a voluntary commitment obliging member companies to not purchase any soybean cultivated on lands deforested after July 2006 (Andrade and Miccolis 2010a).

In order to monitor and make decisions on the implementation of this pact, the signatories set up the soybean working group, comprised of representatives from the soybean industry: ABIOVE, ANEC, ADM, Amaggi, Bunge, Cargill and from NGOs in the *Articulação Soja-Brasil*: Conservation International, Greenpeace, IPAM, The Nature Conservancy, WWF Brazil and IMAFLORA (ABIOVE 2013). Since then, the initiative has also received support from the Ministry of the Environment and Banco do Brasil. Initially designed for a 2-year period, the moratorium has been extended several times and, more recently, up until the end of 2014, which will reportedly be its last year.

According to the working group's latest report, from 2007 to 2012, 62 municipalities in three states (Mato Grosso, Pará and Rondônia) that account for 97% of soybean planted in the Amazon were monitored through flyovers and analysis of INPE satellite images. Only 0.7% of all the deforestation in these three states was associated with soybean cultivation (GTS 2013). This initiative has been widely hailed as successful by industry groups, environmental NGOs and buyers in Europe. The new mechanism currently being designed to replace the soybean moratorium after 2014 will most likely be based on the rural environmental registry system — SICAR, the system for registering CAR.

Sustainable ranching working group (GTPS)

As the main industry-led initiative in the ranching sector, the GTPS was formally set up in 2009 by representatives of different links in the cattle sector value chain, including ranchers' associations, retailers, input companies, banks, civil society organizations, research institutions and environmental NGOs, including many of the same involved in the soybean working group (WWF, TNC, IPAM, among other national NGOs) and international organizations such as the Global Roundtable for Sustainable Beef, Solidaridad and the National Wildlife Federation (NWF).

The main goal of the GTPS is to "debate and formulate, in a transparent fashion, principles, standards and practices to be adopted by the sector that contribute to the development of sustainable, socially just and environmentally friendly ranching". The GTPS took on the commitment of zero deforestation and restoration of 15 million ha through and agreement signed with the agriculture and environment ministries and Embrapa with the aim of achieving the goals in the national climate change plan (GTPS 2014).

Launched in 2013, its flagship Sustainable Ranching in Practice program is comprised of seven initiatives aimed at increasing adoption of sustainable management practices in the states of Mato Grosso, Mato Grosso do Sul, Pará, Rondônia and Bahia. One of these initiatives, known as the Sustainable Beef Project, which is being implemented by The Nature Conservancy (TNC) in São Felix do Xingu, Pará State, is drawing together ranchers with Marfrig (a major beef company) and Walmart to encourage management practices that aim to reconcile increasing yields with forest conservation, while also raising consumer awareness (TNC 2014).

The group's underlying principles include: constant improvements; transparency and ethics; best farming and grazing practices; and supporting compliance with the law. The group has established global partnerships with the Global Roundtable for Sustainable Beef (GRSB), with FAO/GAoA (Global Agenda of Action) and with Codegalac, while also taking part in the creation of roundtables to discuss cattle ranching in Argentina and Colombia.

In this context, a groundbreaking study shows the enormous potential for the integration of agriculture, ranching and forestry in Brazil, while restoring pasturelands and mitigating climate change effects, by utilizing degraded pasturelands and reducing deforestation rates to zero (Strassburg et al. 2014). The main results of this study show that current productivity of Brazilian cultivated pasturelands is 32–34% of its potential and that increasing productivity to 49–52% of the potential would be enough to meet demands for meat, crops, wood products and biofuels until at least 2040, without deforestation, avoiding 14.3 GtCO2eq.

The main challenge to fulfilling this potential lies in increasing livestock productivity in Brazil, which will require significant orchestrated political and economic efforts, including integrated territorial planning, provision of credit lines compatible with livestock, preferably with integrated environmental services in the livestock value chain (Costa 2014).

5 Discussion and conclusions

Historically, the policy framework in Brazil has played a decisive role in shaping the rural landscape. Land reform and colonization policies backed by a wide range of direct financial incentives fueled the occupation of the Cerrado and Amazon forests (Correa 2013). Meanwhile, the development of agricultural technologies suited to nutrient-poor and acidic soils by publically funded research institutions such as Embrapa, enabled the expansion of large-scale farming in areas before considered unsuitable (Heredia et al. 2010; Martha and Ferreira Filho 2012).

