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Challenges to the Expansion of Ethanol Production in Brazil

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1. Introduction

In the early 1990s, climate change came onto the agenda and was identified as being one of the most serious environmental problems of our time (UN 1992, article 2). The United Nations Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at the United Nations Conference for Environment and Development (UNCED, also known as the Rio Earth Summit) held in Rio de Janeiro in 1992. The objective of the treaty is to stabilise greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The main outcome of the treaty is the Kyoto Protocol, which sets mandatory emission limits on the individual signatory countries (Kyoto, 1997).

Since the introduction of the Kyoto Protocol in 1997, world-wide concern about climate change and its impact on global warming has motivated unprecedented discussions on energy sustainability (Cox et al., 2000; Hansen et al., 2005). It is generally agreed that current energy resources, largely based on fossil fuels, are not sustainable for the long term (FAO, 2008). To meet these new challenges, research on the possible contribution of biomass to future global energy supply was initiated at international level (e.g. Hoogwijk et al., 2003; Berndes et al., 2003) and new policies to promote renewable energy in general, and its use in the transport sector in particular, were launched.

Policies to promote renewable energy existed in a few countries in the 1980s and early 1990s, but emerged in many more countries, states and provinces between 2005 and 2010. By 2009, 85 countries had some type of policy target, compared with 45 in 2005 (REN 21, 2010). Mandates for blending biofuels into vehicle fuels have been enacted in at least 41 states/provinces and 24 countries at the national level. Most mandates require blending 10-15% ethanol with petrol. There were 53 states/provinces/countries with biofuel mandates in 2007, 55 in 2008 and 65 in 2009 (REN 21, 2010).

Following this tendency, in 2007 the EU set the ambitious goal of obtaining 10% of its transport sector's energy consumption from biofuels by 2020, as a method of reducing emissions of greenhouse gases. Based on estimates of future petrol consumption, these 10% represent 10-14 billion litres of ethanol. The US Energy Mandate set a target for the production of 68 billion litres (15 billion gallons) from maize using current technologies by 2015 and an additional 95 billion litres (21 billion gallons) from *advanced biofuels* by 2022.

Many other countries have already adopted blends of 2% (E2), 5% (E5) or 10% (E10) ethanol with petrol, among them China, Canada, Australia, and Vietnam. Others, such as Colombia, Argentina, the Philippines and South Africa, will adopt E2 or E10 by 2010-2012 (Licht, 2008a, 2008b; Goldemberg, 2008).

It was in this scenario that Brazil's long-standing biofuel programme attracted world-wide attention. The programme has reduced the country's dependence on petrol (by 2009 the nation's petrol consumption had been cut by 50%) and significantly cut emissions of CO_2 (Macedo et al., 2008). A sign of the world interest in the Brazilian biofuel programme was the visit in 2007 of the US president George W. Bush to Brazil to establish cooperation for developing a global market for ethanol. The US pursuit of alternatives to oil led the country to search for technical and commercial cooperation with the 'world leader in biofuel' (The Washington Post, 2007). The visit resulted in the *Memorandum of Understanding between the United States and Brazil to Advance Cooperation on Biofuels* being signed by the two countries, with the aim of hosting initiatives to promote biofuels around the world.

However, it was only for a short while as by 2007, a range of divergent views had made media headlines: policy-makers, energy producers, academics and environmentalists in many countries expressed their concerns about the sustainability of Brazilian sugarcane ethanol as a biofuel. In response to the divergent views about ethanol production, the study described in this chapter was set up in order to examine the state-of-the-art of the agricultural stage of ethanol production and its impacts on the biodiversity of the two main Brazilian biomes: Amazon and Cerrado.

2. Theoretical framework

Three theoretical concepts guided this study. The concept of 'risk perception' is central to the understanding of what people mean when they say that something is (or is not) risky. 'Frame' is the core concept. It is used to understand how people make sense of the world around them, how they make sense of issues in a conflicting situation. The concept of sustainable development is used to clarify what people mean when they say that a biofuel is (or is not) sustainable.

2.1 Perception of risk

Risk perception is the term commonly used to refer to judgements made when people are asked to evaluate hazardous activities and technologies (Slovic, 1992). The importance of the knowledge of how people and experts perceive risk lies in the contribution that such knowledge may give to decision-makers who seek to avoid both the creation and the progress of conflicts.

The study of risk perception can be traced back to the late 1960s. It started as a response to the public opposition to nuclear technologies. The seminal work of Starr (1969) about the public attitude towards technologies showed that risk acceptance was related to subjective dimensions of risk and not only to technical estimates of risk. Since then, different approaches have been developed in order to discover what people mean when they say that something is or is not risky and to determine what factors underlie these perceptions.

The debate about the concept of risk perception is well known and has been well documented by Slovic (2000). It was started by scholars of psychology (Fischhoff et al., 1978; Slovic, 1992) and was broadened to include scholars of sociology (Jasanoff, 1997; Otway, 1992) as well as those of anthropology (Douglas and Wildavsky, 1982; Thompson et al., 1990).

In the course of the debates, social constructionists asserted that it is not possible to evaluate the acceptability of a risk within a society solely on the basis of the risk perceptions of the individual members (Cvetkovich and Earle, 1992), a concept that has guided much of the psychological approaches. On the contrary, the social constructionists give great importance to social aspects of risk. It is in this respect that the view of other scholars (Lewicki et al., 2003; Schön and Rein, 1994) and our own view came into consideration. In our understanding the comprehension of a conflict depends on a combination of the social and political context of the conflict, understanding of the characteristics of the individuals involved in the conflict, and how these characteristics may influence their reactions. Considering these assumptions, frame analysis was selected as the main tool in this chapter.

2.2 Frames and framing

Framing has its roots in psychology and sociology. The psychological origins of framing lie in the experimental work by Kahneman and Tversky (1979, 1984), for which Kahneman received the 2002 Nobel Prize in economics (Kahneman, 2002). They examined how different presentations of essentially identical decision-making scenarios influence people's choices and their evaluation of the various options presented to them. In sociology, the concept of frame was inspired by Goffman's work (1984) and employed in making sense of people's behaviour, especially in situations where decisions have to be made. Goffman (1984:24) argues that individuals apply interpretative schemes or 'primary frameworks' to classify information and interpret it meaningfully.

Another way of explaining framing is that a person constructs frames when trying to organise complex phenomena into coherent and understandable categories. When a phenomenon is labelled, meaning is imparted to some aspects of what is observed, while other aspects are discounted because they appear irrelevant or counter-intuitive (Schön and Rein, 1994; Kaufman et al., 2003). As interpretive lenses, frames help people make sense of complex situations in ways that are internally consistent with their world views; they give meaning to events in the context of life experience and understanding.

From the works cited above, it can be deduced that people use frames to help them to make sense of the world around them, the complex reality, abounded by complex and often divergent information. Individuals construct frames in order to comprehend new, complex and sometimes complicated events; to identify and interpret specific aspects that seem to be key to understanding the situation, and to communicate that interpretation to others (Schön and Rein, 1994). Through this process, individuals select the issues they give attention to, 'imparting meaning and significance to elements within the frame and setting them apart from what is outside the frame' (Buechler, 2000:41). The processing of framing may or may not create a conflict situation, which arises when the parties involved observe different aspects of the same situation, or observe the same aspects but interpret them differently. In such cases the parties frame the situation in conflicting ways, i.e. they hold conflicting frames (Schön and Rein, 1994).

Various types of frames underlie the origins of conflicts. As for instance, divergent frames of risk perception directly affect preferences for specific decisions in a conflict, as well as how the conflict should be managed (Elliot, 2003). The importance of how people perceive risks influencing the decision making process is given in this chapter by the set of public policies related to the conservation of the biome Cerrado.

2.3 Sustainable development as a political concept

Sustainable development can be seen as a 'political concept' shaped by political controversy and power struggle. In recent years, issues of environment and human development have been gathered together under the integrative framework of sustainability (sustainable development). Major policy processes have been constructed and are producing new and supposedly far-reaching agreements, policies and strategies.

Since it first appeared in the Brundland report (1987), 'sustainable development' has been defined a number of times (Lélé, 1991; Carter, 2001). There are those who believe that one should not try to define sustainable development too rigorously and claim that, to some extent, the value of the phrase lies in its broad vagueness. It allows people with hitherto irreconcilable positions in the environment development debate to search for common ground without appearing to compromise their positions (Lélé, 1991).

