VICTORIA UNIVERSITY OF WELLINGTON
Te Whare Wānanga o te Ūpoko o te Ika a Māui

Analysing the Brazilian Sugarcane Agroecological Zoning

Is this government policy capable of avoiding adverse effects from land-use change?

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Abstract

There are doubts about the reliability of so-called biofuels to reduce greenhouse gas (GHG) emissions and conserve biodiversity. Brazil is the largest producer of sugarcane ethanol in the world. This thesis analyses the extent to which the Brazilian Sugarcane Agroecological Zoning (ZAE Cana), a federal policy developed in 2009, can contribute to reducing, or avoiding, adverse environmental impacts in terms of GHG emissions and biodiversity degradation. It takes into account both direct and indirect effects of land-use change (LUC) caused by the expansion of sugarcane in Brazil. Because sugarcane expansion has primarily displaced areas of pasture, most of the literature reviewed, and information from the participants, are optimistic in regard to GHG emissions due to direct LUC. But the expansion of sugarcane has caused biodiversity impacts and it may be aggravated in the near future. Despite increase in agricultural productivity, studies contend that indirect LUC caused by the increase in sugarcane ethanol production in Brazil is expected to take place. Qualitative face-to-face, semi-structured interviews were undertaken with experts representing private institutions, the Brazilian government, the sugarcane industry association and the NGO WWF-Brazil. The key stakeholders were chosen to elicit knowledge from a range of respondents with experience of the production of Brazilian sugarcane ethanol. The interviews were also used to investigate the importance of, and motivations to create, ZAE Cana. ZAE Cana has shortcomings and there is significant impact on LUC caused by other agricultural activities. Monitoring and enforcement of specific legal frameworks are important. Agroecological zonings for other activities such as pasture, soybeans and corn should also be developed to control detrimental indirect LUC.

Keywords: Brazilian Sugarcane Agroecological Zoning, greenhouse gas emissions biodiversity degradation, direct and indirect land-use changes.

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Acronyms

ANFAVEA	Brazilian Motor Vehicle Manufacturers Association
BWC	Biofuels Watch Center
CBNE	Biodiversity Corridor of the Northeast region of Brazil
CENBIO	National Reference Center on Biomass
CO_2	Carbon dioxide
Conab	National Supply Company
CTBE	Brazilian Bioethanol Science and Technology Laboratory
CTC	Sugarcane Research Center
EISA	Energy Independence and Security Act
EMBRAPA	Brazilian Agricultural Research Corporation
EU	European Union
GHG	Greenhouse gas
IATA	International Air Transport Association
ICONE	Institute for International Trade Negotiations
IEA	São Paulo State Institute of Applied Economics
INPE	National Institute of Space Research
LUC	Land-use change
MAPA	Brazilian Ministry of Agriculture, Livestock and Food Supply
MCT	Brazilian Ministry of Science and Technology
MDIC	Brazilian Ministry of Development, Industry, and Foreign Trade
MMA	Brazilian Ministry for the Environment
MME	Brazilian Ministry of Mines and Energy
MPF	Brazilian Federal Prosecution Office
NZEECS	New Zealand Energy Efficiency and Conservation Strategy
PCE	Parliamentary Commissioner for the Environment
PIRM	Pacific Institute of Resource Management
REN21	Renewable Global Status Report
RFS2	Renewable Fuels Standard 2
SMA	São Paulo State Secretary for the Environment
SNUC Act	Brazilian National System of Conservation Units

The Map	Map of Priority Areas for Biodiversity Conservation
UNEP	United Nations Environment Programme
UNICA	Brazilian Sugarcane Industry Association
USDA	United States Department of Agriculture
WWF	World Wildlife Fund
ZAE Cana	Brazilian Sugarcane Agroecological Zoning (*Zoneamento Agroecológico da Cana*)

Contents

Tables

Figures

Pictures

Chapter 1

Introduction

1.1 Context of the research

Sustainable development has become a deepening concern on the world's policy agenda (Bohringer and Jochem, 2007; KPMG International, 2012). Many countries have sought to develop alternative fuels to provide greater energy security, deal with oil price spikes and uncertainty, invest in rural development, and reduce greenhouse gas (GHG) emissions (Gallagher, 2008). It has been argued that "with growing concerns about climate change, the choice for solving the problem of energy supply for transport could lie with lower-carbon alternatives like biofuels" (Méjean and Hope, 2010, p 1). For example, New Zealand, aiming to reduce its GHG emissions in the transport sector, has encouraged whey ethanol (a by-product of New Zealand's dairy industry) and Brazilian sugarcane ethanol as alternative sources to blend with gasoline[1] (PCE, 2010).

Nevertheless, there are doubts about the reliability of so-called biofuels to reduce GHG emissions and conserve biodiversity. Recent studies argue that biofuels, depending on their impacts on land-use change, might emit more GHG (at least in the short term) than fossil fuels (Fargione et al. 2008; Searchinger et al. 2008; Biello, 2011). In addition, land-use change due to conversion of natural habitats into human dominated land use has been historically identified as the largest threat to global biodiversity (UNEP, 2009).

This thesis focuses on the production of Brazilian sugarcane ethanol and, more specifically, direct and indirect land-use changes due to the expansion of sugarcane

[1] In 2007 the New Zealand government of the day announced a Biofuels Sales Obligation (BSO) to ensure that the transport sector used 3.4% of biofuels by 2012 (NZEECS, 2007). Although the BSO was then repealed by the National government in 2009, there is support towards the use of bioethanol in NZ. To date, this alternative fuel is exempt from excise tax (Ministry of Transport, 2012).

crops. Direct and indirect land-use changes can impact negatively on the environment. Adverse direct land-use change happens when additional cropland for biofuel production is made available through the conversion of native ecosystems such as forests and grasslands. Adverse indirect land-use change may occur if agricultural land for non-energy production, e.g. crops or pasture, is extended into native ecosystems as the result of a land-use transition from this type of production to biofuel feedstock cultivation (Ravindranath et al. 2009).

In Brazil, sugarcane is mainly milled to produce sugar, energy and ethanol.[2] These products are sold to fuel distributors, the food industry, wholesalers, retailers, exporters, and electricity generators and distributors[3] (Neves, Pinto, Conejero and Trombin, 2011). Brazil produced 36.4 million tonnes of sugar in the 2009/2010 crop year, representing 24 per cent of all sugar produced in the world, and exported 24.3 million tonnes, or 47 per cent of the world's exports (USDA, 2010). In addition, Souza (2011) estimates that 129 sugarcane mills (30 per cent of the total) cogenerated 18.5 Terawatt-hours in 2010 in Brazil, and this represented 5.1 per cent of Brazilian electricity production (MME, 2010). Brazil is the second largest producer of fuel ethanol in the world, behind the United States. According to the Renewable Fuels Association (2011), Brazilian ethanol production from sugarcane in 2011 was 28 billion litres[4] (Conab, 2011); while US corn ethanol production was 49 billion litres in that year (see Table 1.1).

[2] Other products include *cachaça,* which is the most popular distilled alcoholic beverage in Brazil, sugarcane juice, pharmaceutical products, and "green" plastics.
[3] The electricity generated from sugarcane in Brazil is produced through the crushing of bagasse. Bagasse is the dry fibrous waste left after sugarcane is crushed. The bagasse is burned in boilers generating steam and electricity (Neves et al. 2011).
[4] Despite being the second largest producer of fuel ethanol, Brazil imported from the US about 1 billion litres of ethanol in 2011. This is due primarily to strong global demand for sugar, weather adversities and surging domestic motor-fuel demand (BiofuelsDigest, 2011; MDIC, 2012).

Table 1.1: Ethanol Production, Top 10 Countries and EU Total, 2011

Country	Fuel ethanol Billion Litres
1. United States	49
2. Brazil	28
3. China	2.1
4. Germany	1.5
5. Canada	1.4
6. France	1.1
7. Spain	0.6
8. Thailand	0.4
9. Colombia	0.4
10. Belgium	0.3
World Total	**86**
EU Total	**4.5**

Source: REN21 (2011). *The table has been adjusted by the author to show only fuel ethanol production. The table ranking was originally by total fuel ethanol and biodiesel production.

Brazil aims to increase substantially the production of sugarcane ethanol within this decade due to growing national and international demand (Manzatto, 2009). According to the Brazilian Motor Vehicle Manufacturers Association (ANFAVEA, 2010), flex-fuel cars, i.e. those fuelled with pure gasoline, alcohol, or any mixture of these fuels, currently account for over 90 per cent of total sales of light vehicles in Brazil and already represent 40 per cent of Brazil's light vehicle fleet. In 2010 the ethanol share stood at about 54 per cent of the Brazilian total light vehicle fleet demand for fuel (Neves et al. 2011). ANFAVEA (2010) estimates that the Brazilian vehicle fleet may increase from 25.5 million vehicles in 2010 to about 31 million by 2015, of which 19 million may be flex-fuel vehicles.

External consumption of Brazilian sugarcane ethanol may also grow considerably within this decade (Neves et al. 2011). Europe, one of the largest external markets of Brazilian sugarcane ethanol in the world, launched the EU Renewable Energy Directive in 2009. This directive mandates that by 2020 renewable fuels, which reached 5.1 per cent in 2010 (this percentage includes the use of Brazilian sugarcane ethanol), must account for 10 per cent of all transportation fuels (Energy in Europe, 2011). The United States EPA's Renewable Fuels Standard 2 (RFS2), under the Energy Independence and Security Act (EISA) 2007, requires minimum renewable fuels consumption in the US to rise from about 45 billion litres in 2010 to 136 billion litres by 2022.[5] Additionally, Brazilian sugarcane ethanol may be used in the aviation sector. The International Air Transport Association (IATA) set up in 2009 both a cap on aviation carbon dioxide (CO_2) emissions from 2020 and a reduction policy in CO_2 emissions of 50 per cent by 2050, relative to 2005 levels (IATA, 2009; UNICA, 2011).

In this context, recent studies, based on increase in demand for both Brazilian sugar and ethanol, estimate the amount of land which sugarcane crops may occupy in Brazil in the future. For example, the Institute for International Trade Negotiations (ICONE, 2011) estimates that the amount of land used for sugarcane production may reach around 10.5-11.5 million hectares by 2022, compared with 9 million hectares in the 2010/2011 harvest. In addition, the São Paulo State Institute of Agricultural Economics (IAE, 2011) estimates that the amount of land used by sugarcane crops in Brazil may reach 10.6 million hectares by 2020, and 14.6 million hectares by 2030.

In order to provide technical support to sugarcane companies to sustainably expand their production, the Brazilian government announced in 2009 the Brazilian Sugarcane Agroecological Zoning (*Zoneamento Agroecológico da Cana* – hereafter

[5] Of the total of 136 billion litres by 2022, 79 billion litres per year have to be one of the three types of advanced biofuels: cellulosic, biomass diesel, and "other advanced". The RFS2 requests the use of at least 15 billion litres of "other advanced" renewable fuels a year by 2022. The US EPA has designated Brazilian sugarcane ethanol as an advanced biofuel after estimating that it reduces GHG emissions compared to gasoline by 61%, using a 30-year payback for land use change emissions (UNICA, 2010).

ZAE Cana). Two main drivers for creating ZAE Cana are to consolidate Brazil's current sugarcane ethanol market worldwide, and also to gain new international markets in the near future for Brazilian sugarcane ethanol (Biofuels Watch Center - BWC, 2009). It is advantageous for Brazil to demonstrate to potential sugarcane ethanol buyers that Brazilian sugarcane ethanol contributes to mitigating global warming and does not cause other environmental harms such as biodiversity degradation. In other words, for most sales it is useful to demonstrate that increasing the production of Brazilian sugarcane ethanol will not adversely impact native land or relevant biomes, such as the Amazon rainforest and Pantanal wetlands. Nevertheless, ZAE Cana is a recent policy (less than three years old at the time of writing of this study), so there is still a lack of information, understanding and data regarding its effectiveness.

1.2 Contribution of this research

1.2.1 Research purpose

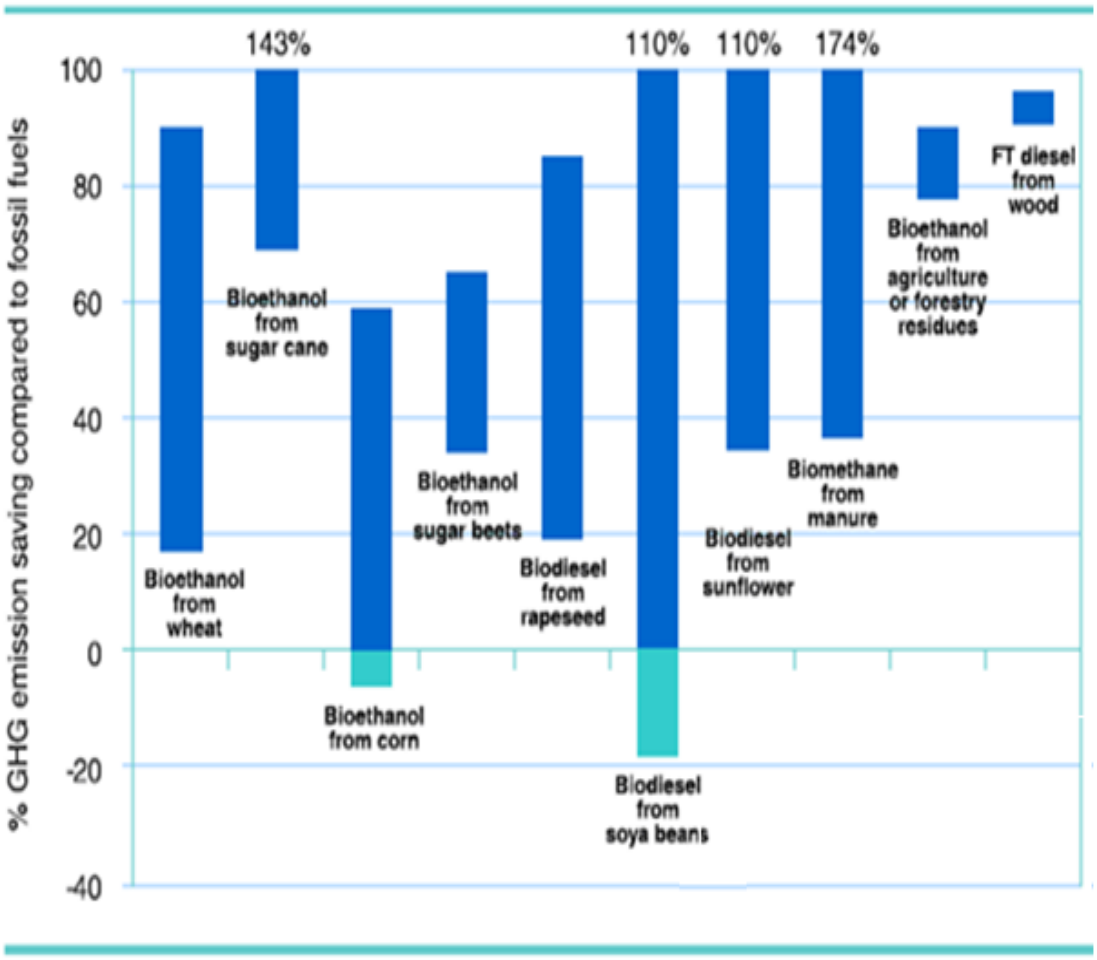
In 2009, the New Zealand government developed the Sustainable Biofuel Bill, which aims to ensure that biofuels supplied or sold here are sustainable biofuels (NZ Parliament, 2009). To date, this Bill still needs to receive the Royal assent to become law. However, the aspects of sustainability that are investigated in this thesis are to a great extent based on principles 1 and 3 of the Sustainable Biofuel Bill. Principle 1 of this Bill requires that biofuels supplied or sold in New Zealand reduce at least 35 per cent of GHG emissions in comparison to other engine fuels. Principle 3 of this Bill requires that the production of biofuels does not reduce indigenous biodiversity or adversely affect land with high conservation value.

This thesis discusses different projections on the expansion of sugarcane crops in Brazil, i.e. likely locations and amount of land required for this expansion. These projections, which are discussed in the literature review (Chapter 4) and in the findings from fieldwork (Chapter 5), are the primary resources underpinning this thesis. The core of this thesis analyses whether or not ZAE Cana, a national policy to

limit unsustainable expansion of sugarcane crops in Brazil, is capable of preventing adverse land-use change (LUC) caused by this expansion. The aim is to develop knowledge on the extent to which ZAE Cana can contribute to reducing, or avoiding, adverse impacts in terms of GHG emissions and biodiversity degradation, taking into account both direct and indirect LUCs.