With the advent of the 1988 Constitution, increasing social participation in policy making processes, as well as growing pressures form civil society and environmental groups, both nationally and internationally, led to the emergence of a series of new governance initiatives aimed at curtailing deforestation and reducing GHG emissions (Nepstad et al. 2014). Since then, Brazil has put in place a comprehensive set of policies and programs, some of which have been successful at stymieing deforestation and regulating land use in the Amazon biome. Much of the recent 70% decline in deforestation in the Amazon has been attributed to more effective environmental governance and command and control policies, such as satellite monitoring in real time, concerted efforts by police and environmental agencies to enforce environmental protection laws and financial measures such as prohibiting credit to municipalities with high deforestation rates (Nepstad et al. 2014)

Nonetheless, an overall analysis of Brazil's policy framework shows contradictions and constraints that still need to be addressed in the long run. One such contradiction is suggested by trends and disparities in rural credit and finance policies. The available data on access to credit suggests that the scales area heavily tipped in favor of large-scale farming as opposed to family farming (Heredia et al. 2010; Fernandes et al. 2012). Moreover, while substantial funding is being invested in programs such as the ABC to promote low-carbon agricultural practices (USD 1.58 billion in 2013), much larger sums of funding have been allocated to support large-scale farming activities (USD 56.7 billion in 2013).

Another basic contradiction is the dichotomy between climate change policies and mainstream agricultural and rural development policies. The national climate change policy set ambitious targets for reducing GHG emissions and created associated sectoral plans including PPCDAm. This program was coordinated from the outset under the President's Office, up until recently, when the Environment Ministry took over. This strategic position within the government enabled it to implement a series of actions cutting across several government ministries and enforcement agencies and thus was pivotal to enabling its effectiveness (Nepstad et al. 2014).

As overarching policies on climate change, these programs have had synergistic effects through a combination of enforcement, environmental licensing, land tenure and rural credit policies (Nepstad et al. 2014). However, efforts have focused largely on the Amazon biome. Policies aimed at the Cerrado such as PPCerrado, which have emerged more recently, are still in the early stages of implementation so their effectiveness is difficult to assess.

Meanwhile, key commodity crops including soybeans and corn, the main source of agricultural GHG emissions in Brazil besides cattle, have continued to expand rapidly in other eco-regions, especially in the Cerrado forests spanning across the Central West, Southeast and Northeast. (CONAB 2013) The rising demand for bioenergy has also spurred increases in the areas of eucalyptus plantations, charcoal and fuelwood extraction, compounding pressures on native vegetation in these same regions (IBGE 2012a).

While there is little direct evidence, to our knowledge, of the cumulative effect of land-use policies on these crop expansion trends, the agricultural sector in general has benefitted from a series of tax and credit incentives aimed primarily at large-scale farming and, to a much lesser extent, at smallholders (see Section 2.4). The Forest Code also clearly favors conversion of native vegetation in the Cerrado and eco-regions of Brazil other than the Amazon by establishing much smaller percentages that must be protected as legal reserves on all private properties (80% in the Amazon biome, 35% in areas

of Cerrado within the Amazon region and 20% for Cerrado forests outside the Amazon) as well as for other eco-regions in Brazil.

Despite the ongoing controversy surrounding the effects of indirect land-use change, a growing body of evidence has been pointing to the displacement of cattle herds northwards due to the expansion of soybeans and sugarcane, especially in the Central West. (Lapola et al. 2010; Arima et al. 2011; Andrade de Sá et al. 2013; Correa 2013) Additionally, official data on crop expansion provided earlier suggests a trend whereby national staples (rice, beans and cassavas) declined in area, making way for export and energy-oriented commodities such as soybeans and sugarcane.

So while Brazil has made remarkable strides towards bringing about more sustainable land use through its policy framework, it remains to be seen if the government will continue to muster the political will to push on enforcing these policies given the stagnant economic situation (Nepstad et al. 2014). Another recent development that might entail a retraction of — or increase resistance to — some of these policies is the increased influence of the agribusiness lobby in the national congress. After the national elections in October of 2014, according to preliminary estimates, 53% of the members of congress are linked to the rural caucus (Camara dos Deputados 2014). Other signs that seemingly point to a shift in policy goals are the recent reduction of conservation units for infrastructure in the Amazon (ISA, IPAM and IMAZON 2014; Nepstad et al. 2014), as well as legislative attempts to weaken indigenous land rights (CIMI 2014; ISA 2014) and large-scale energy projects, such as the Belo Monte hydropower plant, which has gone ahead without abiding by provisions set forth in licensing procedures (ISA, IPAM and IMAZON 2014).

Thus, Brazil's overriding challenge in the policy arena is harmonizing and effectively coordinating these different policy agendas at their various levels of implementation so as to effectively manage trade-offs between their disparate goals. This stands as a key constraint in coordinating efforts between federal and state agencies under the ABC program (Assad 2013), as well as in implementing CAR (CI 2014). One of the key features behind the success of the Green Municipalities program is precisely the effective coordination between local authorities, NGOs, farmers and other stakeholders.

One path forward for developing a more cohesive land-use policy agenda at a national level would be to develop a cross-cutting zoning and planning process, to take into account the complex interactions between drivers of land-use change among states and between eco-regions. The lessons from PPCDAm also show the importance of high-level political backing and ensuring that program design and implementation cut across different line ministries and agencies.