According to others (Dryzek, 2005), the proliferation of meaning of sustainable development is not just an exercise in academic or practical clarification: 'It is also an issue of different interests with different substantive concerns trying to stake their claim in the sustainable development territory' (p. 146). As sustainable development has become more important, key interests have tried to define sustainable development to suit their own purposes. 'Thus an African government might emphasise the need for global redistribution of wealth from North to South in order to eliminate poverty, while a transnational corporation might insist that sustainability is impossible without vibrant economic growth to conquer poverty, stabilise population levels, provide for human welfare and, of course, maintain profit levels (Carter, n/d). To Carter (n/d), sustainable development, like beauty, is in the eye of the beholder; it therefore promises something for everyone. As Lélé (1991) has put it:

'Sustainable development is a 'metafix' that will unite everybody from the profit-minded industrialist and risk-minimizing subsistence farmer to the equity-seeking social worker, the pollution-concerned or wildlife-loving First Worlder, the growth-maximizing policy maker, the goal-oriented bureaucrat and, therefore, the vote-counting politician' (p. 613).

These chameleon characteristics attract a wide array of supporters, but they also make sustainable development a highly contestable concept that not only deals with interdependencies between economy and ecology, but also combines the ecological question with the social question on a global scale. Some aims of sustainable development are radical: the elimination of poverty, the pursuit of global equity, wider use of appropriate technologies, and a shift away from consumerist lifestyles. Other themes, such as the preference for the capitalist economic system and the need for continued economic growth, seem to call for the acceptance of the status quo. Old questions need to be answered: What are basic needs? Should they reflect the needs of citizens in the USA and/or Bangladesh? How far will the living standards of rich industrialised nations have to be adjusted to achieve sustainable consumption patterns? Different answers to these questions produce conflicting interpretations of sustainable development (Carter, n/d, 2001).

For example, those defending the rights of less developed countries may have cause for complaint, particularly about a widespread attitude among Europeans, who tend to see sustainable development as an exercise in the conservation of nature and in environmental management, while forgetting about equitable distribution and economic growth in less developed countries (Huber, 2000, 2005). What comes to mind at this point is that any discussion of sustainable development, and of sustainability, must first answer the questions:

'What is to be sustained? For whom? How long?' The value of the concept of sustainability, like that of sustainable development, however, lies in its ability to generate an operational consensus between groups with fundamentally different answers to these questions, i.e., those concerned either about the survival of future human generations, or about the survival of wildlife, or human health, or the satisfaction of immediate subsistence needs (food, fuel, fodder) with a low degree of risk. It is therefore vital to identify those aspects of sustainability that do actually cater to such diverse interests, and those that involve tradeoffs' (Lélé, 1991:615).

In this chapter we show how differently people 'frame' issues of sustainability, for example, how they perceive the risks concerning the expansion of ethanol production to the Amazon and to the Cerrado biome.

3. Methodology

This chapter describes part of a larger study on the developments, divergent views and conflicts concerning the agricultural phase of the production and expansion of ethanol in Brazil. The approach adopted here combined a literature review with field work carried out in the north-east of São Paulo state, where 30 ethanol and sugar industries/plants are located. Data were obtained through interviews with representatives of the parties and through listening to their talks at conferences, seminars, workshops and on TV, reading their communications and watching their behaviour, and studying items in the media. The field work was complemented by consulting scientific literature, official statistics, non-governmental organisations and official reports. The research was carried out from October 2007 to June 2011.

Exploratory interviews were carried out with around 20 key actors such as sugarcane and ethanol producers, engineers and other experts on the production of ethanol and with academics knowledgeable about natural ecosystems. In these interviews, as is typical of exploratory interviews, just a few questions were used to structure the interview. The questions differed according to the expertise of the interviewee.

Data were also obtained at several academic seminars promoted by the School of Economics, Business and Accounting of the University of São Paulo (FEA/USP) and Institute of Advanced Studies of the USP (IEA/USP), and during the Ethanol Summit 2009 and 2011, organised by the Sugarcane Industry Association (UNICA). The latter events can be considered *ambulant bibliotheca,* since so many national and international scholars, government representatives, NGOs, industry representatives, students and representatives of civil society were present. They represented Brazil, European Union, Sweden, Belgium, Netherlands, United Kingdom, USA and Japan. The presentations revealed their position in relation to global ethanol production and expansion in general, and Brazilian ethanol production in particular. Attendance at such events, as observer and interviewer, was an essential part of the data gathering process and the frame construction. The actors were asked about how they included the dynamics of land use in Brazil in models to evaluate land competition and how they related the expansion of sugarcane to the Brazilian main biomes.

The methods of analysis used were concerned with the issue of how actors' constructions of meaning (frames) were constructed and represented on the basis of the available material. A combination of analytical tools was used for analysis of the texts, as proposed by Kvale (2008). This approach gave us the possibility to freely change between different approaches, an eclectic form of generating meaning that is a common mode of interview analysis, in contrast to systematic analytical modes. Bricologe, as the mode was called by Kvale (2008), involves interplay of different techniques during the analysis of interviews or other text. As proposed by Schmidt (2005) and Kvale (2008), all the texts were read through once to gain a first overall impression. Repeated readings of the texts were then carried out to allow interesting passages that had gone unnoticed in the previous reading to be identified. As advised by Böhn (2005), in the first stages of the analysis as many different people, situations and documents as possible were selected to obtain data covering the complete spectrum of the research question. Subsequently, data were sought that confirmed or modified the first categories of analysis that had been developed.

4. Background

Frame analysis requires familiarity with the object of study: the divergent views over the expansion of sugarcane plantation to increase ethanol production in Brazil. In turn, analysis of the divergent views and the conflicts they have created requires a broad understanding of the context in which the conflicts take place. To fulfil such requirements, a detailed background description is given here. This consists of: description of land use in Brazil and of the instruments concerning its control, the evolution of Amazonian deforestation, the peculiarities and importance of the Cerrado biome and a description of the proposal for the expansion of ethanol production in the country. This description consists of what I, the researcher, after an intense analysis of the data, considered to be the background to the divergent views and the divergence in the perception of risks associated with the expansion of sugarcane for ethanol production.

4.1 Land use

At present, some 11% (1.5 billion ha) of the global land surface (13.4 billion ha) is used in crop production (arable land and land under permanent crop) and 26% (3.5 billion ha) for pasture land (United Nations Food and Agriculture Organisation [FAO], 2002; Hoogwijk et al., 2003). According to FAO, a lack of land is not forecast for the period until 2030. Suitable land for rain-fed crop production is almost three times the capacity currently used (FAO, 2002).

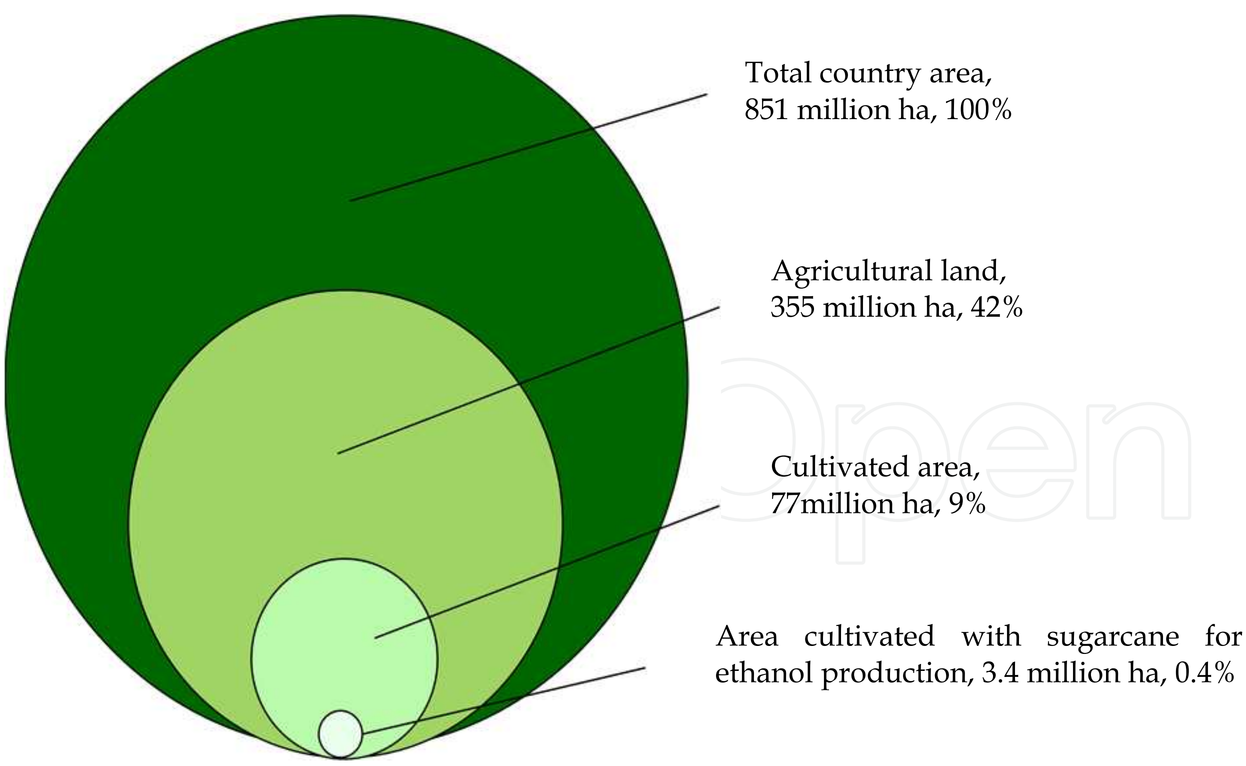
Concerning Brazil, the total area of the country's territory is 851 million hectares. In 2007, the total area of agricultural land occupied 355 million ha (42% of territory), with pasture land occupying 172 million ha and arable land 77 million ha, subdivided as shown in Table 1.