The focus of this research project is on Brazilian sugarcane ethanol for three reasons. Firstly, it is argued that ethanol from sugarcane has one of the highest potentials for GHG savings relative to fossil fuels (see Figure 1.1). However, direct and indirect LUCs are not included in most of the current GHG life-cycle assessments (Seabra et al. 2011). Secondly and as discussed above, Brazil is the second largest producer of bioethanol in the world, behind the United States. Thirdly, New Zealand has encouraged biofuel blends, with the result that Brazilian sugarcane ethanol is available as an alternative fuel at a number of service stations in New Zealand (PCE, 2010).

Figure 1.1: Greenhouse gas savings of biofuels compared to fossil fuels (no LUC included)



Source: UNEP (2009)

1.2.2 Aim of this thesis

This thesis seeks to answer the following questions:

Is ZAE Cana capable of ensuring conservation of native biomes and environmentally sensitive areas as production of Brazilian sugarcane ethanol increases and causes direct land-use change? Additionally, how likely is ZAE Cana to prevent adverse environmental side effects caused by indirect land-use change, particularly deforestation of native biomes and environmentally sensitive areas?

The specific objectives of the research are to:

1. Analyse environmental impacts, i.e. GHG emissions and biodiversity degradation, caused by direct land-use change (LUC) arising from the expansion of Brazilian sugarcane crops to date and in the future.

2. Analyse environmental impacts caused by indirect LUC arising from the expansion of Brazilian sugarcane crops to date and in the future.

3. Discuss the strengths and shortcomings of ZAE Cana.

4. Understand what may be improved in ZAE Cana in order to avoid detrimental direct and indirect land-use changes from Brazilian sugarcane expansion.

1.2.3 Process for examining research questions

This thesis is organised as follows: Chapter Two details the methodology selected to fulfil the aim of this study. Chapter Three reviews the specific Brazilian sugarcane context and the broader picture relevant to the production of sugarcane ethanol. Chapter Four reviews the literature relevant to the three first objectives. The literature review provides important information to further discuss the fourth objective in the discussion Chapter. Chapter Five presents the major findings of the stakeholder interviews conducted in mid-2011 in Brazil (and one from New Zealand). The focus of Chapter Six is an analysis and discussion of the empirical and literature-based results; this is followed by a Conclusion chapter.

1.2.4 Scope and approach

This thesis analyses the objectives from, primarily, a legal and regulatory standpoint. Scientific information comes from reviewing the literature and official data, and eliciting the opinion of key experts. This research project focuses not only on the national context, but also on the specific context of the state of São Paulo, where more than 60 per cent of sugarcane ethanol is produced (CANASAT, 2011). The research project discusses projections on the expansion of sugarcane crops, i.e. likely locations and amount of land required for this expansion, in Brazil up to 2030. The

fieldwork conducted in Brazil from May-August 2011, and in New Zealand in August 2011 via Skype, is mainly focused on the state of São Paulo. Regulatory analysis of the environmental policies in the state of São Paulo contributes significantly to the picture developed in this thesis. Additionally, in order to further explore the dynamics with which ZAE Cana deals, this thesis also discusses other legal frameworks. These legal frameworks are the São Paulo Sugarcane Agroecological Zoning, National System of Conservation Units (SNUC) Act and Brazilian Forest Code.

Chapter 2

Methodology

This chapter describes the methodology used to address the aim of this thesis. It describes the author's positionality, disciplinary context, and research design. It then presents specific methods selected to address the four objectives of this study.

2.1 Methodological approach

2.1.1 Disciplinary context and positionality

In New Zealand in April 2010 a public meeting, *The Reality Behind Brazilian Biofuels in New Zealand*, challenged the sustainability of Brazilian sugarcane ethanol. The Pacific Institute of Resource Management (PIRM), for example, called for a moratorium on sugarcane ethanol imports from Brazil (PIRM, 2010). All the debates around Brazilian sugarcane ethanol in New Zealand in 2010 were significant drivers of this study. This thesis was also motivated by the assumption that mainstream information on the sustainability of Brazilian sugarcane ethanol may have been motivated by short-term economic gain; and by noting that critical viewpoints have not been as accessible as studies provided by the sugarcane industry and the Brazilian government. It is also noted that 'biofuel' is the term most commonly used to refer to Brazilian sugarcane ethanol. Alves (2008) contends that 'biofuel' is a term with great marketing appeal as it has the prefix *bio*, which means life, so directly indicates a contrast to fossil fuels. 'Agrofuel' is an alternative and more neutral descriptor with (arguably) less marketing appeal. 'Agrofuel' focuses on the mode of production of Brazilian sugarcane ethanol as it is produced from sugarcane crops that require arable land to grow.

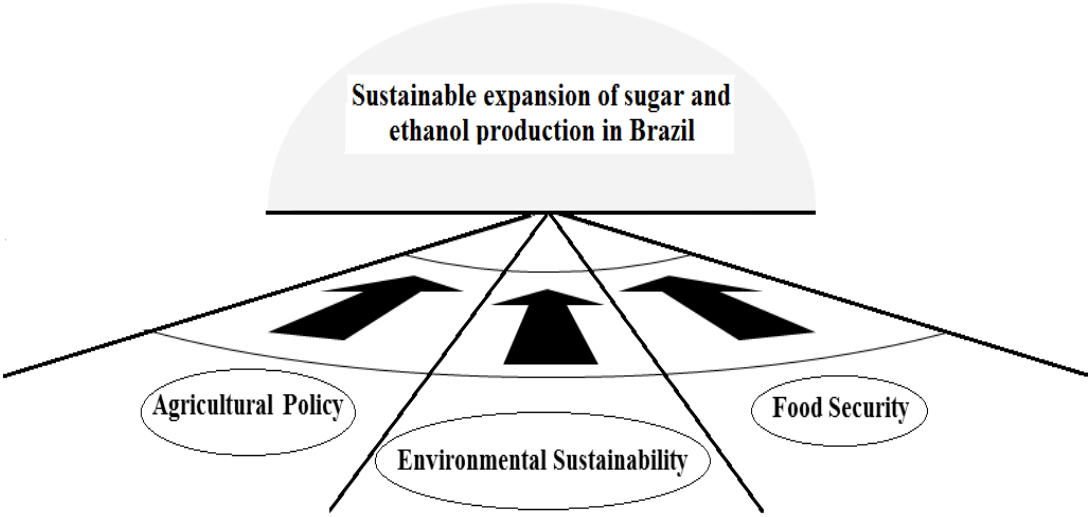
In order to minimise author bias and, hence, present a study as judgment-free as possible, this research project selected experts representing different types of

institution, and reaches policy conclusions which draw on their analysis. Additionally, the author's background in Law played a role in this study. It underpins the assumption that legal instruments such as ZAE Cana, if properly drafted and implemented, are necessary (although not usually sufficient) to regulate economic processes and, thus, improve environmental, social and economic outcomes.

2.1.2 Research design

This thesis was carried out mainly as evaluative research. It used a qualitative empirical research strategy to analyse data sets arising from the literature review and the experience and expertise of key stakeholders. In addition, this thesis used the tool of "Goal-Free Evaluation" to design the methodology process (Crabbé and Leroy, 2008, p 77). This tool allows for a better understanding of how this study was conducted and, hence, facilitates other researchers in replicating the analysis. However, the term 'goal-free' is to a great extent a misnomer, so it requires careful explanation and interpretation. It is 'goal-free' in the sense that this study does not assume that the goals of ZAE Cana presented by policy-makers are necessarily the goals of interest. According to the Brazilian government, the aim of ZAE Cana to provide guidance for a sustainable expansion of sugar and ethanol production in Brazil is divided into three goals (see Figure 2.1). This thesis discusses specific environmental aspects of sustainability. Within the 'environmental sustainability' goal of ZAE Cana this thesis focuses, as discussed above, on GHG emissions and biodiversity degradation potentially caused by the expansion of sugarcane crops in Brazil.

Figure 2.1: Goals of ZAE Cana, according to the Brazilian government



Source: Author's database, after Manzatto (2009)

The tool of goal-free evaluation supports the evaluator to answer the following question: "Is this policy 'right'?" (Crabbé and Leroy, 2008, p 77). In this thesis, the word 'right' is taken not in a normative sense, but in the sense of whether or not ZAE Cana is capable of achieving ecological outcomes. These outcomes are to ensure conservation of native biomes and environmentally sensitive areas as production of Brazilian sugarcane ethanol increases and causes land-use change (LUC). Therefore, such a question could be framed and asked as follows: Is ZAE Cana an effective policy to avoid biodiversity degradation and avoid GHG emissions due to LUC? [6]

2.2 Research process

The tool of goal-free evaluation is divided into four steps. The first step deals with designing the study evaluation, so a selection of methods for evaluating the intended object is made. The second step deals with selecting the evaluator, who subsequently brings key experts with knowledge in the policy field in question. Although key

[6] The analysis of effectiveness investigates whether or not implementing ZAE Cana may avoid detrimental LUC in terms of GHG emissions and biodiversity conservation. The analysis of efficiency, which refers to the most economical way to perform a task, is outside the scope of this thesis.

experts were in this study selected to enhance the understanding of the objectives presented in Section 1.2.2 above, this second step was not used literally. Using step two literally would not suit the specific purpose of an academic study. The 'evaluator' is the author of this thesis, i.e. the conductor and initial person to design and implement this study. The third step deals with evaluating information and data from the first step. The last step consists in formulating policy conclusions.

2.2.1 Step one: Selection of methods

This thesis uses two different qualitative methods to meet the four objectives presented in Section 1.2.2 above. These methods are: (1) analysis emerging from the literature review and official data, which is presented in Chapter 3 (specific research context) and Chapter 4 (literature review); and (2) face-to-face, semi-structured, exploratory interviews with key stakeholders (see Table 5.1). The findings from the interviews are presented in Chapter 5. The key stakeholders were chosen in order to elicit knowledge from a range of respondents with experience of the production of Brazilian sugarcane ethanol and its impacts due to land-use changes. The group of participants included experts from a variety of backgrounds, in order to ensure a heterogeneous range of opinions.

2.2.2 Step two: Engaging key experts

Participant selection

An initial research process carried out by the author enabled the identification of the main writers specialising in the specific topic of this thesis after review of a wide range of articles. The articles were initially selected on the internet by using 'Google Scholar' and the webpages of institutions involved with the study of Brazilian sugarcane ethanol. The library database of Victoria University of Wellington was also used. Thus, potential participants were first selected from academic and non-academic publication databases. These potential participants (nine of the total of 13) were approached by email, and confirmation of the interview appointments was by phone when the author was in Brazil. From the first nine participants a 'snowballing'

approach was used where they were asked to recommend other individuals for interviews. In-depth interviews were thus conducted with 13 stakeholders from government, industry consultants with Brazilian sugarcane ethanol expertise, the sugarcane industry, and the NGO World Wildlife Fund (WWF) Brazil. The relevance of the participants for this thesis is explained in **Appendix A**.

Interview protocol

Seven of a total of eight interviews (covering the 13 stakeholders) were performed between May and July 2011 in Brazil, taking place in person and typically lasting around one hour. The last interview was performed in August 2011 when the author was back in New Zealand and was via Skype with the participant in Brazil. Interviews were semi-structured and based around an indicative questionnaire with ten questions listed in the interview schedule (**Appendix B**). This schedule was sent to interviewees in advance of the interview. The detail of the wording and order of questions was regularly modified to improve clarity and suit each participant's area of expertise. Interviews were digitally recorded. Interviewees were given the option of remaining confidential or being identified by name, as approved by the Victoria University of Wellington Human Ethics Committee (**Appendix C**).

2.2.3 Step three: Analysis of data from fieldwork

The data that emerged from the interviews were coded. Coding is a common technique used in qualitative research (Bryman, 2008). The coding of the transcripts entailed reviewing the data, labelling component parts and organising the data into emergent themes. Here, the review of the data required listening to the recordings of the interviews and then extracting the main findings, which were simultaneously translated from Portuguese into English. Second, the main findings were labelled and then organised into themes. The themes were created based on the following three points:

- The topics found in the questions presented to the participants;

- Outcomes from those parts which the participants specifically answered;
- The ZAE Cana's shortcomings discussed in the section 4.3.1 below.

2.2.4 Step four: Formulation of policy conclusions

The conclusions that emerged from data analysis (literature review, official data and interviews) are presented in Chapter 7. The Grounded Theory approach to data analysis was used as a strategy for generating theory from data. The inductive nature of grounded theory allows for an exploratory approach, as theory is generated and enhanced through the collection of data (Bryman, 2008). However, grounded theory had to be adapted for the specific purpose of this thesis. The requirement to form a research proposal at the start of this thesis necessitated formulation of a specific research question, a practice often discouraged in grounded theory (Bryman, 2008). In addition, the data analysis differed from a pure grounded theory approach in that it employed certain assumptions discussed in Section 2.1.1 above, along with a hypothesis that emerged during the formulation of the research question. This hypothesis refers to the notion that the agricultural stage of the production of Brazilian sugarcane ethanol may involve unsustainable practices. This hypothesis was underpinned by two facts. Firstly, direct and indirect LUCs are not included in most of the current GHG life-cycle assessments of Brazilian sugarcane ethanol (Seabra et al. 2011). Secondly, Brazil has recently, i.e. in 2009, developed ZAE Cana, which means a policy was viewed as necessary to control sugarcane expansion in Brazil. Thus, this study does not use a pure grounded theory approach. Nevertheless, it is believed that the approach adopted is desirable in making clear the assumptions of the study, as this helps form a more focused investigation, and builds upon the work done by others (Bryman, 2008).

Chapter 3

Brazilian sugarcane ethanol context

This chapter describes the context in which Brazilian sugarcane ethanol is produced, by reviewing the literature and analyzing official data. This description addresses not only the specific context of Brazilian sugarcane ethanol, but also the broader picture relevant to the production of this fuel.

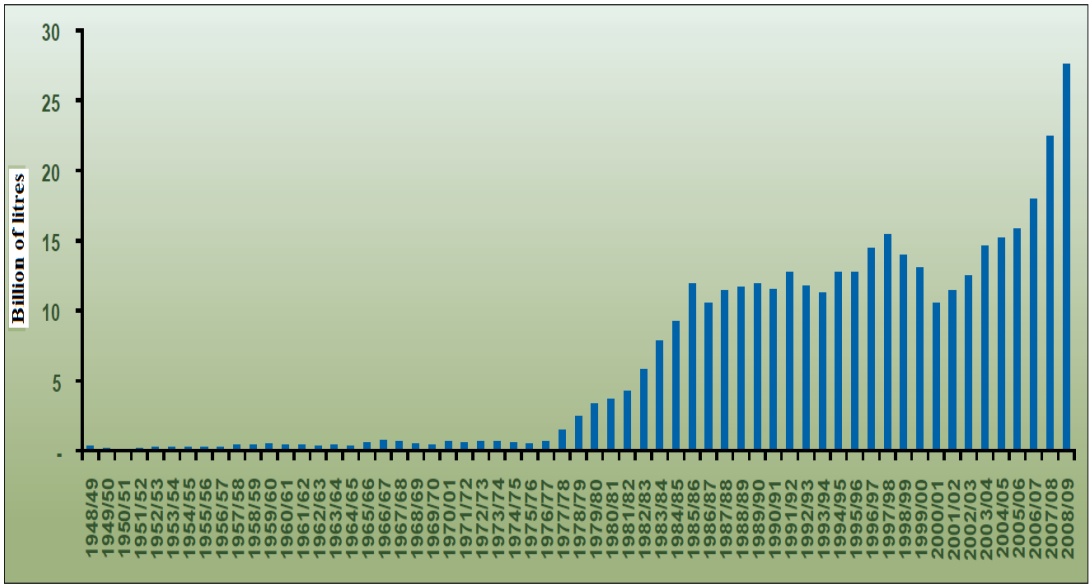
3.1 History of sugarcane in Brazil and the location of main crops

Sugarcane has been a crop in Brazil since its initial colonisation period in the 16th century, when this plant was used to produce just sugar. Brazilian sugarcane ethanol was first introduced in the 1920s, but it was only in the 1970s, during the first global oil crisis, that Brazil started producing significant amounts of sugarcane ethanol (Martines-Filho et al. 2006). Brazil launched in 1975 the National Alcohol Programme (*Pró-Alcool)* to reduce the need for oil imports, provide an additional market for Brazilian sugarcane and create new jobs in the agricultural sector (Schuring, 2008). More recently, with the introduction of flexible fuel cars in the Brazilian market in 2003 and a significant increase in exports of Brazilian sugarcane ethanol since 2004, the sugarcane area has considerably expanded (Neves et al. 2011). The sugarcane area increased from about 5.4 million hectares in 2003 to 9 million hectares in the 2010/2011 harvest (MAPA, 2009b; IBGE, 2011). About 60 per cent of the area cultivated with sugarcane is used for the production of ethanol[7]

[7]Brazil produces two types of ethanol: hydrous, which contains about 5.6% water content; and anhydrous, which is virtually water-free. Hydrous ethanol is used to power vehicles equipped with pure ethanol or Flex-Fuel engines, while anhydrous ethanol is mixed with petrol before it reaches the pump. All petrol sold in Brazil must contain between 20% and 25% anhydrous ethanol in the blend (Neves at. 2011). Brazil produced 19 million litres of hydrous ethanol and 7 million litres of anhydrous ethanol in 2010 (Conab, 2011).

and 40 per cent for the production of sugar (Conab, 2011). Figure 3.1 shows the growth in ethanol production in Brazil overtime.