Ultimately, policy-making processes across biomes should also take into account not just the carbon implications but also the environmental and social costs associated with large-scale monocrop farming systems spreading mostly across the Cerrado (e.g. contamination of waterways, health and human rights issues, as well as biodiversity loss). In a more integrated approach to land-use planning, these costs might be considered as indirect subsidies propping up the growth of the agricultural sector given the low level of environmental restrictions in this biome compared to the Amazon.

The contradiction in policy aims is epitomized by the country's approach to corporate and smallholder farmers, as agribusiness receives a disproportionate amount of rural credit compared to smallholders, despite the prominent role of family farming for food production and job creation. While the climate change policy has been gaining enormous strides by reducing emissions associated with deforestation, the agribusiness sector, currently the leading cause of emissions (MCTI 2013), enjoys substantial benefits through low-interest loans and a series of tax incentives.

The question regarding agricultural policies, then, is what measures can be put in place to enable continued growth of agricultural production, while also reducing its negative social and environmental costs? The answer lies partly in increasing support for implementing and up-scaling initiatives such as the government's ABC program. The solution also lies in providing other economic incentives for adopting more sustainable use and conservation-oriented agricultural and land-use practices in the Cerrado forests and elsewhere in Brazil.

What other sorts of incentives are required to ensure a transition to a low-carbon future in the two main drivers of land-use change sources of GHG in Brazil: the agricultural and ranching sector? Nepstad et al. (2014) attempt to address this question in

the context of the Amazon, stating that punitive measures need to be complemented by "positive incentives and finance at scale for landholders, indigenous communities, counties and states to make the transition to low deforestation, productive, sustainable rural development."

One example of such a path forward for making this transition at the local level can be gleaned in innovative environmental governance mechanisms such as the Green Municipalities program adopted by the State of Pará in which multiple stakeholders, including farmers, conservation NGOs and governments pool financial, technical and political resources to help implement best agricultural practices and establish pacts on natural resource use (Nepstad et al. 2014; TNC 2014). Market-based initiatives such as the soybean moratorium and working group on sustainable ranching also have a key role to play in increasing the sustainability of supply chains, especially when they complement command and control measures (Nepstad et al. 2014).

A World Bank study conducted in 2010 also addresses some of these questions through a series of recommendations as ways forward towards a future of low-carbon agriculture in Brazil, including: intensification, scaling up no-till farming, supporting research to develop forage of higher nutritional value, more efficient fertilizer use, soil conservation practices and incentives for farmers to increase on-farm conservation practices (Gouvelle et al. 2011). While many of these recommendations are key components of the federal ABC program, coordination between different levels of government (Assad 2013) and more positive incentives to farmers still stand as key constraints to scaling up more sustainable land-use practices (Godar et al. 2014). Although economic incentives for sustainable land use have been created in specific sectors and programs, they need to be further mainstreamed into wider rural development policies.

Clearly, many of the technical and governance solutions have been designed or are in the process of being developed and implemented. Looking across these solutions, the key constraint seems to be implementation and scaling up, as seen with CAR (CI 2014), ABC (Assad 2013) and Green Grant programs.

Reconciling agricultural production with conservation and rural livelihoods requires greater coordination — and harmonization — among sectoral policies at various levels of government. Achieving this goal also requires adopting a combination of a value chain-based and territorial approach to land-use planning with an integrated production system and landscape-based approach that enables making decisions according to multiple trade-offs and impacts.

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Historically, the policy framework in Brazil has played a decisive role in shaping land use and changes in the rural landscape. Over the last three decades, the country has made impressive gains on socio-economic, environmental and rural development policy fronts. Nonetheless, an overall analysis of Brazil's policy framework pertaining to land use shows contradictions and constraints that need to be addressed in the long run. One such contradiction is given by disparities in rural credit and finance policies, with greater amounts favoring large-scale farming as opposed to family farming, despite the key role of smallholders in food production and job creation, and still low resources allocated to programs promoting low-carbon agricultural practices. Another contradiction is the dichotomy between climate change policies and mainstream agricultural and rural development policies. Brazil's overriding challenge is harmonizing and effectively coordinating these different policy agendas at their various levels of implementation so as to effectively manage trade-offs. The question is what measures can be put in place to enable continued growth of agricultural production while also reducing its negative social and environmental costs? The answer lies partly in increasing support for implementing and up-scaling initiatives to promote low emissions agriculture and providing other economic incentives for adopting more sustainable use and conservation-oriented agricultural and land-use practices. Ultimately, reconciling agricultural production with conservation and rural livelihoods requires greater coordination and harmonization among sectoral policies at various levels of government. Achieving this goal requires the adoption of a combination of a value chain-based and territorial approach to land-use planning with more integrated farming systems in order to enable making improved decisions according to multiple trade-offs and impacts.

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