	Area 10^6 ha	*% of Brazil's territory*	*% of agricultural land*
Brazilian territory	851	100	--
Total agricultural land (1+2+3)	355.0	42.0	100.0
1. Total crop land	77.0	9.0	21.0
Soybean	21.0	2.4	5.8
Maize	14.0	1.6	3.9
Sugarcane	7.8	0.9	2.2
sugarcane for ethanol	3.4	0.4	1.0
Oranges	0.9	0.1	0.3
2. Pasture	172.0	20	49
3. Available land	106.0	12	30

Source: MAPA 2007

Table 1. Land uses in Brazil (10^6 hectares; percentage of total territory) in 2007.

In 2007, for the global production of 50 billion litres of ethanol that replaced 3% of the world consumption of petrol, 15 million ha were used, which represented 1% of agricultural land world-wide (Goldemberg, 2008, 2009). As regards Brazilian sugarcane-based ethanol, sugarcane plantations for the production of 22.5 billion litres of ethanol used 3.4 million hectares, which represented 0.4% of the total area of the country's territory and 5% of the 77 million ha of arable land. This volume would be enough to substitute about 1% of global demand for petrol and replace 50% of the petrol consumption in Brazil (Goldemberg, 2009).



Source: Adapted from The Brazilian Ministry of Agriculture Livestock and Supply [MAPA] 2007 and from the Brazilian National Economic and Social Bank [BNDES]/Center for Strategic Studies and Management [CGEE], 2008.

Fig. 1. Illustration of the percentage of land use in Brazil.

4.2 Instruments for the control of land use

There are various sections of legislation and public policies that influence the land use in the country. Within this set of restriction and obligation, 25% of the Cerrado receives some form of protection, as defined in the Forestry Code (Smeets et al., 2008). However, only seven per cent of the biome is designated as Protected Areas for Conservation (Conservation International, n/d).

4.2.1 National Forestry Code

Brazilian environmental legislation is based on the National Forestry Code (Federal Law 4771/65), and the Environmental Crimes Law (Federal Law 9605/98). According to the Forestry Code, a legal reserve (LR) of 80% is required for rural properties in the Amazon region, 35% in the Amazonian Cerrado (savannah) and 20% in the rest of the country, including São Paulo State. The LR regulation means that all properties must guarantee at least the required percentage of forestry cover with native trees (or reforested with native trees).

The Forestry Code also designated areas close to rivers and water streams, as for example riparian forest, as Areas of Permanent Protection (APPs), which means that these areas must be maintained in, or restores to their natural state. APPs, as well as LRs, are protection areas within a property. LRs are estimated to cover 32% of the territory and APPs 17% (Miranda, 2009).

4.2.2 ZAE Cana

Another government instrument was launched in 2010 to avoid the destruction of valuable forest and in response to international criticism (Galli, 2011). The countrywide agro-ecological land use zoning for sugarcane will restrict sugarcane growth in or near environmentally sensitive areas (MAPA, 2009a). The no-go areas for expansion are Amazonian and Pantanal biomes, and areas of high biodiversity. Although this zoning has no status in law, the expansion of sugarcane to *non-suitable* land is restricted through state credits, i.e. state credits are unavailable for such expansion.

The ZAE Cana includes a set of mandatory environmental, economic, social, climate and soil restrictions, limiting future expansion of sugarcane to around 8% (65 million ha) of the nation's territory, most within the Cerrado biome. Today, one per cent of Brazil's territory landmass, equivalent to 8 million ha, is used for growing sugarcane (with great regional variation); half of this area is used for growing sugarcane for ethanol production and the other half for sugar production.

4.2.3 National Action Plans

Among the national policies are the Action Plan to Prevent and Control Deforestation in the Legal Amazon, starting in 2004. At first, the main concern was with loss of biodiversity, but by 2007, carbon emissions from deforestation in the Amazon had become the main cause for concern. The Action Plan is a set of cross-government policies and measures to improve monitoring, strengthen enforcement, define conservation areas and foster sustainable activities in the region, and it uses the images from INPE’s near real-time deforestation detection system.

Again at national level, the Action Plan to Prevent and Control Deforestation and Fire in the Cerrado (PPCerrado) was launched in 2010. Its main goals are to decrease deforestation in this biome by 40% by 2020 in order to fulfil the requirements of the National Climate Policy and to increase the protected area for biodiversity. It should be noted that while the Action Plan in the Legal Amazon used images from the INPE deforestation detection system, which has shown great efficiency in the control of fire and deforestation in the area, for PPCerrado a detection system is not yet available.

4.2.4 The Brazilian protected areas programme

The Brazilian strategy to select new protected areas includes two key considerations: a focus on areas of high biological importance and prioritisation of those areas under strong anthropogenic pressure (Silva, 2005). In 2000, the Sistema Nacional de Unidades de Conservação da Natureza (SNUC) was made law. It focuses on the creation and management of federal protected areas. The SNUC divides protected areas into two main categories: (1) strictly protected, with biodiversity conservation as the principal objective; and (2) sustainable use, allowing for varying forms and degrees of exploitation, with biodiversity protection as a secondary objective. Analogous instruments for creating and managing protected areas exist at the state and municipal levels (Silva, 2005).

The Federal Conservation Units (FCUs) defined and protected by legislation cover 8.6% of the country’s territory. Indigenous land (IL) also defined and protected by the legislation covers 12.8% of the territory. The State Conservation Units, defined by state governments (SCUs), cover 7%of the territory. In total, these protected areas cover 28% of Brazilian territory (Miranda, 2009), unevenly distributed in the biomes, with most of them located in the Amazon Biome, followed by the Cerrado. All legally protected areas, including the LRs and APPS, account for 70% of the country’s territory, resulting in land legally available for agricultural use occupying an estimated 30% of Brazilian territory (Miranda, 2009).

4.3 Brazil’s second biggest biome: Cerrado

The Cerrado is a complex ecosystem of grass and shrub land that extends over ten Brazilian states. It is the second largest vegetation formation in Brazil, after the Brazilian Amazon. Originally the Cerrado occupied an area of around 200 million ha, 24% of Brazil’s territory (Figure 2), but by 2009 it occupied around 12%. It is known as the world richest savannah in terms of biodiversity. It houses more than 10,000 known species of plants, of which 4,400 are endemic; 837 species of birds, 160 species of mammals, 1,200 species of fish, and many others kinds of animals (EMBRAPA, n.d). The Cerrado has a dry landscape with small and twisted trees, and it supports several species of wild cats, such as puma and jaguar, as well as maned wolves, giant armadillos and giant anteaters. In addition, the Cerrado region shelters the headwaters and the important part of South American watersheds; it borders and holds areas of transition with other major Brazilian ecosystems, e.g. the Amazon, and is essential to their ecological equilibrium (EMBRAPA, n.d).

Fig. 2. Original areas of biomes in Brazil, expressed in terms of percentage of Brazil's territory.