Figure 3.1: Growth in ethanol production in Brazil, 1948-2009



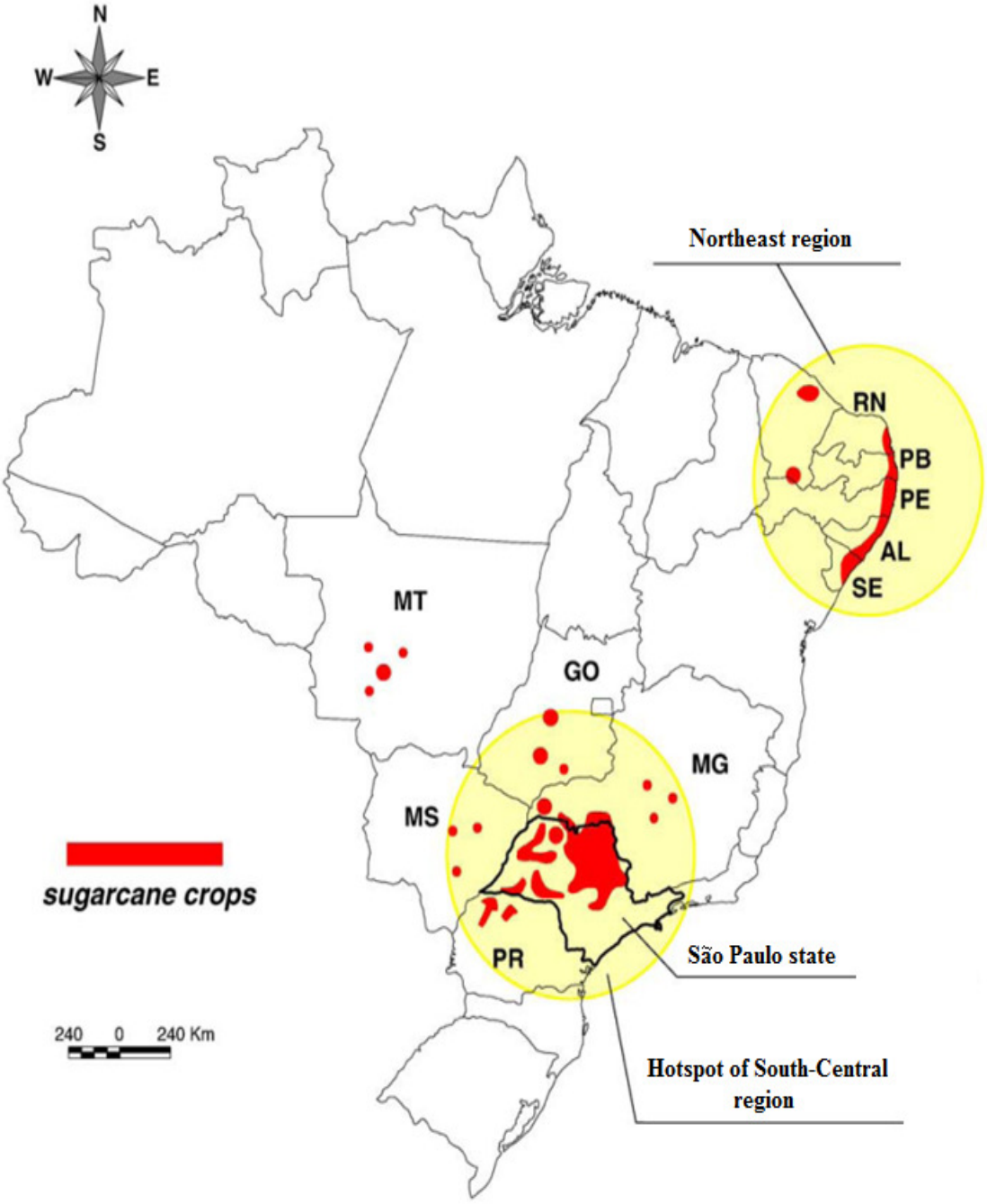
Source: Ministry of Agriculture, Livestock and Food Supply (MAPA, 2010)

According to Neves et al. (2011), ethanol sales accounted for about US$ 12,4 billion in 2008, taking into account the domestic and international markets. In addition, of the total of 26 billion litres of ethanol produced in Brazil in 2010, 1,9 billion litres were exported mainly to the United States, Jamaica, Japan, and the Netherlands. These exports accounted for about US$ 1 billion, representing around 0,5 per cent of the total exports of US$ 202 billion and 0,02 per cent of the Brazil's GDP of R$ 3,6 trillion (~ NZD 2,5 trillion) (MDIC, 2012).

Sugarcane mills in Brazil most often obtain the cane by growing it in their own areas or leasing an area where they manage all the agricultural activity. The Interdisciplinary Centre of Energy Planning at the São Paulo State University of Campinas (NIPE/UNICAMP, 2005) estimates that 65 per cent of the area cultivated with sugarcane is either owned or leased by mills, while 35 per cent belongs to

independent producers. To date, there are 437 sugarcane mills in Brazil located mainly in the South-Central region (comprising the states of São Paulo-SP, where 56 per cent of the total sugarcane area is located, Minas Gerais-MG, Paraná-PR, Goiás-GO, Mato Grosso do Sul-MS, and Mato Grosso-MT). The remainder of sugarcane mills are in the Northeast region and other states such as Rio de Janeiro (Souza, 2011). The Brazilian Ministry of Development, Industry and Foreign Trade (MDIC) states that of the total of 437 mills in Brazil, 168 mills produce only ethanol, 16 only sugar and 253 are capable of producing both ethanol and sugar (MDIC, 2012). According to Neves et al. (2011), sugarcane in Brazil is largely cropped within a distance of about 50 kilometres from the mill. This is due to transportation costs and because sugarcane is an input that has a short shelf life after harvest (about 48 hours). Thus, most of the sugarcane crops in Brazil are located close to the existing mills (compare Figures 3.2 and 3.3).

Figure 3.2: Location of main sugarcane crops in Brazil



Source: Gallardo and Bond (2010)

Figure 3.3: Location of all existing and projected mills in Brazil

Source: MAPA (2009)

3.2 Background of land use in Brazil

Brazil possesses a territory of 851 million hectares, making it the fifth biggest country in the world (IBGE, 2011). About 511 million hectares of the Brazilian territory remains predominantly as natural vegetation and, although not all pristine, much of this area has high conservation value (Sparovek et al. 2012). For example, the Amazon rainforest occupies about 419 million hectares and its forest cover is currently about 354 million hectares (MMA, 2010). Of Brazil's total area, 340 million hectares (40 per cent of the total) can be used for crops and livestock (Neves et al. 2011). Table 3.1 summarises land use in Brazil, showing the total areas under preservation and other uses, total arable land, the amount of land in pasture and used for some of the crops including sugarcane, and the available land for agriculture and livestock expansion. Sugarcane crops occupy only around 1 per cent and 2.6 per cent of Brazil's total land and arable land, respectively. However, more than 20 per cent (5.4 million hectares) of the territory of the state of São Paulo, where 60 per cent of the national sugarcane ethanol is produced, is occupied by sugarcane (CANASAT, 2011).

Table 3.1: Land use in Brazil and expansion possibilities, 2011

Land use in Brazil and expansion possibilities			
	Million hectares	% of total land	% of arable land
Brazil	851	100%	
Total Preserved Areas and Other Uses *	511	60%	
Total Arable Land	340	40%	100%
1 Cultivated Land: All Crops	72.0	8.5%	21.1%
Soybeans	24.3	2.85%	7.1%
Corn	14.6	1.7%	4.3%
Sugarcane	9	1.05%	2.64%
Sugarcane for ethanol **	5.4	0.63%	1.58%
Orange	0.9	0.1%	0.3%
2 Pastures	200	23.5%	58.8%
3 Available Land (agiculture and livestock)	68	7.9%	20%

*These areas include the Amazon rainforest, protected areas, conservation areas and reforestation, cities and towns, lakes and rivers. **Harvested area for ethanol production based on the allocation of sugar to ethanol, which is currently about 60 per cent.
Source: GBEP (2011); Neves et al. (2011)

3.2.1 Land-use change due to Brazilian sugarcane crops

As discussed in Section 1.2.1 above, this thesis focuses on environmental impacts caused by the expansion of sugarcane crops in Brazil and, more specifically, biodiversity degradation and GHG emissions due to this expansion.

Biodiversity and sugarcane crops

The expansion of agriculture is a long-running historical phenomenon in a large country such as Brazil. The sugarcane industry itself has undergone intensive expansion cycles (Macedo, 2007). On top of the period of the last decade, in which most of the increase in Brazil's production of sugarcane ethanol has occurred, other cycles of major sugarcane expansion occurred during the National Alcohol programme, 1975-1990. During this programme the Brazilian military government stimulated the conversion of forests into sugarcane plantations to supply the internal

market with ethanol. This expansion had a significant negative impact on the Atlantic Forest biome, contributing to reducing this biome to about 26 per cent of its original area of 111 million hectares (Bernard, Melo and Pinto, 2011). The area currently occupied by sugarcane crops in Brazil is largely located in lands that were originally covered by the Atlantic Forest biome (WWF, 2008). Another Brazilian biome which is currently threatened by the expansion of sugarcane crops is the Cerrado savannah. This is due to the location of sugarcane crops being mainly in the South-Central region, where a large amount of this biome is located (ICONE, 2011).

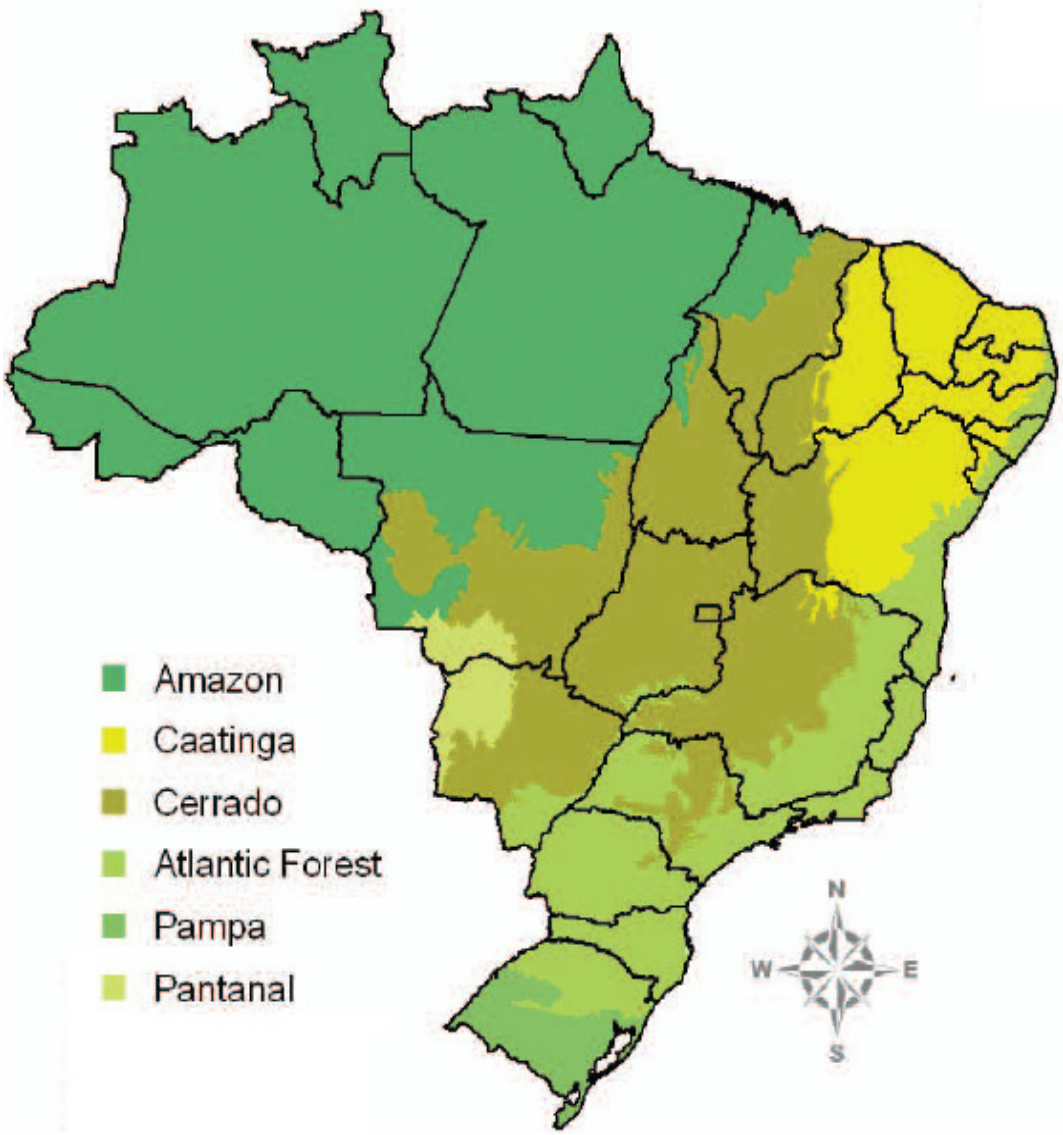
The Atlantic Forest and Cerrado biomes are the two biodiversity hotspots of Brazil according to Conservation International.[8] The Atlantic Forest biome, and its associated ecosystems, encompasses nearly 13 per cent of the Brazilian territory and has 20,000 plant species, 40 per cent (~ 8,000) of which are endemic. Even though the area of this biome has been reduced to a highly fragmented area of about 29 million hectares over centuries of environmental pressure (due to, for example, cattle ranching, logging, urbanization, and coffee and sugarcane crops) it still hosts a significant portion of Brazilian biological diversity (MMA, 2009). The Cerrado biome, comprising 24 per cent of the Brazilian territory, is the most extensive woodland-savannah in South America and represents about 9 per cent of the total area of tropical savannahs in the world (Bustamante et al. 2009). The Cerrado biome is considered a biodiversity hotspot as it has about 44 million hectares of remaining primary vegetation of the total of 203 million hectares and 4.400 endemic species.[9] According to Conservation International (2011), there are currently 90 and 16 endemic threatened animals in the Atlantic Forest and Cerrado savannah, respectively, including birds, mammals, and amphibians. Figure 3.4 shows the six

[8] A region is considered a biodiversity hotspot when: (1) it contains at least 1,500 species of vascular plants (> 0.5 percent of the world's total) as endemics; and (2) it has lost at least 70% of its original habitat (Conservation International, 2011).

[9] The exact amount of remaining primary vegetation in the Cerrado biome is controversial. For example, Sano et al. (2009) state that 60.5% of the Cerrado biome's total area is primary vegetation, while MMA (2009) estimates that 30% of the Cerrado biome is primary vegetation. These estimations are quite discrepant and the reason for this is the use of different classifications, methodologies and satellite images (MMA & IBAMA, 2011).

biomes in Brazil: the Amazon rainforest, Caatinga thorny scrub, Cerrado savannahs, Atlantic Forest, Pampa grasslands, and Pantanal wetlands.

Figure 3.4: Brazilian biomes



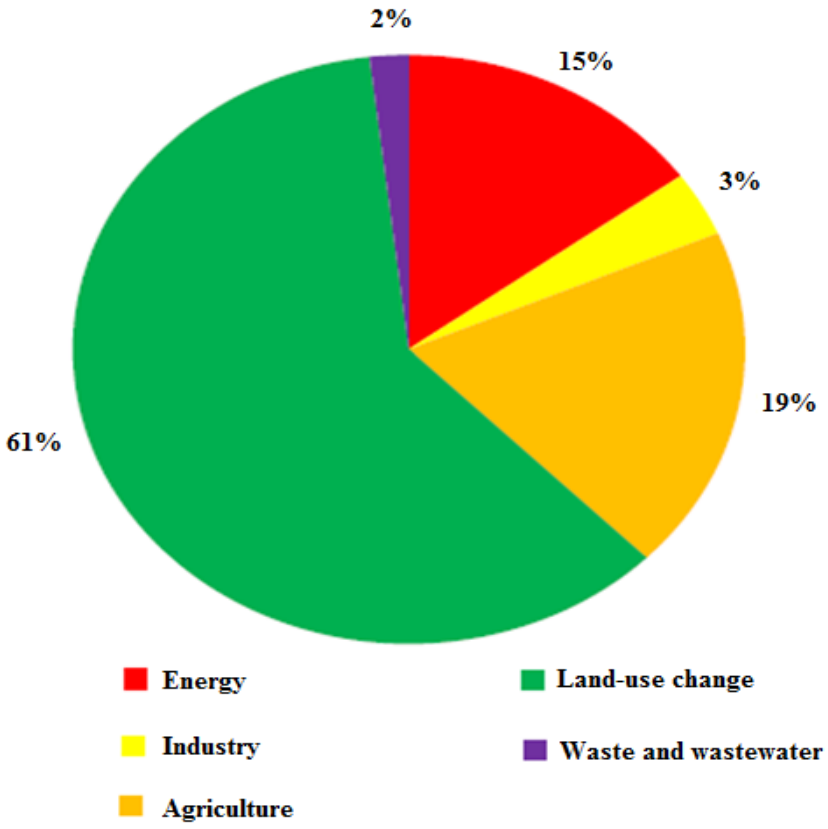
Source: Brazil's Ministry for the Environment (MMA, 2009).

Greenhouse gas emissions and sugarcane crops

According to Barker et al. (2007), GHG[10] emissions resulting from land use change (LUC) have been estimated at around 17 per cent of total global anthropogenic GHG emissions in 2004. Cederberg et al. (2011) contend that a key driver of deforestation is the expansion of pastures for beef production in South America. In addition, estimates indicate that LUC, mainly deforestation, caused by the growing livestock sector is the source of approximately 6 per cent of global GHG emissions (Cederberg et al. 2011). In Brazil, which is the world's second largest beef producer and the top global exporter of beef, pasture is the main subsequent land use occupying (60-75 per cent) of newly deforested land (Margulis, 2004; Morton et al. 2006). As shown in Table 3.1 above, pastures have an approximate area of 200 million hectares, whereas sugarcane crops occupy about 9 million hectares. Thus, sugarcane crops emit much less GHGs than pastures, due to direct LUC. Furthermore, because sugarcane crops have occupied, primarily, pasture lands since 2002, some authors, e.g. Nassar et al. (2010) and Seabra et al. (2011), estimate that sugarcane crops have stored rather than emitted GHGs. Data on GHG emissions from the expansion of sugarcane crops are discussed in Chapter 4. The 2005 Brazil's GHG inventory estimates that land-use change and ongoing agriculture are responsible for 61 per cent and 19 per cent, respectively, of Brazil's GHG emissions (see Figure 3.5).

[10] GHG includes carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphurhexafluoride (SF_6), whose emissions are covered by the United Nations Framework Convention on Climate Change (UNFCCC). These GHGs are weighted by their 100-year Global Warming Potentials, using values consistent with reporting under the UNFCCC (Barker et al. 2007).

Figure 3.5: GHG emissions in CO_2-eq[11] from different sectors in Brazil, 2005



Source: Ministry of Science and Technology (MCT, 2010)

Note that, unlike most of the developed countries where the burning of fossil-fuels to supply energy for the industry and transport sectors is the main cause of GHG emissions, Brazil's GHG emissions come primarily from land-use change, mainly deforestation. This difference in the causes of the GHG emissions is primarily because Brazil's energy supply comes mainly from hydroelectricity (approximately 75 per cent), which emits less GHGs than fossil-fuels, and other energy supplies such as biomass from sugarcane (MME, 2010).

[11] To reduce confusion and complexity, scientists use the notion of "Carbon dioxide-equivalent" (CO_2-eq) units to describe the warming effect in units equivalent to CO_2, exerted by all GHGs and aerosols arising from human activities.

The agriculture sector shown in Fig 3.5 above includes crops and livestock, but the livestock sector is the largest emitter of GHGs. This is due, primarily, to the process of enteric fermentation, which occurs when ruminants digest their food. The process of enteric fermentation emits methane and represents around 75 per cent of GHG emissions from the Brazilian beef production, excluding LUC (Cederberg et al. 2011). Additionally, within the agriculture sector, sugarcane crops contribute to GHG emissions through, primarily, the practice of sugarcane burning. This practice is used to facilitate manual cutting by burning most of the straw and leaves, and to increase the quantity harvested (the practice of sugarcane burning is discussed in Chapter 6).

3.3 General policy context

Government financial incentives towards sugarcane ethanol

During the National Alcohol Programme (*Pró-Alcool*), 1975-1990, the Brazilian sugarcane ethanol sector relied on market intervention through quotas, marketing orders, price setting, and subsidised interest rates (Martines-Filho, Burnquist and Vian, 2006). The National Alcohol Programme was deactivated in 1990 because a decrease in international petroleum prices along with an increase in international sugar prices reduced the importance of this programme (Martines-Filho, Burnquist and Vian, 2006). Many sugarcane mills preferred to produce more sugar than ethanol. Since the reestablishment of the ethanol market in 2003, the sugarcane ethanol sector has received substantial financial incentives through, primarily, bank loans with subsidised interest rates. These financial incentives are provided by the federal government and account for about 3 per cent of producers' revenues (Neves et al. 2011). In February 2012 the Brazilian government instituted a plan to increase ethanol production over the next four years (2012-2015) by investing R$ 60.5 billion (about NZD 42.3 billion) in subsidised credit (Global Energy World, 2012).[12] This

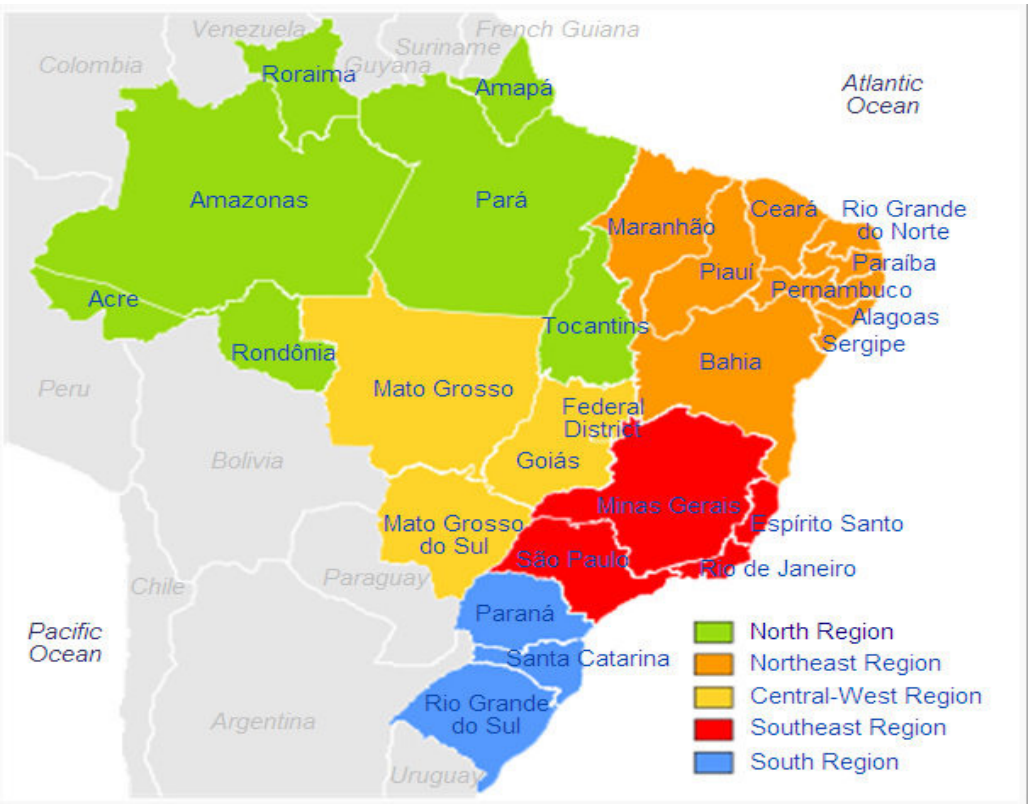
[12] The Brazilian Sugarcane Industry Association (UNICA) argues that the financing programmes described in the government plan are being offered at market rates, not subsidized rates. However, the credit rate is 8,7%, which is lower than the current market rate of around 10,5% (BiofuelsDigest, 2012b; UNICA, 2012)

credit is mainly provided by the Brazilian Bank of Development (BNDES) and includes the investment of R$ 4.5 billion (about NZD 3.15 billion) in 2012 in the expansion of sugarcane crops and renovation of old sugarcane areas (BiofuelsDigest, 2012).

Structure of the Brazilian political regime

Brazil is a federation divided into three levels of government: federal, state, and municipal. The Union hosts the federal government; the 26 states of Brazil host state governments; the Federal District has state and municipal competence and hosts the capital of the country, Brasília; and the municipalities host municipal governments.

Figure 3.6: Map of Brazil - political regions, states, and the Federal District

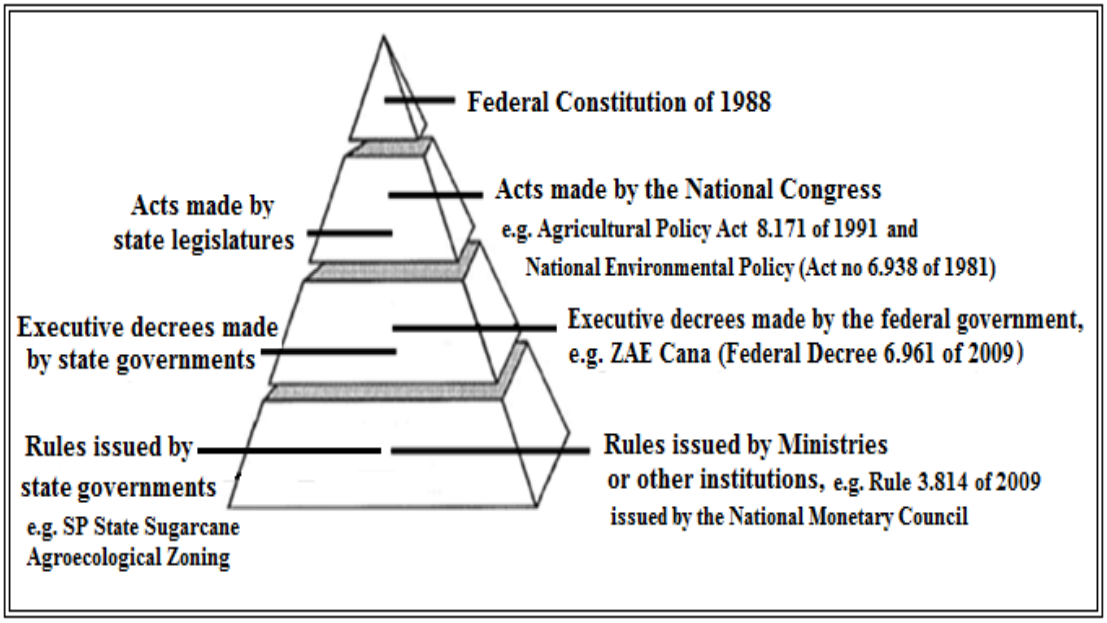


*Note that the South-Central region which is referred to above is not the conjunction of the political regions Southeast, South and Central-West shown in this Figure. South-Central region in this thesis refers to the most important states in terms of sugarcane production: Mato Grosso, Mato Grosso do Sul, Goiás, Minas Gerais, São Paulo, and Paraná.

Legislative context for ZAE Cana

The Brazilian legal regime is based on the Federal Constitution, which was promulgated on 5 October 1988, and is the fundamental law of Brazil. The legal regime applicable to any policy in Brazil is first governed by principles and guidelines established by the Constitution. Every law under the Constitution that sets forth any type of rule has to conform to these principles and guidelines. If not, these laws may be declared unconstitutional and, hence, lose their applicability. To date, ZAE Cana is implemented by a federal decree (type of law made by the executive) that puts into practice provisions on environmental, agricultural and financing policies which are, in turn, set forth in federal acts. These acts include, for example, the Agricultural Policy Act 8.171 of 1991 and the National Environmental Policy Act of 1981. Article 9 of the National Environmental Policy Act of 1981 establishes that environmental zonings are instruments of Brazil's Environmental Policy. These acts specify and render more precise constitutional guidelines. Article 225 of the Constitution states the right to an ecologically balanced environment for all people, including future generations. This Article also states that the duty for defending the environment is imposed on both the government and civil society. Figure 3.7 shows the hierarchical position of the different types of Brazilian legal rules which are discussed in this thesis.

Figure 3.7: Different types of legal rules in Brazil, by hierarchical applicability



Source: Author's database. Note that state laws have to respect the provisions of federal laws. Municipal laws, which are not included in this thesis, have to respect both state and federal laws. In addition, rules on the bottom of the pyramid have similar hierarchical applicability.

3.4 Specific policy context: ZAE Cana

The Brazilian Agricultural Research Corporation (Embrapa) asserts that ZAE Cana aims to guide the sustainable expansion of sugar and ethanol production in Brazil (Manzatto, 2009). This aim is divided into three goals:

(1) Agricultural Policy – This policy goal indicates areas with agricultural suitability, i.e. soil and climate, for sugarcane cultivation, without full irrigation; and areas with land surface slope less than 12%, allowing mechanical harvest.

(2) Environmental Sustainability – This policy goal excludes areas with native vegetation, areas under reforestation, and areas in the Amazon rainforest, Pantanal wetlands and the Upper Paraguay Basin. This policy includes only areas currently under agricultural use (see Figures 3.8 and 3.9).

(3) Food Security – This policy goal aims to decrease direct competition with areas of food production.

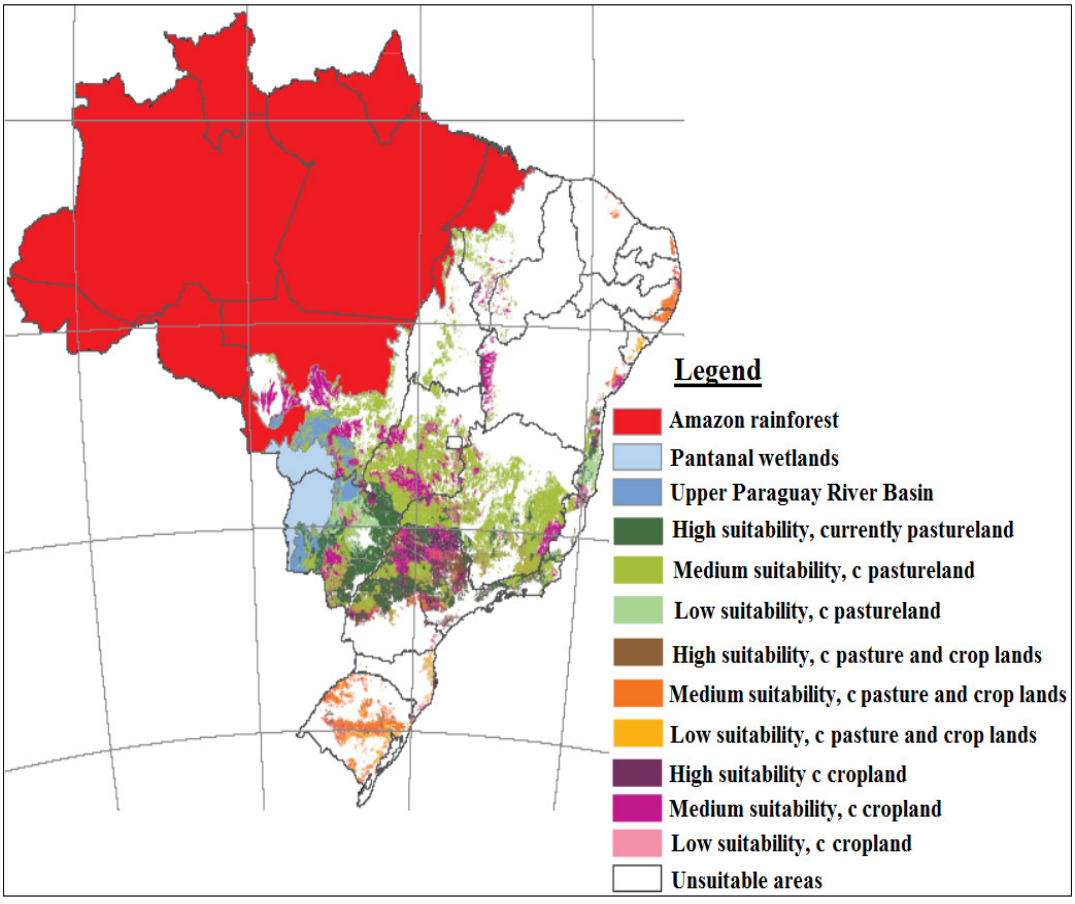
Figure 3.8: Location of the ecosystems excluded by ZAE Cana: Amazon rainforest, Pantanal wetlands and Upper Paraguay Basin.