The Cerrado has supported human populations for a very long time. In the 16th century, Portuguese settlers mainly colonised the Brazilian coastline, and the interior was spared any major development. However, in the mid-20th century the Brazilian government started to build a new capital city in the state of Goiás, in the centre of the Cerrado. The construction of Brasília was accompanied by large-scale infrastructure development, which encouraged movement into the interior of the country, in the remote areas of the North and parts of the Central West regions. It was also when Legal Amazonia, a socio-geographical and political division in the country, was created by the government in 1965. This covers 60% of Brazilian territory and had an estimated 21 million inhabitants in 2000 (IBGE, 2001). It contains the Amazon forest, parts of the Cerrado biome and of other biomes and an area of intense agricultural activities.

Because the soil was considered poor, it was not until the 1980s that agricultural use of the Cerrado biome started to become more intensive. This was the result of a government policy to develop remote areas of the country, in combination with extensive scientific research in soil science which received the 2006 World Food Prize (laureates Lobato and Paolinelli of Brazil and McClung of the USA). To make space for the expansion of arable and pasture land, the rates of deforestation in the Cerrado have steadily increased since the 1980s. The Cerrado became Brazil's new agriculture frontier. This was accompanied by an increase in population and trade development based on agricultural production. In 2000, the Cerrado region was responsible for 35% of all crops produced in Brazil. Currently, 58% of all soy bean production comes from the Cerrado.

4.4 Proposed expansion of sugarcane for ethanol production

Sugarcane plantations require flat land (allowing for mechanical harvesting), good soil quality (lower quantity of fertiliser needed) and a water supply (no or minimum irrigation), among other things. These factors were considered in a formal analysis of Brazilian ethanol production conducted by researchers at the Interdisciplinary Center for Energy Planning (NIPE) at UNICAMP and summarised by Cerqueira Leite et al. (2009). The country's potential to replace 5% (102 billion litres) of the world demand for petrol with sugarcane ethanol by the year 2025 was evaluated. This scenario is the basis for the federal government's expansion policy for ethanol. The analysis estimated that it would take 17 million hectares (ha) of sugarcane to provide the projected demand of 102 billion litres of ethanol, plus 20% required by law for legal reserves, making in total 21 million ha. It also considered that sugarcane plantations will replace degraded areas or areas currently used as low productivity pasture, through the conversion of pasture and the intensification of cattle grazing, following a trend in the country in recent years (Nassar et al., 2008). This model of expansion will avoid the main environmental threat posed by expanding the amount of land under cultivation for energy or any other use through irreversible conversion of virgin ecosystem, guaranteeing a green fuel (Goldemberg et al., 2008). The analysis estimated that 30% of Brazilian pasture land is degraded (more than 50 million ha), most within the Cerrado biome.

Projections from the Brazilian Ministry of Agriculture indicate that if Brazilian production doubled by 2017, no more than 1.7 per cent of the land would be used (MAPA, 2009a). Projections developed for the study carried out by Nassar et al. (2008) indicated that harvested sugarcane area in Brazil will reach 11.7 million ha in 2018, departing from 7.8 million ha in 2008. Area allocated for crops (soybean, maize, cotton, rice and dry beans) is expected to grow from 37.8 million ha to 43.8 million ha. Pasture land will move to the opposite direction, being reduced from 165 to 162 million ha.

The proposed expansion of sugarcane plantations is to occur only on degraded pasture land (although not well defined in the literature, degraded pasture land has been considered areas with natural vegetation that have been used for cattle breeding and abandoned after 4 or 5 years of use due to low productivity). Such land can readily be found in the Cerrado biome (Cerqueira Leite et al., 2009), confirming a trend in recent years (Nassar et al., 2008). This, combined with higher productivity of cattle farming, will make more land available for the expansion of sugarcane for ethanol production, avoiding indirect land use change.

5. The study

The study described below is divided in two main parts: frame analysis of the Brazilian ethanol programme and perceptions of risks concerning the expansion of ethanol production in Brazil. The frame analysis elicited conflicting and non-conflicting frames related to the ethanol programme. In order to understand the conflicting frames, mainly the frames *ethanol as a brown fuel* and *ethanol as green fuel,* the perceptions of risks were also analysed.

5.1 Frame analysis of the Brazilian ethanol programme

The results showed that in the past four decades there has been a continuous process of framing and reframing regarding the issue of ethanol production in Brazil. Although the Brazilian ethanol programme was established more than 30 years ago, it was not until the first decade of the 21st century that the production of ethanol became an international issue. The prospect of future large-scale world production of ethanol raised conflicts in terms of social, economic and environmental factors, the latter especially related to the loss of biodiversity in Brazil's two largest biomes: Amazon and Cerrado, the latter being the focus of this chapter.

5.1.1 The Brazilian independence frame, 1975-2000

For centuries, sugar was Brazil's main product from sugarcane. However, there is information that ethanol (then termed 'alcohol') was already being produced from sugarcane in the early 1900s, when Brazil experienced a rapid increase in the use of by-products from oil. However, it was in the 1970s that ethanol started being more intensively produced as a fuel to make the country independent in energy. Frame analysis showed that an *energy independence frame* was adopted by the Brazilian government. The nationalistic values of the military government ruling Brazil at that time, and their belief in a country self-sufficient in energy and economically strong, were decisive for the creation of the National Alcohol Programme (Proálcool) in 1975 (Decree 76.593 signed by President Enerst Geisel). The programme was a response to the sharp increase in the world price of oil in the 1970s, from $2.90 to $12.45 a barrel. At that time, over 80% of Brazilian petroleum came from imported oil. In 1973, the cost of oil represented 10% of the total import costs of the country and this had increased to 32% by 1974. Brazil's payments for imported petroleum increased from US$600 million in 1973 to US$2.5 billion in 1974, severely affecting the balance of trade. These results came to weigh heavily on Brazilian foreign debt and inflation over the course of the following years. The development of a substitute for petrol was one of the initiatives taken in response to high oil prices (BNDES/CGEE, 2008).

The Proálcool programme addressed two problems simultaneously: it replaced oil consumption and helped to stabilise the international sugar market, where prices had fallen from US$639 a ton in 1974 to US$ 176 in 1979, an example of the large oscillations which were not uncommon in the sugar market at that time (Cerqueira Leite et al., 2009). Given low international sugar prices, the Brazilian government sought to utilise domestic sugar supplies to produce ethanol and, consequently, to reduce the country's dependence on foreign oil.

The second global oil crisis in 1979 exposed the continuing vulnerability of Brazil to international oil shocks and reinforced the political will to continue with the Proálcool programme. The price of oil rose from US$25 in 1979 to US$40 in 1981. From 1979 to 1984, the Brazilian government directed more funds to the construction of new distilleries, capable of producing hydrated alcohol for fuel engines, and the vehicle industries were stimulated to construct 100% pure ethanol-fuelled vehicles (Natale Neto, 2007).

The 1980s was a decade of important economic and political changes in Brazil. The economy had serious problems, with very high inflation rates and foreign debt. Politically, the country began a process of redemocratisation. This coincided with low international oil prices and consequently oil supply became less of a problem. In 1985, under the new administration (the first civilian government administration after a period of two decades of military government), public investment in the Proálcool programme was gradually cut back, for example for the building of new distilleries. In 1988, 63% of all vehicles (around 100% of cars) produced in the country were powered by ethanol. That number declined to 47% in 1989, 10% in 1990, 0.4% in 1996 and less than 0.1 in 1997 (Natale Neto, 2007).

The high price of imported oil on the international market after the oil crisis stimulated the development of Petrobras, the Brazilian Petroleum Company founded in 1953 by President Getúlio Vargas. New incentives were given to the company to drill petroleum off the Brazilian coast. The good results achieved by the company in the 1990s brought Brazil to self-sufficiency in oil in the first decade of the 21st century (for more detail refer to Galli, 2008).

In 1999 the cost of ethanol production was still high compared with the price of petrol manufactured from imported oil. Despite the decrease in government incentives, new technologies for ethanol production were being developed, mainly by the private sector, and the cost-effectiveness of the programme improved significantly (La Rovere, 2004). However, it was not until 2003 with the introduction of the flex fuel engine, which can use ethanol and petrol in any proportions, that the use of this biofuel started increasing again. By 2007, flex fuel cars accounted for 90% of all new cars registered in Brazil (ANFAVEA, 2010). All these changes in combination significantly improved what was re-named the Brazilian Ethanol Programme in the late 2000s.

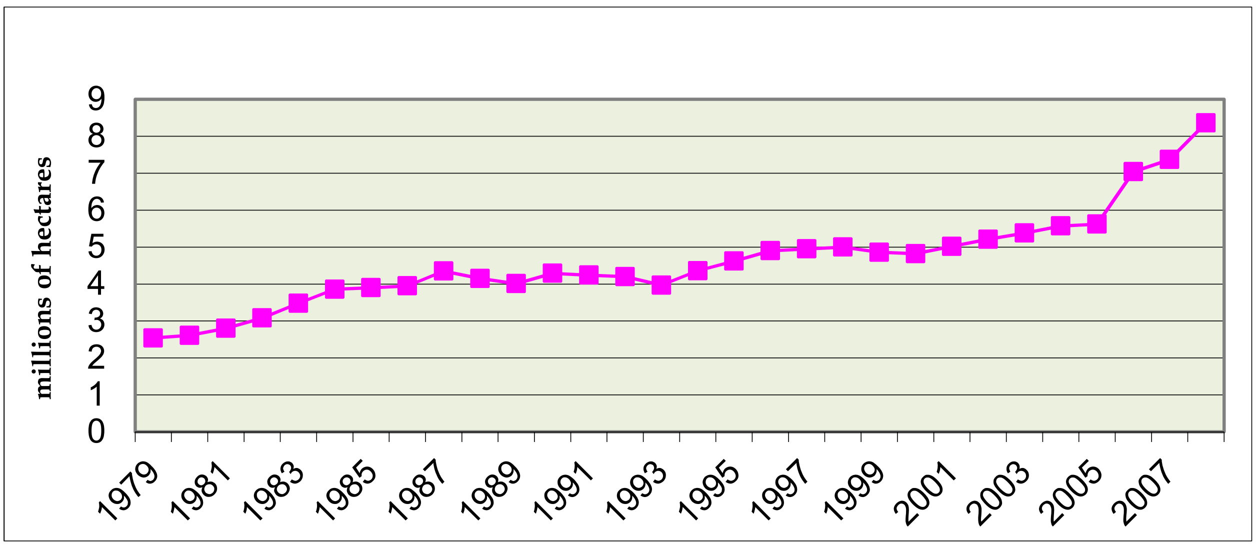
5.1.2 Framing ethanol as a tool for economic development

The international visibility of the Brazilian ethanol programme increased with the need of different countries to meet their emissions targets relating to climate change agreements. In order to fulfil these targets, global ethanol production has increased sharply, from less than 20 billion litres in 2000 to 53 billion litres in 2007, 69 billion litres in 2008 and 76 billion litres in 2009. The US and Brazil accounted for 90% of this production, with the US producing more than 50% and Brazil about 35% (REN21, 2010). Brazil exported 3.5 billion litres of ethanol in 2007, compared with 227 million litres in 2000 (Secex/UNICA).

Brazil saw its competitive advantage as an opportunity to bring its ethanol to the international market. The *energy independence frame* that had orientated the Brazilian government's actions during the 1970s and 1980s was replaced by an *economic frame* strongly orientated towards the international market. The belief of national and international actors in ethanol as a possible alternative to fossil fuel acted as a stimulus to the Brazilian government to plan ethanol expansion for the coming years, aiming at doubling national production by 2017, to 63 billion litres annually (Inter-American Development Bank [IDB], 2010). Bioethanol's share of the Brazilian National Economic and Social Development Bank (BNDES) total loans for capital investment went from 1.5% in 2004 to 7% in 2008 (BNDES in Ethanol Summit 2009), providing a strong indicator of future development. This was reflected in the number of new distillery projects, with 136 new distilleries to be ready by

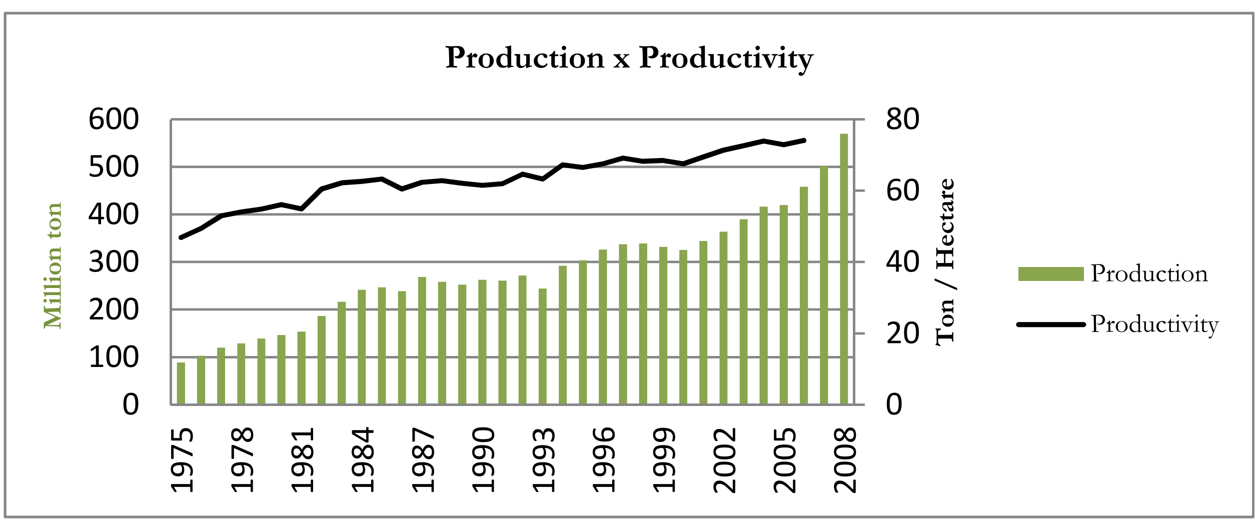
2014 (Nastari, 2006). By 2010 there were 423 distilleries in operation, compared with 350 in 2006 (MAPA 2008, 2010).

Other responses were an expansion of the area planted with sugarcane, as illustrated in Figure 3, and an increase in sugarcane production (volume of sugarcane harvested) and productivity (volume of sugarcane per ha), as shown in Figure 4. The increase in productivity was the result of plant breeding programmes, the introduction of biological pest control, improved management and greater selectivity regarding production sites. As a result of these improvements, in 2008 the area planted with sugarcane for the production of ethanol was 38% less than it would have been had the land use and production procedures of the 1970s remained in place (BNDES/CGEE, 2008).



Source: MAPA (2009b).

Fig. 3. Annual expansion of the area (10^6 hectares) planted with sugarcane in Brazil, 1979-2008.



Source: MAPA (2009b).

Fig. 4. Annual changes in the production and productivity of Brazilian sugarcane, 1975-2008.

5.1.3 Framing and reframing the impacts of ethanol on natural vegetation

By 2007, a wave of criticism was being directed at the production and consumption of biofuels. A reframing process was going on: from being a sustainable and effective alternative to fossil fuel, ethanol turned into a monster that destroys the Amazon forest, competes with food production and increases CO_2 emissions; the 'presidential diplomacy that celebrated biofuels in March 2007 ignited a firestorm of opposition to ethanol and its production in both the US and Brazil' (Langevin, 2008).

In 2008, a second wave of criticism of biofuels in general, and ethanol in particular, was published, mostly in Europe, but also in the US and Brazil. One possible explanation is that two articles published in Science Magazine in early 2008 (Fargione et al., 2008; Searchinger et al., 2008) received a great deal of public attention because they claimed that widespread adoption of biofuels, including ethanol, will produce more greenhouse gas (GHG) emissions, especially CO_2 emissions, than conventional petroleum-based petrol due to indirect land use changes. For Brazil, the first assumption in those articles was that new agricultural land would come from forest. Deforestation of Amazon forest and CO_2 emissions from indirect land use changes have since been the focus of attention in scientific and commercial debates about Brazilian ethanol. Concerns that sugarcane will invade the Amazon region or push soybean plantations and cattle into virgin forests, causing more deforestation, also featured in major media headlines (e.g. Financial Times, 2008; The Guardian, 2008).