Source: Manzatto (2009)

The policy goal on which this thesis focuses is the second, *Environmental Sustainability*. According to Manzatto (2009, p 17), the objective of excluding native vegetation, areas under reforestation and the Amazon rainforest, Pantanal wetlands and the Upper Paraguay River Basin is to protect the environment, conserve biodiversity and "use all the natural resources in a rational manner".

Fig. 3.8 above shows some areas excluded by ZAE Cana, while Fig. 3.9 shows the areas included by ZAE Cana for the expansion of sugarcane. These areas consist of areas currently used for non-energy crops and pastures. According to ZAE Cana, the total land area currently under diverse agricultural usage and with suitability for conversion to sugarcane production is approximately 64.8 million hectares. The areas shown in Fig. 3.9 were drawn up by the Brazilian Agricultural Research Corporation (Embrapa), along with the Ministry for the Environment (MMA). Embrapa is an institution linked to the Ministry of Agriculture and Food Supplies (MAPA). Embrapa and MMA were the major institutions responsible for assessing areas suitable for the expansion of sugarcane and for the creation of ZAE Cana.

Figure 3.9: ZAE Cana and areas suitable for the expansion of sugarcane crops



Source: Manzatto (2009). Currently and 'c', which are the same, means what the current land use is.

Many areas allowed for the expansion of sugarcane crops shown in Figure 3.9 are located next to the ecosystems of the Amazon rainforest, Pantanal wetlands and Upper Paraguay River Basin. This proximity could cause direct environmental pressure due, for example, to sugarcane burning and use of agrochemicals, or indirect degradation due to sugarcane pushing other activities into areas of native land (BWC, 2009). The issues of sugarcane burning and indirect effects of LUC are examined below.

To date, ZAE Cana is implemented through the Federal Decree 6.961 of 2009, which specifies the areas where sugarcane can be cropped and allows subsidised public and private financing only to existing or new sugarcane producers who expand within this zone. This financing is controlled by the National Monetary Council, which formulates policies for the Central Bank of Brazil. In November 2009 the National Monetary Council made the Rule 3.814, which prohibits public and private financing to sugarcane companies that produce sugar and/or ethanol and plan to expand outside ZAE Cana. [13] ZAE Cana may also be implemented in the future by rules set up in the Resource Consent Bill 6.077 of 2009. This bill still needs to be approved by the House of Representatives and the Senate, and finally receive the presidential assent, to take legal effect. According to this bill, resource consents and the possibility to impose administrative, civil, and criminal penalties for illegal sugarcane expansions could become additional tools in the implementation of ZAE Cana.

Nevertheless, a bill was recently proposed (February 2012) by a member of the Chamber of Deputies (the lower house) to halt the effects of the Federal Decree 6.961 of 2009. The argument of the Deputy was that this decree is an autonomous law, i.e. it regulates content not established in any act. The Deputy contends that the Brazilian Constitution prohibits the executive from making autonomous decrees.

[13]The Central Bank of Brazil is an autonomous federal institution and part of the National Financial System (SFN). Among other matters, the Central Bank serves as the financial agent of the federal government. According to the Article 44 of the Law 4.595 of 1964, financial institutions (public and private) are subject to penalties such as fines and imprisonment in case of infringement to policies established by the National Monetary Council.

Therefore, the Federal Decree 6.961 of 2009 would have to be revoked if this bill is passed, or if the decree is considered unconstitutional by the judiciary. Because this bill was proposed in February 2012, there is no literature to be reviewed, no official data, and no information from the present study's participants as the interviews were conducted in May-August 2011. However, Chapter 6 discusses this bill and presents the author's arguments which disagree with this bill.

Other legal frameworks to avoid adverse LUC in Brazil

The National System of Conservation Units (SNUC) Act, the Brazilian Forest Code, and the São Paulo Sugarcane Agroecological Zoning can work along with ZAE Cana. These legal frameworks can contribute to avoiding detrimental *direct* LUC caused by the expansion of sugarcane crops, and, in the case of the SNUC Act and Forest Code, also control *indirect* LUC caused by this expansion. The SNUC Act and Forest Code are the two main legal frameworks in Brazil that contribute to biodiversity conservation. Both laws influence the expansion pattern of crops and pastures by establishing rules of use and occupation of the land (Sparovek et al. 2010). In addition, the São Paulo State Sugarcane Agroecological Zoning, developed in 2008, aims to control the expansion of sugarcane crops and industries within the state of São Paulo.

The SNUC Act establishes that federal, state and municipal governments in Brazil shall create territorial spaces to conserve natural resources and to require territorial limits, under special management regimes. The SNUC Act divides protected areas into two categories: (1) strictly protected conservation areas, with biodiversity conservation as the major objective; this category includes National Parks and Biological Reserves; and (2) areas for sustainable use, allowing for varying forms and degrees of exploitation, while protecting the biodiversity; this category includes Extractivist Reserves and Sustainable Development Reserves. To date, the total area occupied by conservation areas in Brazil is about 151 million hectares (or 17.7 per cent of Brazil's territory), being 52 million hectares of strictly protected areas and 99 million hectares of areas for sustainable use (MMA, 2012). Of the total of 151

million hectares of conservation areas in Brazil, about 100 million hectares are located in the Amazon Rainforest (24 per cent of the area of this biome) and 305,000 hectares in the Pantanal wetlands (2% of the area of this biome). Although there is no specific data on conservation areas in the Upper Paraguay Basin, WWF-Brazil et al. (2009) estimate that of the total area of this ecosystem of 36.8 million hectares, 14.6 million hectares (~ 40 per cent) have already been converted to different anthropogenic uses, such as pasture and crop production, and urban development.

The Brazilian Forest Code divides rural private land into productive land and land dedicated to conservation and/or preservation. The land dedicated to conservation and/or preservation is subdivided into Legal Reserve and Areas of Permanent Preservation (APPs). Legal Reserve is currently defined as the area in a rural private land holding that has to be set aside to promote fauna and flora/biodiversity conservation and sustainable use of natural resources (Sparovek et al. 2010). The size of the Legal Reserve varies according to the biome where the private land is located. Landowners have to set aside 80 per cent of their lands as Legal Reserve in the Amazon rainforest, 35 per cent in the Cerrado within the Legal Amazon,[14] and 20 per cent in the rest of Brazil's territory. Legal Reserve is primarily reserved for native vegetation, but can contain some low-impact production systems including managed low-impact forest extraction and bee-keeping (Sparovek et al. 2010). APPs are areas to be preserved by landowners and these areas contribute to protecting water resources, soils and biodiversity. APPs include riparian areas along water bodies, steep slopes (greater than 45 degrees), high altitude areas (more than 1,800 metres) and hilltops.

The Forest Code has been the subject of debate and the object of analysis by the Brazilian Congress. The Rural Caucus has proposed many amendments to the rules regarding, primarily, Legal Reserves and APPs. The central motivations for this

[14] The Legal Amazon is an area that extends beyond the Amazon rainforest, encompassing about 61% of the Brazilian territory (the Amazon rainforest encompasses 49%). The Legal Amazon was established by Federal Law in 1953 to better manage the area and promote its occupation.

proposal are the alleged ineffectiveness of natural vegetation protection set up by the Forest Code and, for some agricultural producers, the perception that the Forest Code is a barrier to development in the agricultural sector (Sparovek et al. 2012). The Rural Caucus aims to legitimise the situation of thousands of farmers who have infringed the Forest Code since its inception in 1965 by legalising specific infringements and softening some of the Code's rules. Nevertheless, it has been argued that loosening the Brazilian Forest Code would constitute a threat to natural resource conservation (Metzger et al. 2010; Michalski et al. 2010; Brazilian Federal Prosecution Office, 2011).

In 2008 the state of São Paulo made its sugarcane agroecological zoning to control the expansion of sugarcane crops and industries within this state. This zoning is mainly realised through the State Regulation no. 88 of 2008, which establishes rules for public authorities to issue resource consents. The state of São Paulo, which produces 60 per cent of the Brazilian sugarcane ethanol, is the most likely region in Brazil to both indicate trends of sugarcane agroecological zoning as well as allow a study of the intersection between its state zoning and ZAE Cana.

The SNUC Act, the Brazilian Forest Code, and the São Paulo Sugarcane Agroecological Zoning are important accompaniments to ZAE Cana and its effectiveness. These legal frameworks are mainly used to support the discussion in Chapter 6, which analyses the contributions of ZAE Cana in Brazil and sums up the literature review (next Chapter) and the findings from fieldwork (Chapter 5).

Chapter 4

Literature Review

This chapter first reviews the literature on direct land-use change caused by the expansion of sugarcane crops in Brazil (Objective One). This review focuses on previous occupation of land currently used for Brazilian sugarcane crops and the likely locations and amount of land that may be used in the future.[15] Secondly, this chapter reviews the literature on indirect land-use change which the expansion of Brazilian sugarcane crops may have caused primarily in the period 2002-2008 and may again cause in the future (Objective Two). Thirdly, this chapter reviews the literature on ZAE Cana regulatory policy. The third stage aims to understand how this policy has affected the expansion of sugarcane crops until now and its likely shortcomings for the future (Objective Three).

4.1 Direct land-use change

4.1.1 GHG emissions

Past trends

Direct land-use change (LUC) caused by the expansion of sugarcane crops may generate loss of a substantial amount of carbon in three different ways. Firstly, this loss may occur due to the removal of the above-ground carbon (in vegetation and litter). Secondly, this loss may occur due to the below-ground carbon released from soil and roots once grasslands or forest are cleared. Thirdly, direct LUC may also generate loss of ongoing carbon sequestration from maturing forests and grasslands (Searchinger et al. 2008).[16] Because forests stock more carbon than grasslands, the

[15] The review of previous occupation focuses primarily on the period 2002-2008, when the production of ethanol triggered the last great expansion of sugarcane area in Brazil. The review of likely locations and amount of land used by sugarcane crops in the future is based on different literature and extends until the year 2030.

[16] Although it is important to note that if the forest is already mature (before conversion) then it is unlikely to be sequestering any (net) CO_2.

clearance of forests causes bigger emission of carbon than the latter. Nevertheless, as shown in Figure 1.1 above, sugarcane ethanol emits less GHGs than fossil fuels, at least when direct LUC is excluded from ethanol's emissions lifecycle assessment. In addition, sugarcane is a C4 plant, which means it generally has higher rates of carbon absorption than most other feedstocks such as palm, soya and wheat, which are C3 plants[17] (Ciesin, 1990; Fischer et al. 2008). Hence, depending on how Brazilian sugarcane is cropped, its continued production may eventually offset the carbon debt caused by detrimental direct LUC associated with conversion to sugarcane. Table 4.1 below shows that Brazilian sugarcane ethanol has a shorter payback period than other feedstocks.

Table 4.1 Illustrative GHG savings and payback times for biofuel feedstocks causing LUC.

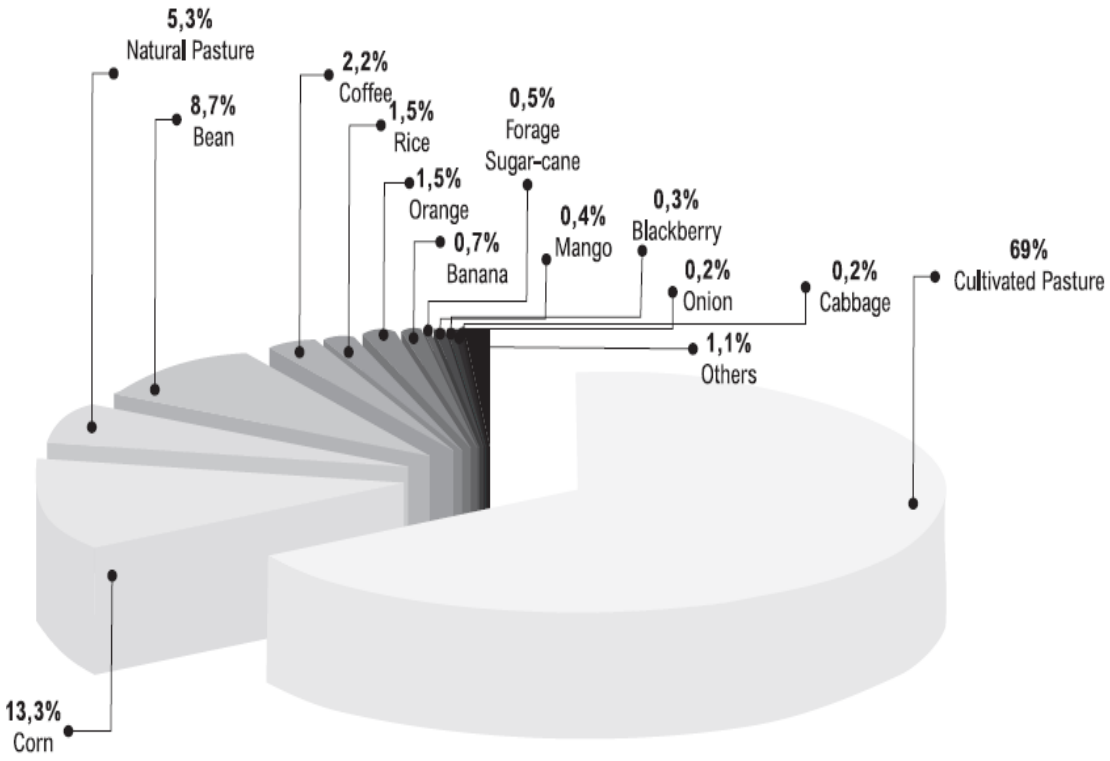
Fuel chain	**Assumed country of origin**	**GHG savings excluding the impacts of land-use change**	**Carbon payback (years)**	
		%	**Grassland**	**Forest**
Palm to biodiesel	Malaysia	46	0-11	18-38
Soya to biodiesel	USA	33	14-96	179-481
Sugarcane to bioethanol	**Brazil**	**71**	**3-10**	**15-39**
Wheat to bioethanol	UK	28	20-34	80-140

Source: E4tech (2008) [emphasis added, in bold]

[17] C4 and C3 are types of photosynthesis. C4 plants photosynthesise faster than C3 plants under high light intensity and high temperatures because the CO_2 is delivered directly to the enzyme RUBISCO, not allowing the plants to grab oxygen and undergo photorespiration. This is one of the main reasons C4 plants absorbs more carbon than C3 plants (Ciesin, 1990).

Notwithstanding, based on more specific studies conducted in Brazil, the carbon payback period of sugarcane to bioethanol shown in Table 4.1 seems not to be the rule for most of the Brazilian sugarcane ethanol production. Macedo and Seabra (2008) argue that direct LUC derived GHG emissions caused by the expansion of sugarcane crops in Brazil were actually negative in the period 2002-2008. In addition, Nassar et al. (2010) estimate that direct LUC caused by the expansion of sugarcane crops in Brazil between 2005 and 2008, when ethanol production grew from 16 to 27 billion litres per year, instead of releasing carbon into the atmosphere, resulted in the removal of about 47 thousand tons of carbon. This is because sugarcane crops, according to the specific estimations of Macedo and Seabra (2008) and Nassar et al. (2010), are capable of stocking more carbon than the land areas for which they have substituted. Camargo et al. (2008) estimate that in the period from 2001 to 2006 in the state of São Paulo pastureland, cropland and other areas corresponded to nearly 69%, 20%, and 1.1% of almost 1 million hectares subsequently occupied by sugarcane crops (see Figure 4.1).