The fear of increasing CO_2 emissions and deforestation of Amazonia strongly affected the international negotiations for Brazilian ethanol. The European Union's representative at the Ethanol Summit (2009) argued that EU consumers 'need to have a guarantee that Brazilian ethanol is sustainable', reflecting the EU Directive specifying that biofuel feedstock must not come from areas of high carbon stock and must conserve biodiversity and that the resulting biofuel must reduce CO_2 emissions by at least 35%. In the USA the Californian Air Resources Board (CARB) and Environmental Protection Agency (EPA) required that CO_2 emissions due to direct and indirect land use changes be included in the life cycle analysis of ethanol (for more about the debate over CO_2 emissions due to direct and indirect land use changes, see Galli, 2011; Galli, 2013).

Once again, the way their views (that sugarcane plantations will cause deforestation of Amazonia and increase CO_2 emissions) were expressed in the media captured the attention of the public and policy-makers, and led them to view ethanol as *a* fuel destructive for nature, *framing ethanol as a brown fuel*.

However, many of the criticisms were denied by important Brazilian actors (e.g. BNDES/CGEE, 2008; Cerqueira Leite et al., 2009; Goldemberg et al., 2008) who argued that the expansion of sugarcane is not a threat to Brazilian natural vegetation. These actors were holders of what we named an *ethanol as green fuel frame* (for a more detailed frame analysis see Galli, 2011). One explanation for such divergent views on the expansion of sugarcane is the way the actors perceive the risks concerning this expansion, as described below.

5.2 Perceptions of risks

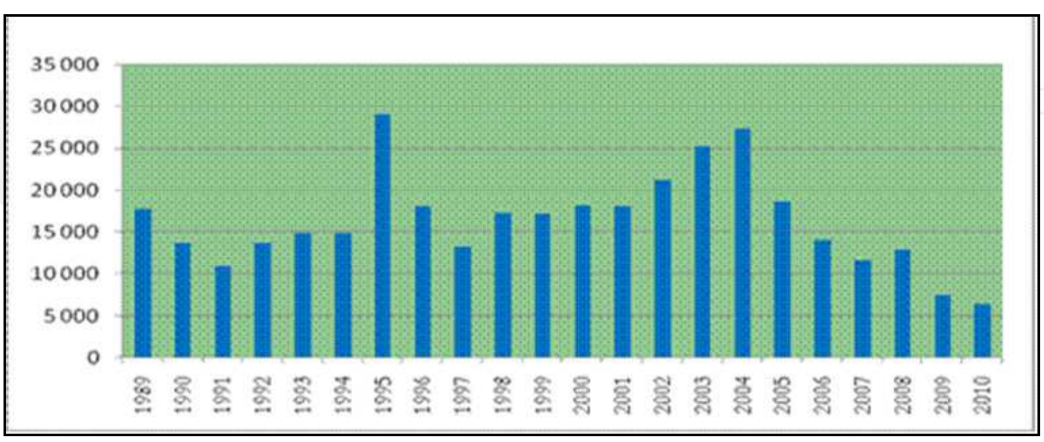
We were first alerted to the threat posed by the expansion of sugarcane to the Cerrado biome during exploratory interviews with academics knowledgeable about natural ecosystems when this study had just started in 2007. Their perceptions of the risks to the Cerrado biodiversity due to this expansion stimulated us to carry out a broad literature review on the subject.

5.2.1 Risks deriving from expansion of sugarcane to the Amazon forest

A study conducted by Miranda (2007a) showed that Brazil has mostly preserved its primary forest (70%), while Europe (excluding Russia), the worst case, has preserved 0.3%. It is estimated that 75% of the world original forests have disappeared. However, the international frame concerning Brazil's forest has not been one of preservation, but rather one of destruction. Paradoxically, this is in spite of the fact that Brazil is one of the countries that has destroyed least forest (Miranda, 2007b).

On the other hand, in the last three decades, Legal Amazonia has suffered high deforestation rates (Figure 5), with 372 thousand km^2 of rainforest - an area almost the size of Japan[1] - being converted either to pastoral or arable land in this period. One hypothesis is that these high deforestation rates have attracted the world's attention and have given some international actors cause to fear that the expansion of sugarcane would induce displacement of natural vegetation. However, deforestation rates in the Amazon have declined markedly since 2004, by 75% between 2004 and 2009 (National Institute of Space Research [INPE], 2010). It is reported that the slowing of deforestation levels is primarily a result of the Action Plan for Deforestation Control and Prevention in the Amazon, which uses Satellite images from INPE's near real-time deforestation detection system. This system has enabled government inspectors to focus their efforts at where deforestation is most critical and to act quickly to prevent new areas from being cleared.

The international view over the Brazilian biodiversity is also very negative, in spite of the fact that Brazil is one of the world's richest megadiversity countries. However, it rarely attracts attention for what it has, rather, it is criticized for what it is losing through deforestation and conversion of natural landscapes into plantations, soybean fields, and pastures (Mittermeier, et al., 2005).

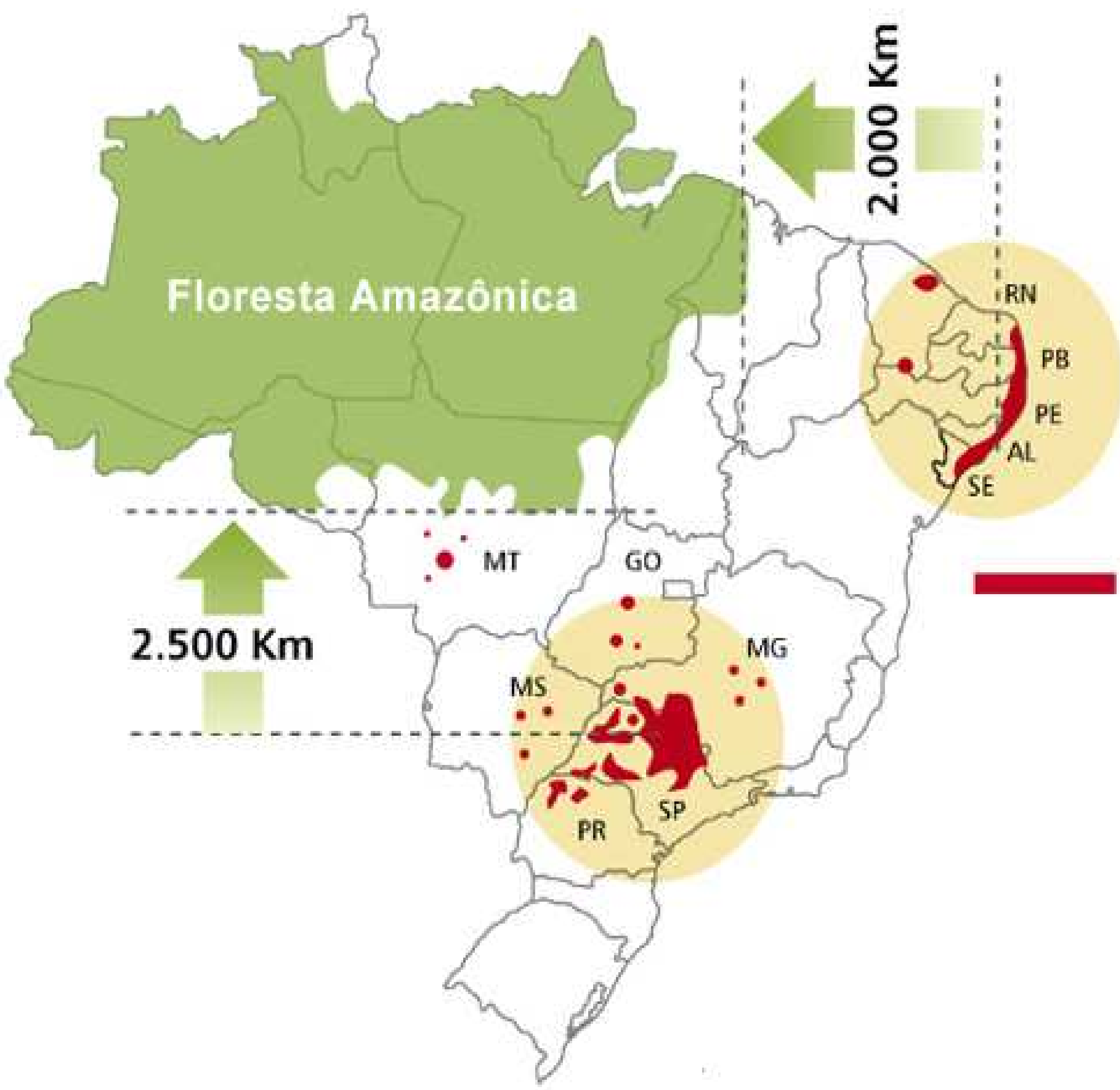


Source: INPE, 2010.