Figure 4.1: Area replaced by sugarcane in the state of São Paulo, 2001-2006.[18]



Source: Cordeiro (2008)

In addition, studies contend that since 2002 most of the expansion of sugarcane in Brazil has occurred on existing cropland and, primarily, on pastureland located in the South-Central states (see Table 4.2) (Macedo, 2007; Goldemberg et al., 2008; Sawyer, 2008; Lapola et al. 2010). Nassar et al. (2008), through an analysis of remote sensing images as well as secondary data from the Brazilian Institute of Geography and Statistics (IBGE) and environmental licensing reports, show that the expansion of sugarcane in the period between 2002 and 2006 took place, primarily, over pastureland and, in smaller proportion, over cropland (see Table 4.2). According

[18] In regard to sugarcane crops competing with food production, Camargo et al. (2008) state that, apart from rice and beans from the dry season, the total production of food has not decreased in the state of São Paulo despite the increase of sugarcane crops. However, Cordeiro (2008, p 141) contends that both in São Paulo and in other Brazilian states, it is expected that the consequences of sugarcane expansion on food prices and production be more "noticeable and impressive" at the municipal level.

to Sparovek et al. (2007), the main factors that have propelled the expansion of sugarcane crops over pastureland are:

- Areas of pasture are largely available in the South-Central states.
- Land prices or rent payments are usually lower in areas used for pasture than for native land, so pasture is usually cheaper for investors.
- Cattle ranchers find it economically feasible to sell or rent out their land in order to augment income.[19]

Table 4.2: Areas displaced for sugarcane expansion by state, from 2002 to 2006 (1.000 hectares).

	State	Total agricultural expansion	Sugarcane expansion			
			Total growth	Displacing pasture	Displacing other crops	N.A.[1]
South-Central states	São Paulo	146	639	460	115	65
	Minas Gerais	-1,251	160	157	2	1
	Paraná	535	92	58	2	32
	Goiás	-775	63	56	0.1	6
	Mato Grosso do Sul	281	45	44	0.6	0.1
	Mato Grosso	4,945	31	18	3	10
	Bahia	124	27	19	5	3
	Maranhão	-655	16	12	0	5
	Piauí	-122	3	0.2	0	2
	Tocantins	148	1	0.5	0	0.6
	Total	3,376	1,077	773	103	125

[1] N.A. means not allocated over previous productive area.

Source: Nassar et al. (2008) ['South-Central states' added, in bold]

The areas classified as *others* and *N.A.* in the Figure 4.1 and Table 4.2 above, respectively, include native vegetation. The Biofuel Watch Centre (BWC, 2009) of NGO Repórter Brasil argues that sugarcane cultivation has expanded into native

[19] For example, Smeets et al. (2006, p 37) contend that in the state of São Paulo in 2005 the annual net income per hectare were U$350 for sugarcane, U$170 for crops (bean, corn and soybean), and U$58 for cattle farming.

biomes of Pantanal wetlands, Cerrado savannahs, Amazon rainforest, and Northeastern Atlantic forest. Additionally, Sparovek et al. (2009) show that, despite occurring at lower rates, the expansion of sugarcane directly deforested areas in the Amazonian biome and the Northeast region of Brazil in the period 1996-2006. However, data for the specific land-use change caused by sugarcane expansion in the last decade, the period in which the production of sugarcane ethanol has mostly increased in Brazil, indicates that less than 2 per cent occurred in native vegetation areas (Nassar et al., 2008; Conab, 2010; Nassar et al., 2010). On this basis, Seabra et al. (2011) contend that GHG emissions due to direct LUC caused by the expansion of sugarcane crops in Brazil were not significant in the last decade.

Future trends

The Institute for International Trade Negotiations (ICONE, 2011) estimates that Brazilian sugarcane crops may in the future expand mostly over pastureland and occupy from about 10.5 million hectares (baseline scenario) to 11.5 million hectares (shock scenario) by 2022 (see Table 4.3). In order to reach these estimates, ICONE (2011) used an economic model called the Brazilian Land Use Model (BLUM), which simulates supply of and demand for agricultural products produced in Brazil and impacts on the demand for land.

Table 4.3: Land use in Brazil: Sugarcane, other crops and pasture (thousand hectares)

Region	Activity	2009	2022			
			Baseline		Shock	
			Previous	Updated	Previous	Updated
Brazil	Corn - 1st crop	9,285	7,678	8,214	7,442	8,134
	Corn - 2nd crop	5,011	6,503	6,223	6,573	6,264
	Soybean	21,557	31,118	31,105	31,026	31,108
	Cotton	856	1,782	1,808	1,736	1,806
	Rice	2,894	3,033	3,155	3,025	3,153
	Dry Bean - 1st crop	2,963	2,511	2,651	2,470	2,657
	Dry Bean - 2nd crop	1,212	1,145	1,071	1,151	1,072
	Sugarcane	8,120	10,525	10,551	11,558	11,575
	Wheat	2,424	2,632	2,541	2,540	2,540
	Barley	80	42	83	83	82
	Pasture	203,973	206,199	199,982	205,794	199,237

Source: ICONE (2011). The *updated* column refers to the most recent calculations done by ICONE (2011) [emphasis added, in green]

Nassar et al. (2008) estimate that the harvested sugarcane area in Brazil may reach 11.7 million hectares in 2018, compared with 9 million hectares in 2011. Additionally, they contend that sugarcane expansion will follow trends in terms of land-use change similar to the ones discussed above, i.e. displacement of areas of existing crops and pasture. Due to this projected displacement, Macedo and Seabra (2008) state that very little impact, if any, on direct LUC GHG emissions is expected until 2020. In addition, Olivette et al. (2011) of the São Paulo State Institute of Applied Economics (IAE) project two scenarios for the expansion of sugarcane crops for the year 2030 in the state of São Paulo:

> (1) The first scenario projects that the sugarcane sector would increase yield to the extent that *degraded* areas of pasture[20] would be able to accommodate the expansion of sugarcane crops. This expansion would reach 5.3 million hectares by 2030, compared with 5 million hectares in 2010.

[20] *Degraded* areas of pasture are most often defined as those of low productivity, i.e. usually less than one cattle head per hectare.

(2) The second scenario projects the demand for sugar and ethanol rising at a greater pace than the increase in sugarcane yield. Thus, for cattle ranchers to accommodate the expansion of sugarcane crops, which in this case would reach 6.8 million hectares by 2030, they would have to invest heavily in technology to constrain their herd in a smaller area.

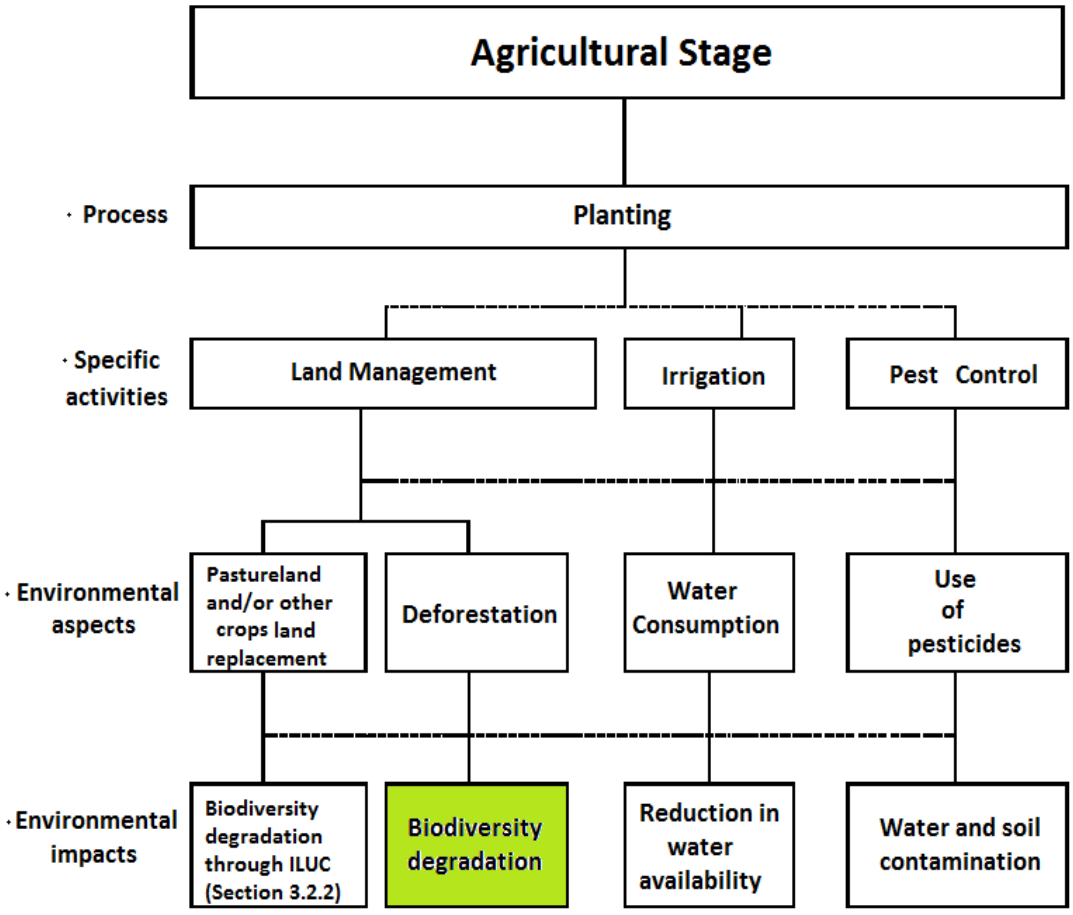
Regardless of what scenario projected by Olivette et al. (2011) is realised in the future, it is clear that their study generally corroborates the projections shown in other literature cited above: the expansion of sugarcane crops is most likely to occur over areas currently used for crops and, primarily, pastures.

The next section discusses biodiversity impacts caused by the expansion of sugarcane crops in Brazil. Despite most of the literature reviewed being optimistic in regard to GHG emissions due to direct LUC, the expansion of sugarcane has caused biodiversity impacts and it may be aggravated in the near future.

4.1.2 Biodiversity impacts

Groom, Gray, and Townsend (2008) contend that although some biofuels have shown advantages over fossil fuels in terms of GHG emissions, the production and use of biofuels may result in significant negative consequences for biodiversity through, for example, deforestation. Figure 4.2 illustrates, in the green box, how biodiversity degradation can occur as a consequence of the expansion of sugarcane crops causing direct deforestation:

Figure 4.2: Impacts caused by Brazilian sugarcane ethanol at the agricultural stage

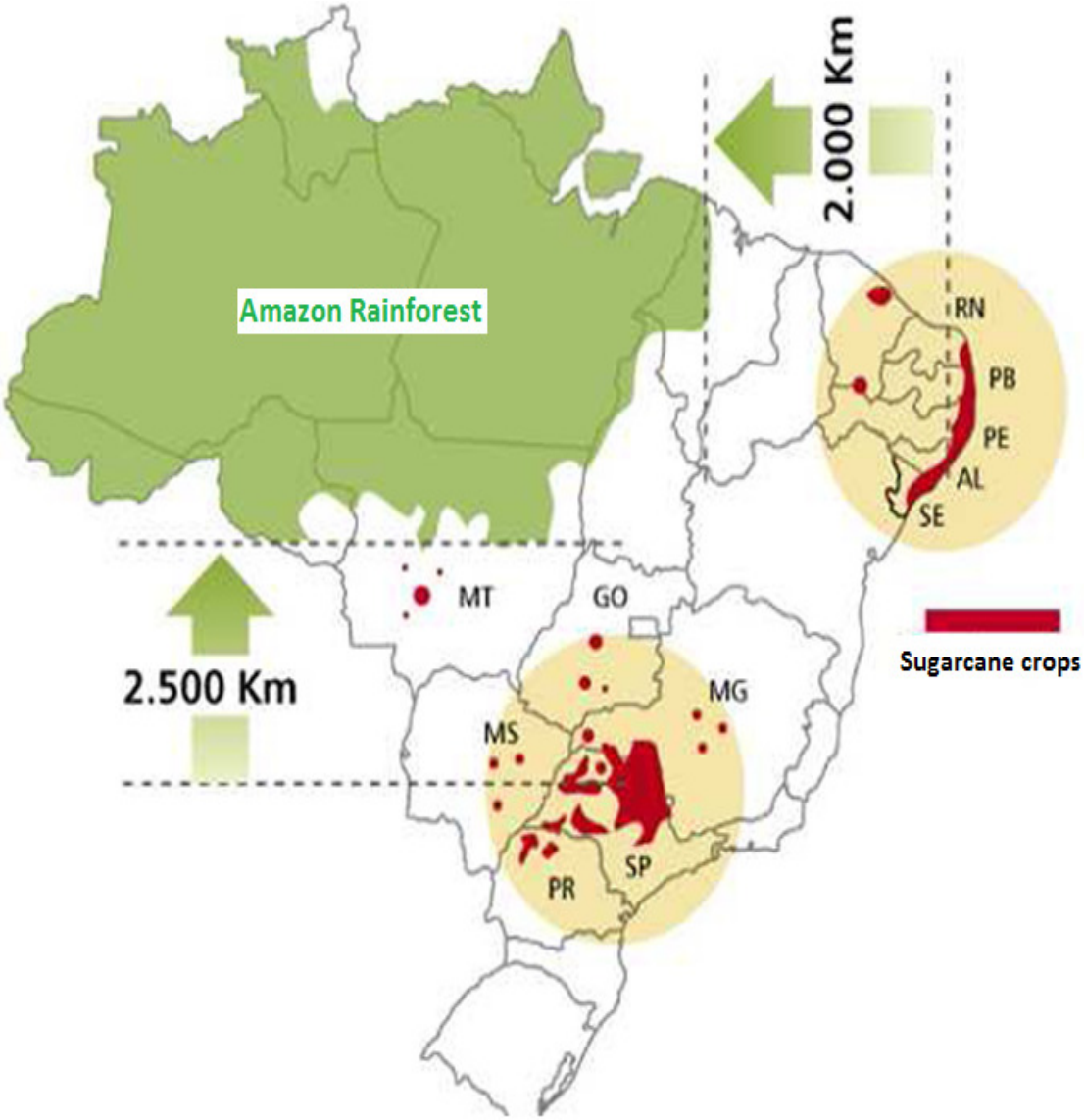


Source: Silva (2010). Translated from Portuguese into English and adapted by the author.

Past trends

According to the Brazilian Sugarcane Industry Association (UNICA, 2010a), nearly 90 per cent of sugarcane production for ethanol is harvested in the South-Central states of Brazil, over 2,500 kilometres from the Amazon rainforest. The remainder is grown mostly in Northeastern Brazil, about the same distance from the Amazon easternmost fringe, and less than 0.2 per cent in the Amazon region (UNICA, 2010a). Figure 4.3 shows the location of most (about 99.8 per cent) of the sugarcane crops in Brazil and their relation to the Amazon rainforest.