Fig. 5. Deforestation in Legal Amazon per year (km^2) over the period 1989-2010.

[1] Area of the Japan's territory = 378,815 km^2

Concerning the expansion of sugarcane, important Brazilian actors, holders of the *ethanol as green fuel frame,* seem to be more confident about the preservation of the Brazilian Amazon, a confidence that may derive from the history of sugarcane expansion in Brazil. A comparison of rates of deforestation in Amazonia between 1988 and 2009 and of sugarcane expansion in the same period shows that deforestation rates ranged from 1.1 to 2.9 million ha/year (INPE, 2010), while the average rate of sugarcane expansion in the whole country was 0.20 million ha/year (FAOSTAT, 2010). This means that the former was five to fifteen times higher than the latter in the period. Research also shows that the expansion of sugarcane plantations in Brazil is occurring mostly over degraded pastures far from the Amazon (Cerri et al., 2007; Goldemberg, 2008). Most of this expansion to date has occurred in the state of São Paulo. The northern region (which includes almost all of Brazil's Amazon rainforest) has only 21,000 hectares planted with sugarcane, i.e. only 0.3% of Brazil's sugarcane plantations (MAPA, 2007). This means that 99.7% of sugarcane plantations are at least 2,000 km from the Amazon forest, as shown in the map below (Figure 6).



Source: UNICA, adapted from MAPA 2007.

Fig. 6. Location of sugarcane plantations in Brazil in relation to the Amazon forest.

Another position relating to the expansion of sugarcane is that the current sugarcane area represents only 3% of the 264 million ha of agricultural land in use in Brazil, of which nearly 200 million ha are pastoral land. Furthermore, the hotspots of deforestation in the Amazon region have a low suitability for sugarcane production and are not directly threatened by the current sugarcane expansion (Smeet et al., 2008). Fearnside (2005) concluded that Amazon deforestation has been caused mainly by conversion to pastoral land for livestock production and, more recently, for expansion of soybean production.

5.2.2 Risks deriving from expansion of sugarcane to biodiversity in the Cerrado

By 2000, the risks deriving from the expansion of arable and pasture land to the Cerrado biodiversity were already perceived. It was then that the Cerrado was defined as one of the 25 biodiversity hotspots in the world for conservation priorities (Myers et al., 2000). This was due both to its exceptional concentration of endemic species (native to the Cerrado) and to the severe threats to which these species are exposed. The term 'hotspot' was created by the English ecologist Norman Myers in 1988 to identify major terrestrial bio-geographical regions based on the number of endemic species and the degree of threat to biodiversity. It should be noted that at least 130 Cerrado animals are threatened with extinction because of large-scale agricultural expansion (Klink & Machado, 2005).

In 2004, concerns were raised about the high deforestation rate of the biome, which was estimated to be 1-1.5% of the total original area per annum (Machado et al., 2004). This continued up to 2009, when around half the original area of the Cerrado (equal to almost three times the area of Japan) had already been transformed into pasture and other agricultural uses. This is around three times the deforested area of Brazilian Amazon, an area which is double the size of the Cerrado (Machado et al., 2004). Annual clearing in real terms is also higher than in the Amazon: between 1970 and 1978 the average was 40,000 km^2/year, which is 1.8 times the deforestation rate for the Amazon from 1978 to 1988 (Klink & Moreira, 2002).

Devastation of priority areas for biodiversity conservation has also been perceived as a risk to the biome in recent years. For example, 67% of the priority areas in the state of Goiás have already been converted to cropping and pastoral uses (Lobo and Guimarães, 2008). Priority areas for conservation are defined as areas where the biodiversity is very sensitive or vulnerable to anthropogenic pressure (Machado et al., n.d.).

The expansion of sugarcane plantation has tended to occur in the State of São Paulo, very often in areas of the Cerrado. In 2007, the Central South[2] region was responsible for 86% of total sugarcane production in the country. The state of São Paulo alone produced more than 60% (Embrapa, 2007). However, a decrease in the rate of expansion in this state is expected,

[2]Two methods of dividing the country into regions are used in this study depending on the reference, namely geo-political and geo-economic. The official geopolitical method was established by IBGE in 1969 and divides the country into five regions (North, Northeast, South, Southeast and Central-West). The geo-economic method divides the country into three regions (Amazonia, Northeast and Centro-South). The Centro South comprises the states of the South and Southeast regions (except north of Minas Gerais) and the states of Goías, Mato Grosso do Sul and Tocantins. The geo-economic division is intensively used by academics (e.g. Esalq/USP) and government agencies (e.g. EMBRAPA).

mainly due to the lower availability and consequently higher price of land compared with other regions of the country (Torquato, 2006).

The second movement of the expansion of sugarcane production has been towards the Central-Western region. For example, the area of sugarcane increased by 40% between 2007 and 2008 in the states of Goías and Mato Grosso do Sul, which mostly comprise the region of the Cerrado; 16% is the average increase for the Central-Western region as a whole (Canasat, 2008).

In the future, even more significant expansion of sugarcane into the Cerrado biome is expected. This is due mainly to the lower price of land compared with the state of São Paulo, flat landscape suitable for mechanical harvesting and climate conditions suitable for sugarcane plantations (Torquato, 2006). This expansion 'may directly or indirectly affect parts of the Cerrado area with native vegetation and unprotected forest where biophysical, infrastructural and socio-economic conditions are favourable for sugarcane cultivation. Most threatened are those lands adjacent to current production areas. Environmental consequences of sugarcane expansion might range from quite acceptable (conversion of crop land and managed pastures) to very negative where sugarcane expands directly or indirectly in unprotected areas, which still have native vegetation with high bio-diversity, or into unprotected native forests area' (Fisher et al., 2008, p.56). Another consideration is that the cost-benefit of sugarcane production is directly related to the distance between the sugarcane plantation and the mill and distilleries, which is at best up to 30 km and at a maximum 50 km (Gall1, 2011). This means that high biodiversity lands adjacent to current production areas are at risk of destruction. Not so obviously, biodiversity is also reduced when mixed farming systems are replaced by monoculture landscapes (Sawyer, 2008). The result of a study by Feltran-Barbieri (2008) in the Cerrado biome confirms that the use of extensive pasture land (instead of intensive cattle production) helps to protect biodiversity.

The view of the Cerrado as an agricultural resource has also been adopted internationally, as shown by a recent article published by The Economist (2010). It confirms the view of the Cerrado as the Brazilian agricultural frontier and as an example of large-scale agricultural production that should be followed by other countries. The article cites the FAO as stating that Brazil has a lot of spare land, mostly in the Cerrado area: 'It [Brazil] is often accused of levelling the rainforest to create its farms, but hardly any of this new land lies in Amazonia; most is cerrado' (The Economist, 2010).

Although many of the Brazilian actors who are holders of the *ethanol as a green fuel frame* see the expansion of the sugarcane as unthreatening to the conservation of biodiversity in the Cerrado, others point out the uncertainties surrounding how the expansion of ethanol production will occur. The actors in favour argue that the expansion will only occur on degraded land and land of low productivity. These actors ignore (or maybe, do not agree with) the alert issued by Martha Jr (2008) that the dynamics of land use are determined by the profitability of agricultural commodities and by any perceived risks to business. This implies that there is no guarantee that the expansion of sugarcane plantations will occur in low productivity or degraded areas, as suggested in the expansion policy. Furthermore, the adoption of new technologies for intensification of pastoral management (e.g. use of fertilisers, rotational grazing) will increase agro-chemical inputs, production costs (e.g. the final cost of cattle and of meat) and greenhouse gas emissions (Fisher et al., 2008; Galli, 2011).

5.2.3 Risks deriving from public policies and lack of environmental control

Some actors see the high deforestation rates in the Cerrado as deriving from past land use policies, which were often formulated with little attention to their implications for Cerrado conservation, in part because the Amazon Forest was the main focus on the conservation agenda (Klink & Machado, 2005). One example is that the Cerrado is not mentioned in the *Brazilian Magna Carta* from 1988, while the Amazon Forest is considered 'a national patrimony and its use will be in accordance with the law, within the conditions that make sure the preservation of its environment, including the use of its natural resources'. Another example that denotes the scant attention given to Cerrado conservation in public policy in the past, according to Klink & Machado (2005), is to be found in the Forest Code concerning the legal reserve (LR) requirements. While the Code requires that 20% to 35% of a holding in the Cerrado be maintained in its natural state as LR, in the Amazon rainforest this proportion is 80%.