Figure 4.3: Amazon rainforest and location of most of the sugarcane crops in Brazil

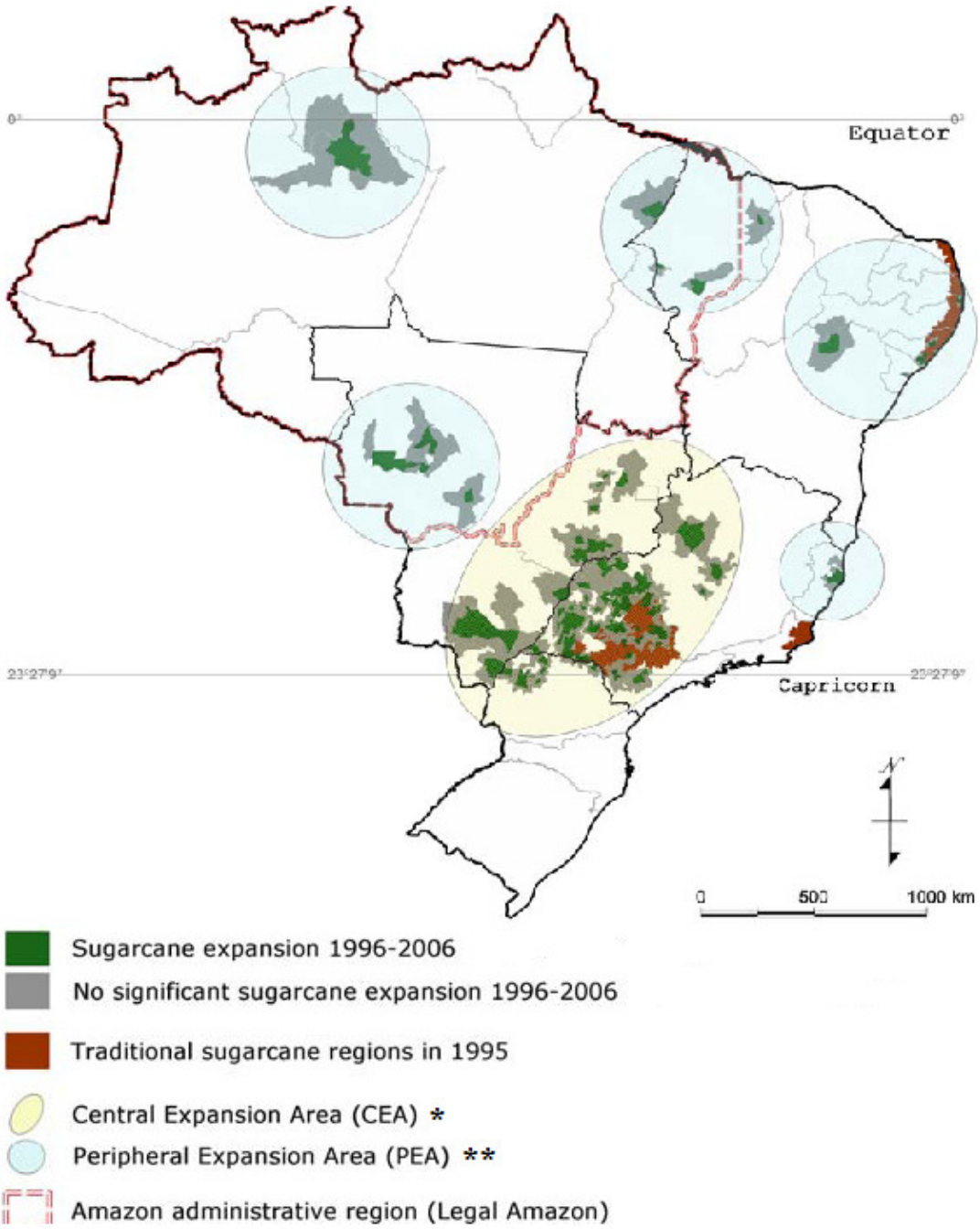


Source: UNICA (2010c)

Nevertheless, it is argued that little or no attention has been given to past and current clearing caused by sugarcane crops in the Atlantic Forest and the Cerrado savannah biomes (Bernard, Melo and Pinto, 2011; Sawyer, 2011). As discussed in Chapter 3, these biomes are the two biodiversity hotspots of Brazil according to Conservation International.

Macedo et al. (2007) state that the agricultural expansion cycle (including sugarcane) in the Atlantic Forest biome preceded concerns about ecological preservation. The sugarcane expansion cycles took place, primarily, during the colonisation period and the National Alcohol programme (1975-1990). According to Macedo et al. (2007), a large amount of areas within the Atlantic Forest biome representing the original biodiversity, therefore, were not preserved. But regardless of the date when sugarcane crops occupied native areas of the Atlantic Forest and the level of people's environmental awareness, there are currently large areas of sugarcane on Areas of Permanent Preservation, primarily riparian vegetation, and Legal Reserve within the Atlantic Forest biome. Sparovek et al. (2010) estimate that in the state of São Paulo and, counting the area of all the agricultural activities including sugarcane, there is a deficit in Legal Reserve of about 2.6 million hectares or 13 per cent of the area of established agriculture. In addition, Sparovek et al. (2009) contend that there were several negative externalities, such as direct deforestation, between the years of 1996 and 2006 in the Northeast region of Brazil, where part of the Atlantic Forest biome is located, due to the expansion of sugarcane crops (Figure 4.4).

Figure 4.4: Sugarcane crops until 2006 in Brazil



*CEA means the expasnion that occurred radiating from the current main production region, i.e. state of São Paulo and neighbouring states, between the years 1996 and 2006.
** PEA means all other expansion areas between the years 1996 and 2006.
Source: Sparovek (2009)

Goldemberg and Guardabassi (2008) state that although the Cerrado biome has been extensively utilised for more than 40 years for agriculture and cattle breeding, 50% of this biome is not adequate, or has low suitability, for sugarcane plantation. Macedo et al. (2007) contend that the expansion of sugarcane crops in areas that were originally taken up by the Cerrado biome has been relatively small because, as discussed above, this expansion has mainly occurred on pasture and croplands. However, Bustamante et al. (2009, p 6) state that some studies on the Cerrado biome have shown the expansion of sugarcane over some unprotected priority conservation areas of biological importance. These studies show that although large native areas in the Cerrado biome had already been converted into pasture and crops, and these areas could have been used more often for sugarcane crops, some sugarcane crops have occupied areas with high biodiversity importance. A study conducted by NGO Instituto Sociedade, População e Natureza (ISPN) estimates that an area of 142,000 hectares of biodiversity importance in the Cerrado biome was turned into sugarcane crops in the 2006/2007 harvest (ECOA, 2009). This area of 142,000 hectares in the Cerrado biome is considered as priority for biodiversity conservation according to the Map of Priority Areas for Biodiversity Conservation of the Ministry for the Environment.

Picture 4.1: Example of sugarcane planted in riparian zones in the state of Pernambuco

Source: Author's database, 2011

Future trends

The literature on the impacts caused by the expansion of sugarcane crops in Brazil on biodiversity conservation shows contrasting results. Sparovek et al. (2010) contend that some studies point to risks of further ecosystem conversion, biodiversity loss, large GHG emissions, and resource degradation; while others highlight that increased productivity and good agricultural practices can reduce agricultural land expansion requirements and mitigate negative impacts on the environment. Contrasting results also occur because the literature varies as to the scale of analysis, i.e. national, regional or local, and how a specific aspect of sustainability is interpreted (WWF,

2008). For example, on one hand, Moreno (2010) and Sawyer (2011) contend that the sole fact that sugarcane is a monoculture impacts biodiversity very negatively as it contributes to soil erosion and requires large amounts of agrochemicals. On the other hand, Goes and Marra (2008) state that the expansion of sugarcane crops is not likely to cause further environmental damage because this expansion can take place on areas currently under some form of agricultural use.

According to Bernard, Melo and Pinto (2011), the expansion of sugarcane crops in Brazil may impact forest remnants within the Atlantic Forest biome located in the states of Alagoas, Pernambuco, Paraíba and Rio Grande do Norte. This region is known as the Biodiversity Corridor of the Northeast (CBNE) region of Brazil and is located in the second largest sugarcane ethanol area of the country (WWF, 2008). Although ZAE Cana does not allow sugarcane crops to expand on native vegetation, nearly all forest remnants in the CBNE region belong to private landowners, mainly sugar and ethanol producers (see Picture 4.2). Thus, despite ZAE Cana allowing approximately 865,000 hectares of already cleared areas in the states of CBNE to be used for sugarcane expansion, most of the easiest areas for use by sugarcane producers in the future are already located within the lands they own, and are of high biodiversity value (Bernard, Melo and Pinto, 2011). On the face of it, therefore, significant biodiversity is at risk, and the behavior of the landowners will be critical.

Picture 4.2: Forest remnants, surrounded by sugarcane plantations, in the Atlantic Forest in the Biodiversity Corridor of the Northeast (CBNE) region of Brazil.

Source: Bernard, Melo and Pinto, 2011.

Despite the likely impacts on forest remnants in the Atlantic Forest biome, ICONE (2011) states that the Cerrado biome is the main agricultural frontier in Brazil, where the most suitable croplands and other lands are located and available. Unlike the Amazon rainforest and the Pantanal wetland biomes, agricultural lands within the Cerrado biome are not excluded by ZAE Cana for the expansion of sugarcane crops (Manzatto, 2009). This aspect of ZAE Cana is discussed in section 4.3

4.2 Indirect land-use change

Indirect land-use change (LUC) caused by the increase in Brazilian sugarcane ethanol production occurs when pressure on agriculture (crops and pasture) due to the expansion of sugarcane crops induces LUC on other lands. Thus, 'knock-on' effect of LUC is also referred to as leakage, as effects 'leak' outside the initial system boundary. One example of leakage is when the expansion of sugarcane crops in areas of pasture and crops induces, indirectly, deforestation as these areas of pasture and crops are pushed into native ecosystems (Gnansounou et al. 2008; Ravindranath et al. 2009). Nassar et al. (2008) argue that the analysis of indirect LUC must consider many variables: indirect LUC is market driven, reflects global interactions, and is spatially and time dependent; so there are difficulties in isolating the contribution of each agricultural activity to the overall indirect LUC effect. It is also possible that the argument by Searchinger et al. (2008) that the displacement of one activity as a result of the expansion of biofuel's feedstocks may be leading to deforestation elsewhere, may be proven incorrect. This is because deforestation may be taking place regardless of the expansion of biofuel's feedstock production (Nassar et al. 2008). This section discusses the literature on indirect LUC caused by the expansion of Brazilian sugarcane crops from 2002 and likely impacts in the future.

Past trends

Due to complexity of the interaction of the variables discussed above and consequent uncertainties, the literature on impacts of indirect land-use change caused by sugarcane ethanol production is either vague or controversial. Despite this vagueness, some studies have started to investigate the indirect impacts that the production of sugarcane may have upon Brazil's land and the environmental consequences of this production (Nassar et al. 2008; Lapola et al, 2010; Gallardo and Bond, 2010). Nassar et al. (2008) state that results on past data, i.e. the period of 2002-2008, show that increased cattle herd stocking rates and crop yield improvements were able to offset pasture and crop land reduction where they lost land area to sugarcane, and these avoided indirect deforestation pressure. But

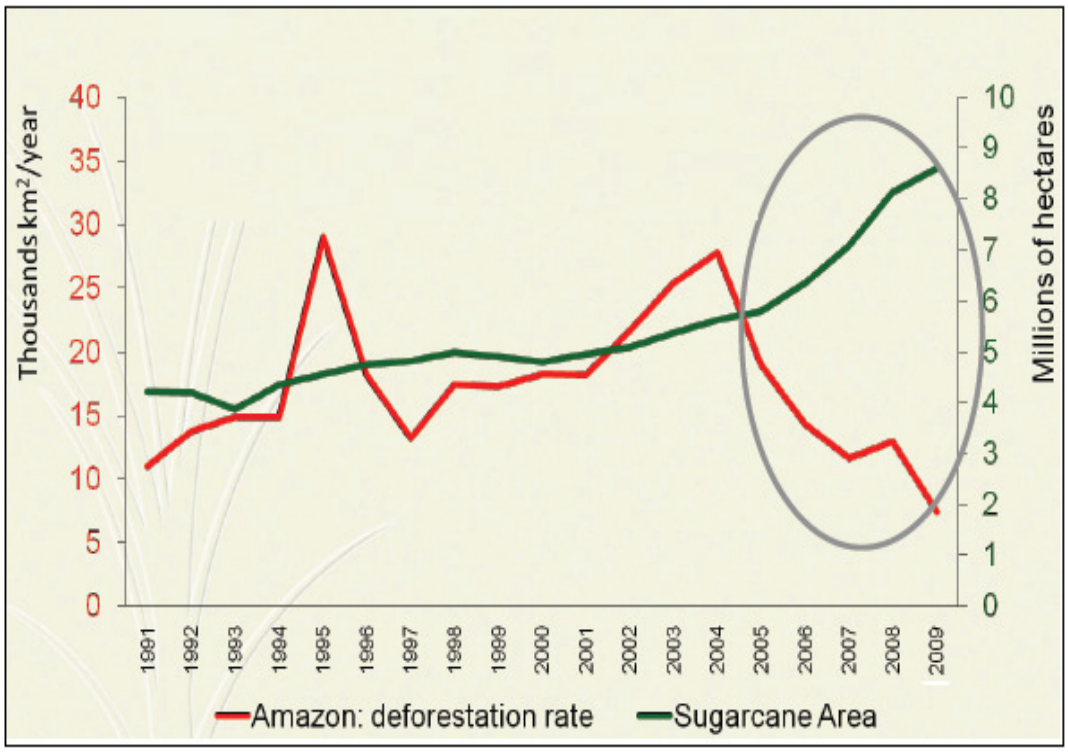
avoiding deforestation does not mean that sugarcane has not caused indirect LUC. In fact, Nassar et al. (2010) estimate that the conversion of native vegetation which was caused indirectly by sugarcane in the period of 2005-2008 totalled about 181,200 hectares, nearly 20 times greater than the conversion caused directly.

The Brazilian Sugarcane Industry Association (UNICA, 2010) contends that Amazon deforestation has been caused by a complex set of social and economic factors totally unrelated to the expansion of Brazil's sugarcane industry. These factors include:

- Lack of clear property rights and enforcement of the law (mainly the Forest Code, which currently forbids landowners to deforest more than 20 per cent of their lands in the Legal Amazon).
- Illegal logging and cattle ranching.
- Poverty, which makes it harder for standing forest to have value for the immediate well-being and economic survival of the poor.

Amaral (2010), using empirical data, shows that while the production of Brazilian sugarcane ethanol increased between 2005 and 2009, deforestation rates of the Legal Amazon decreased in this period (see Figure 4.6).

Figure 4.6: Sugarcane area and annual deforestation rate in the Legal Amazon



Source: Amaral (2010)

Notwithstanding, Mendonça (2009) contends that the monocropping system to produce sugarcane ethanol has expanded and pushed the agricultural area into the borders of the Amazon rainforest and the Cerrado savannah biomes. Although Mendonça (2009) does not present a quantitative estimate of the amount of land that has been deforested in these biomes due to sugarcane expansion, she concludes that Brazilian sugarcane ethanol contributes, directly and indirectly, to depleting the Amazon rainforest and the Cerrado savannah biomes.

Likewise, Moreno (2010) contradicts the argument that increasing cattle herd stocking rates has allowed the expansion of sugarcane crops without deforesting new areas. She states that if this argument was valid there would not be, to date, about 70 to 140 million hectares of pastures considered of low productivity, with less than one cattle head per hectare, in Brazil. Moreno (2010) argues that extensive cattle farming

is used in Brazil to assert land ownership and is a strategy to incorporate degraded areas, public or under dispute, and this is how agribusiness most often works. Thus, indirect LUC caused by the expansion of sugarcane crops on areas of pasture is a *logical* consequence in Brazil (Moreno, 2010).

Future trends

In 2009 the US Environmental Protection Agency (EPA), through a Draft Regulatory Impact Analysis (DRIA), concluded that Brazilian sugarcane ethanol could reduce GHG emissions compared to petrol by 26 per cent, using a 30-year payback, and taking into account indirect LUC emissions (ICONE, 2009). However, based on the Brazilian Land Use Model (BLUM), which is claimed to be more accurate for the Brazilian context than the current global models, ICONE (2009) argues that the EPA has overstated the impacts of indirect LUC due to the increase in the production of Brazilian sugarcane ethanol. ICONE (2009) contends that, actually, Brazilian sugarcane ethanol can reduce GHG emissions compared to gasoline by 60 per cent, using the same 30-year payback and taking into account indirect LUC. According to UNICA (2010b), in 2010 the EPA published its final regulations for the expanded Renewable Fuel Standard program (RFS2), revising its first calculations and agreeing with the study of ICONE (2009). These discrepant results confirm that the analysis of indirect LUC presents substantial uncertainties due to the variables discussed above.

Macedo and Seabra (2008), even acknowledging the difficulties to estimate indirect LUC due to the expansion of Brazilian sugarcane crops, state that local conditions in Brazil suggest a positive scenario for significant increases in ethanol production without increasing indirect LUC GHG emissions. These local conditions include, primarily, the projection that the area needed for the expansion of Brazilian sugarcane ethanol, i.e. approximately 5 million hectares by 2020, is small when compared with the areas liberated with increased cattle raising efficiency, i.e. 30 million hectares, and other disused arable lands (Macedo and Seabra, 2008). Nonetheless, many studies contend that indirect LUC caused by the increase in

sugarcane ethanol production in Brazil is highly likely to be taking place. This indirect LUC may range from small to large amounts of native land being cleared mostly by cattle farming which will in turn be pushed by sugarcane crop expansion (Sparovek et al. 2008; Lapola et al, 2010; Gallardo and Bond, 2010; ICONE, 2011).