The negative impacts of public policies are also perceived as a risk to natural vegetation. According to Brandon et al., (2005), underlying most of habitat conversion in Brazil is public policies supporting transportation, energy and communications infrastructure that open up areas for conversion, colonisation and other uses.

Lack of effective environmental regulation control is also perceived as a risk to deforestation of the Cerrado biome. An example of the lack of enforcement of the environmental legislation is given by Feltran-Barbieri (2008). He studied the state of preservation of the LRs and APPs in 65 rural properties, 37 dedicated to agriculture and 28 to cattle breeding, located in areas of intense agricultural activities within the Cerrado. The results showed that less than 20% of all properties fulfilled the requirements of the environmental legislation and only 13% of the agricultural properties. This coincides with the results of the study by Chomitz et al. (2005) that related the no compliance of the land owner with the legal reserve obligation.

Fisher et al. (2008) also perceive the risk deriving from lack of environmental control. According to them, increasing demand for livestock products will require replacement of the land converted to sugarcane, leading to substantial shifts of arable and pasture land to other regions, causing pressure on the ecosystems there. This could be avoided by effective environmental regulations and control and by implementation of agricultural policies supporting intensification of production.

5.3 Need for reframing

The availability of agricultural land is an issue that has been debated and discussed in Brazil since the start of the Proálcool programme. From the outset, it has been claimed that the country has sufficient potential land to expand sugarcane plantations (Borges, 1990), a potential that still exists nowadays, as shown in section 4.1. However, more recently, experts have issued warnings about such expansion, which they see as a determining factor in the destruction of the high biodiversity of the Cerrado biome (e.g., Lobo and Guimarães, 2008; Feltran-Barbieri, 2008; Machado et al., n/d; Sawyer, 2008).

Although many authors point to the generally high levels of threat to the biodiversity of the Cerrado biome, Branton et al. (2005, p.598) note that others see 'numerous reasons for cautious optimism provided Brazilian decision makers make choices that favour environmental and economic sustainability over short-term gains'. Lovejoy (2005) highlights the strong conservation science capability, one of the strongest in the world, and major conservation advances that have taken place in Brazil in recent decades. Marina Silva, the former Brazilian Ministry of Environment, believes that protected areas are the major tools available for the conservation of the country's natural resources, and says that experience has shown that 'even when suffering deficiencies in personnel, infrastructure, and management procedures, they are still effective barriers to the disorderly and rapacious occupation of natural environments…' (Silva, 2005, p.611).

In addition to these measures, this chapter identified a need for reframing to guarantee socially and environmentally sustainable expansion of ethanol should the hypothesis of a future large-scale expansion of sugarcane plantations become reality, especially in relation to the preservation of the biodiversity of the Cerrado biome. A great part of the biome has been replaced by arable and pasture land in recent decades and its biodiversity is now being seriously threatened. While some believe that the expansion of sugarcane will only occur on degraded pasture land (e.g. BNDES/CGEE, 2008; Cerqueira Leite et al., 2009; Goldemberg, 2008; 2009; Goldemberg et al., 2008; Macedo et al., 2008; Macedo & Seabra, 2008).

However, others point out that it is not clear how the displacement of crops and cattle for the expansion of sugarcane plantations will occur (Lobo and Guimarães, 2008; Feltran-Barbieri, 2008; Machado et al., n/d; Sawyer, 2008; Martha Jr, 2008). There is a good chance that such expansion will not happen in the Amazon region, as there are so many eyes, nationally and internationally, watching the Amazon forest for signs of deforestation and Brazilian law is attempting to severely limit such devastation. The same cannot be said for the Cerrado, which is seen as an agricultural frontier and not as a biome to be legally protected.

The conclusion in this chapter is that the natural vegetation of the Cerrado is not generally seen as such an important part of nature as the rainforests, especially considering that those defending the latter ignore the former. The dry, open landscapes dotted with the small, twisted trees that make up a large part of the vegetation in the Cerrado biome are remote from the idea of 'natural vegetation' inspired by the images of the luxuriant Amazon rainforest, which is considered to belong to the world.

The sustainability criteria adopted by the EU Directive on highly biodiverse grasslands may still result in the designation of some savannah as 'no-go' areas, according to Zahniser (2010). However, there is no final definition as yet. The EU environmental sustainability criteria have been viewed by ethanol producers and other Brazilian actors as a protectionist restraint on biofuel trade, but from a different standpoint they may be viewed as a genuine attempt to regulate production.

An impetus for reframing the use of the Cerrado biome may be given by the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilisation*, recently agreed by the parties during the UN Biodiversity Summit in 2010, to which Brazil is a signatory since February 2011. The Protocol creates a framework that balances access to genetic resources on the basis of prior informed consent and mutually agreed terms with the fair and equitable sharing of benefits, while taking into account the role of traditional knowledge. In addition, a plan to guide international and national efforts to save biodiversity and a resource mobilisation strategy to increase the current levels of official development assistance in support of biodiversity were drawn up in the meeting (Normile, 2010).

In addition to these, other incentives should be available to stimulate the conservation of the Cerrado biodiversity. A list of economic incentives to protect the areas of natural vegetation has been proposed to the Brazilian Congress within the scope of the Forest Code by the Instituto de Pesquisa Ambiental da Amazônia, IPAM (2011). Another important aspect of the proposal is the country's need of a better environmental management and control. Without both, the economic incentives and a good and efficient environmental management and control, it will be very difficult for the country to achieve its objectives and targets related to biodiversity and reduction of CO_2 emissions, as well as to consolidate its position as a sustainable agricultural power (IPAM, 2011).

6. Conclusions

During more than 30 years of the Brazilian Ethanol Programme, few conflicts arose in the country. It was not until the first decade of the 21st century that the production of ethanol became an international issue. The perspective of future, large-scale global production of ethanol raised conflicts involving environmental, social and economic factors, and these had an international dimension.

Some Brazilian actors believe that sustainable expansion of ethanol production is possible. They frame *ethanol as green fuel,* arguing that there is enough land available in Brazil for safe expansion of sugarcane plantations. Their arguments are based primarily on the high productivity of sugarcane per hectare and on the fact that an increase in ethanol production will not require much land. Another assumption is that sugarcane expansion will replace degraded pasture areas. Overseas actors, on the other hand, frame *ethanol as brown fuel* and express their concerns about its sustainability, with the focus on deforestation of the Amazon.

Developments during the past five years indicate that the risks to the Amazon forest are being controlled. However, the biodiversity of the Cerrado savannah seems not to be a concern of key actors to date. On the contrary, the Cerrado has been seen as fit for conversion to crops and pasture. Thus, a reframing of the use of Cerrado is needed to protect this fragile biome. The new Nagoya Protocol signed in 2010 may be a first step in placing value on biodiversity, an economic incentive to leave the Cerrado savannah standing that can compete with the economic incentive to tear it down.

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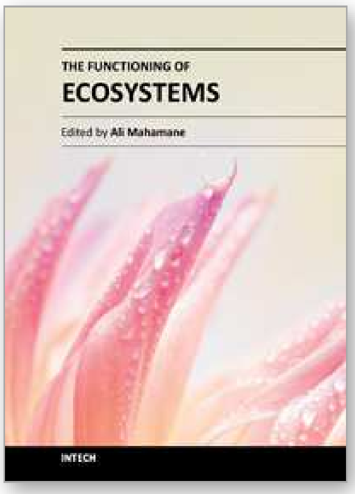

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The ecosystems present a great diversity worldwide and use various functionalities according to ecologic regions. In this new context of variability and climatic changes, these ecosystems undergo notable modifications amplified by domestic uses of which it was subjected to. Indeed the ecosystems render diverse services to humanity from their composition and structure but the tolerable levels are unknown. The preservation of these ecosystemic services needs a clear understanding of their complexity. The role of the research is not only to characterise the ecosystems but also to clearly define the tolerable usage levels. Their characterisation proves to be important not only for the local populations that use it but also for the conservation of biodiversity. Hence, the measurement, management and protection of ecosystems need innovative and diverse methods. For all these reasons, the aim of this book is to bring out a general view on the biogeochemical cycles, the ecological imprints, the mathematical models and theories applicable to many situations.

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