4.3 ZAE Cana

Some ZAE Cana shortcomings have been observed by reviewing the literature. Sections 4.3.1 and 4.3.2 below discuss the major issues in terms of likely direct LUC and indirect LUC.

4.3.1 Direct land-use change

Some of ZAE Cana's potential shortcomings in regard to likely direct LUC are divided into four topics.

1. Reliance on increasing cattle herd stocking rates

As discussed above, most of the literature estimates that the largest expansion of sugarcane crops is likely to occur in areas currently used for pastures. Notwithstanding, ICONE (2011) contends that clear policies to stimulate stronger intensification of cattle per hectare need to be implemented. According to ICONE (2011), the market alone is unlikely to trigger the pasture intensification which is expected by many studies and ZAE Cana. Additionally, Sparovek et al. (2009) state that it is uncertain whether sugarcane crops will follow the trend of occupying areas used for crops and pastures beyond the coming 7-12 years. They contend that the establishment of mitigating measures in areas outside the south-central states is warranted. In this context, Silva (2010) contends that the aim of ZAE Cana to direct the expansion of sugarcane crops into areas already used for pasture and crops needs to be systematically pursued, and policies to stimulate pasture intensification, e.g. pasture zoning, need to be established.

2. Expansion on the Cerrado biome and biodiversity conservation

Unlike the Amazon rainforest and the Pantanal wetland biomes, the Cerrado biome is not excluded by ZAE Cana from areas for the expansion of sugarcane crops (Manzatto, 2009). The Biofuel Watch Centre (BWC, 2009), based on projections by Nilson Clementino Ferreira, from the Goiás Federal University's Institute of Socio-Environmental Studies (IESA), shows that about 600,000 hectares of native land in the Cerrado biome may be deforested by sugarcane expansion by 2035. The projections of Ferreira go further in terms of time length than the other studies discussed above, which extend up to 2030, so Ferreira's level of uncertainty is higher than these studies. However, the projections of Ferreira confirm the recommendation provided by ICONE (2011) that it is necessary to formulate policies capable of minimising negative environmental impacts associated with degradation of the Cerrado biome.

BWC (2009) contends that the Cerrado biome will lose large amounts of its biodiversity to sugarcane crops in the coming years. This is, primarily, because the Cerrado biome is the agricultural frontier in Brazil and ZAE Cana does not consider the Map of Priority Areas for Biodiversity Conservation, which was revised and concluded by the Brazilian Ministry for the Environment in 2007. This Map is discussed further in the next chapter. Thus, ZAE Cana permits the expansion of sugarcane crops to take place in areas officially considered strategic for environmental conservation (BWC, 2009).

3. Resource Consent Bill 6.077 of 2009 still to be passed

Wilkinson and Herrera (2008) contend that, once an agricultural zoning such as ZAE Cana is defined for a particular activity, this usually means that credit and crop insurance will only be provided if the activity takes place within the area ruled appropriate. The Federal Decree 6.961 of 2009, which specifies the areas of ZAE Cana and allows public and private financing only to existing or new activities that expand within these areas, is currently the only policy to implement ZAE Cana (Manzatto, 2009). In this context, ZAE Cana as it is today does not prevent

sugarcane crops from being planted in non-zoned areas including the Amazon rainforest. The issue of whether ZAE Cana can prevent sugarcane crops from expanding out of its zoning is a key question given the ability of companies to raise their own financing. In short, the financial incentive in ZAE Cana may not be determinative.

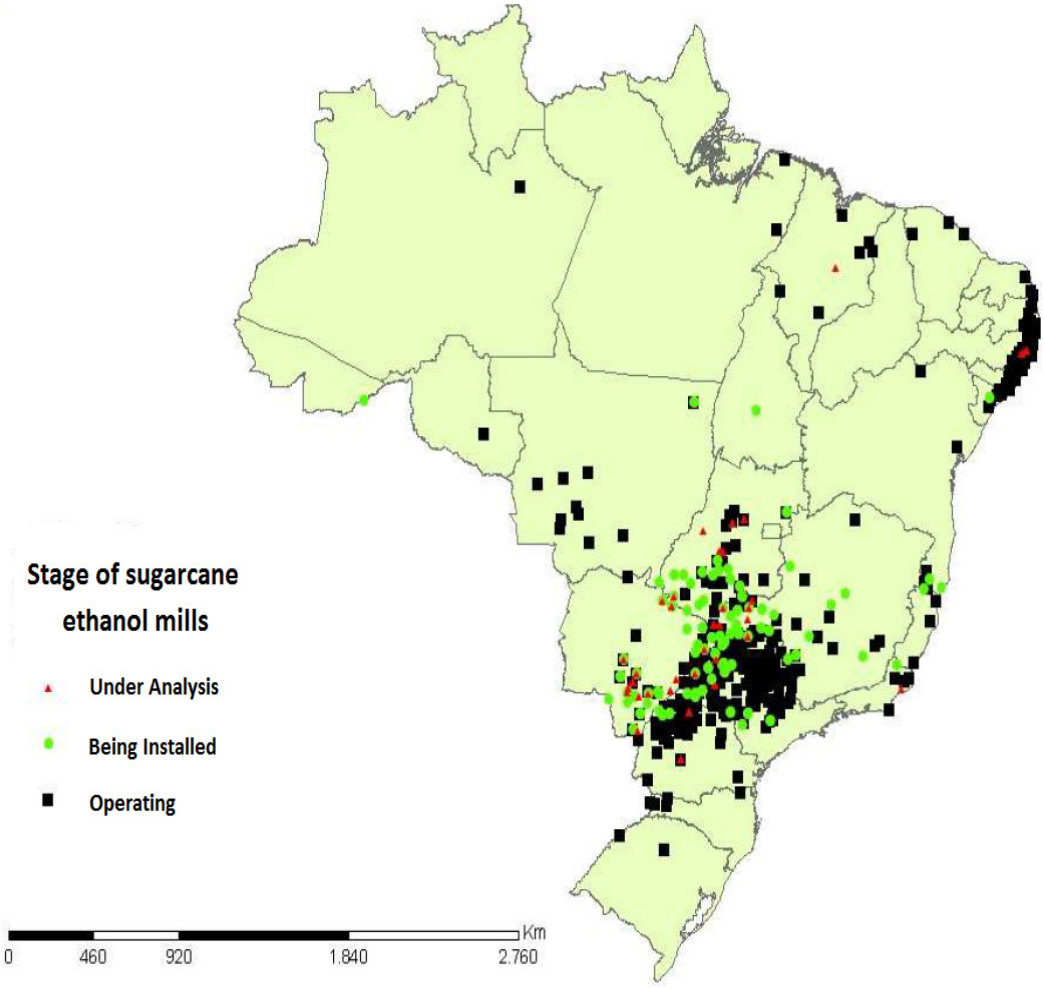
ZAE Cana, through the approval of Resource Consent Bill 6.077 of 2009 would prohibit the expansion of sugarcane cultivation for the production of sugar and ethanol in the areas currently excluded by its zoning. For example, it would prohibit removal of *native vegetation*[21] for the expansion of sugarcane cultivation for sugar and ethanol in the entire national territory (Manzatto, 2009).

4. Projects of sugarcane expansion before September 2009

ZAE Cana does not prohibit expansion of sugarcane crops from taking place in the exempt areas for those companies which have sought resource consent before it came into existence, i.e. September 17, 2009 (Manzatto, 2009). Silva (2010) contends that this fact limits ZAE Cana from being a mechanism which, alone, can guarantee that established sugarcane producers do not contribute, among other issues, to deforesting. In this context, Silva (2010) shows that there are ten mills operating in areas restricted by ZAE Cana or very near these areas, being two in the Amazon rainforest and eight very near the Pantanal wetlands biome (see Figure 4.8).

[21] *Native vegetation* is a term that has not been defined by ZAE Cana. This is an issue discussed in Chapter 5.

Figure 4.8: Map of the Sugarcane Ethanol Mills in Brazil.



Source: Silva (2010)

However, ICONE (2011) contends that most of the expansion of sugarcane crops has been within the limits established by ZAE Cana. But Silva (2010) states that because the mills in the Amazon rainforest and the Pantanal wetlands were already operating before ZAE Cana came into existence in 2009, the government needs to monitor the expansion of these mills in order to avoid deforestation.

4.3.2 Indirect land-use change

ZAE Cana aims to direct sugarcane expansion primarily into areas currently used for pasture and non-energy crops. In addition, ZAE Cana is a policy to control the expansion of sugarcane crops only (Manzatto, 2009). According to several studies, indirect land-use change due to the expansion of sugarcane crops in Brazil is likely to occur (Sparovek et al. 2008; Lapola et. al, 2010; Gallardo and Bond, 2010; ICONE, 2011). Cederberg et al. (2011, p 5) state:

Increased global demand for bioethanol from sugarcane and soy meat is raising land prices, which contributes to the migration of cattle production to the north of Brazil. Livestock farmers in the South who sell their land to soya and cane farmers and move to the northern region can multiply their pasture area: the average land price is seven times lower than in the south and the difference is increasing.

In addition, Silva (2010) contends that other activities such as soybeans and corn, which occupy much larger areas than sugarcane and are likely to be replaced, in some areas, by sugarcane crops, may expand into native ecosystems. Next chapter, from Section 5.4 and using the findings from the interviews, discusses indirect LUC caused by the expansion of sugarcane crops.

Chapter 5

Interview Results: Findings from Fieldwork

In this chapter, the major findings of the stakeholder interviews are presented. In addition to the literature review, this chapter presents the results of the main method used to address the objectives of this thesis. Interviews with Brazilian sugarcane ethanol experts representing private institutions, the government, the sugarcane industry association and the NGO WWF-Brazil were used to investigate the importance of, and motivations to create, ZAE Cana. The interviews were also used to analyse direct and indirect impacts caused by land-use change arising from the expansion of Brazilian sugarcane crops and how ZAE Cana has dealt with this expansion. Participants were also asked to discuss the strengths and shortcomings of ZAE Cana, and what may be improved in order to avoid detrimental direct and indirect land-use change from Brazilian sugarcane expansion.

The participants involved in this study comprise 13 people representing seven organisations and are organised into four categories (See Table 5.1). Throughout this chapter, the participants are identified by their last names along with their categories, which are explained in Table 5.1. For most of the questions, all of the participants stated that their responses represented their informed professional opinions as individuals rather than the organisations that they worked for.[22] Selected quotes have been included to clarify and emphasise opinions shared by the participants.

[22] In accordance with Victoria University of Wellington's Human Ethics Committee guidance, participants are referred to according to how they agreed to be identified in this research, i.e. either by name or as a representative from their category.

Table 5.1: Interview participants

Categories	Government (Gov)	Independent consultants (Con)	Industry representatives (Ind)	NGO representatives (NGO)
- Participant:	• Luis Ricardo Viegas de Carvalho	• Patricia Guardabassi	• Beatriz Secaf and Luana Maia	• Maria Cecilia Wey de Brito
- Position and Institution:	• Director of the Department of Sustainable Development of the São Paulo State Secretary for the Environment and Manager of the Green Ethanol Project	• Researcher of the National Reference Centre on Biomass (CENBIO), located in the city of São Paulo	• Experts (Beatriz is Environmental Scientist and Maia is Institutional Relations Chief at the Brazilian Sugarcane Industry Association (UNICA)	• General Secretary of the World Wildlife Fund (WWF) Brazil and former secretary for biodiversity and forests at the Brazilian Ministry for the Environment (2008-2009)
- Participant:	• Celso Vainer Manzatto	• Marcelo Moreira and Luciane Chiodi		• Edegar de Oliveira Rosa
- Position and Institution:	• Chief Executive of the Brazilian Agricultural Research Corporation (EMBRAPA)	• Researchers at the Institute for International Trade Negotiations (ICONE)		• Member of the World Wide Fund (WWF) Brazil
- Participant:	• Katia Nachiluk, Eduardo Castanho, Mario Olivette, and Felipe Camargo			
- Position and Institution:	• Experts (Economists and Agronomist Engineers) at the São Paulo State Institute of Applied Economics (IAE)			

[23]

[23] Further description of each institution is available in **Appendix A**.

5.1 Importance and motivations to create ZAE Cana

Section 3.4 above discussed the importance of, and motivations to create, the Brazilian Sugarcane Agroecological Zoning (ZAE Cana) which was officially announced by the government in 2009. This official announcement encapsulates the point of view held by the participant Manzatto (Gov), who participated directly in the elaboration of ZAE Cana. This viewpoint is that ZAE Cana aims to guide the sustainable expansion of sugar and ethanol production in Brazil.

More insights were given by Secaf and Maia (Ind), Rosa (NGO) and de Brito (NGO). Secaf and Maia (Ind), answering in the name of the institution they work for, contended that the Brazilian Sugarcane Industry Association (UNICA) supports ZAE Cana because it provides guidelines for sugarcane producers to expand their areas. In addition, Secaf and Maia stated that UNICA sees ZAE Cana as a high positive instrument for the sugarcane ethanol market. This is because companies can show to consumers that important biomes such as the Amazon rainforest are excluded from the zone of sugarcane expansion. One example of the ZAE Cana's positive profile for the sugarcane ethanol market was discussed by the participants:

> In 2010 UNICA hosted 200 foreign delegates comprising a range of experts including MBA and Masters students, entrepreneurs and policy makers. Most of these experts did not know the specific reality of Brazilian sugarcane ethanol. Thus, having a practical instrument like ZAE Cana facilitated UNICA to demonstrate that Brazil has taken serious steps towards sustainable production of ethanol. Secaf and Maia (Ind)

But whether ZAE Cana is an instrument that will indeed contribute to a sustainable expansion of sugarcane crops in Brazil is still debatable. Secaf and Maia (Ind) stated that, as ZAE Cana is a policy that emerged recently, i.e. 2009, there is a lack of robust data and studies which focus on the practical application of ZAE Cana.

Rosa (NGO) contended that ZAE Cana is an important tool for the environment as it limits the expansion of sugarcane crops into native areas and relevant biomes. In addition, Rosa stated the following about the importance of ZAE Cana for the sugarcane industry:

> ZAE Cana is based on robust studies and shows suitable areas for sugarcane expansion, and this is very positive for the sugarcane companies. The Brazilian government, in fulfilling its duty of organising the occupation and use of Brazil's sugarcane land, transmits to the sugarcane sector the idea that sugarcane expansion is positively under control and there is great opportunity for economic growth. Rosa (NGO)

However, Rosa (NGO) contended that ZAE Cana is at present an indicative rather than a punitive tool. This is because the Resource Consent Bill 6.077 of 2009, which would prohibit the granting of resource consents for producers who plan on expanding out of ZAE Cana, has yet to be passed by the Congress and sanctioned by the president. But Rosa also argued that, when the production chain of sugarcane is investigated, the sugarcane sector has generally followed the guidelines set up by ZAE Cana. Rosa believes that the market, primarily importing countries, has been more and more concerned about the sustainability of Brazilian sugarcane ethanol. Thus, if the sugarcane sector does not follow the rules set up by ZAE Cana, producers are likely to face problems including their market image.

Maria de Brito (NGO) contended that ZAE Cana is quite an important instrument for the control of the expansion of sugarcane crops in Brazil. The participant provided some insights into why ZAE Cana came into existence in 2009:

> One of the greatest motivations for the Brazilian government to create this instrument was the rapid expansion of sugarcane crops over areas that had never been used for cane. There were uncertainties in terms of the expansion of sugarcane crops and, hence, guidelines were needed to avoid and mitigate environmental impacts. de Brito (NGO)

Maria de Brito (NGO) also discussed a ZAE Cana characteristic which differentiates this instrument from other policies in Brazil. The participant contended that in Brazil the few agricultural zonings that exist for certain crops, such as cotton, beans and rice, focus exclusively on showing the favourable conditions of production for these crops. For example, these agricultural zonings point out depth of soil, whether the soil is rich in nutrients and adequate climate, but rarely take into account the importance of environmentally sensitive areas. Maria de Brito stated that, although ZAE Cana does not include some measures defended by the Ministry for the Environment, such as the Map of Priority Areas for Biodiversity Conservation (hereafter the Map), ZAE Cana is still relevant because it aims to protect other environmentally sensitive areas such as the Pantanal wetlands and native vegetation.

But the fact that the Map has not been included in ZAE Cana's policy is a significant issue in itself. The next two sections analyse the following: (1) the reasons for not including the Map; and (2) the likely consequences of this.

5.2 Analysis of direct land-use change

5.2.1 Reasons for ZAE Cana not including the Map

This topic contributes to understanding the likely consequences of ZAE Cana not addressing the Map, which was revised and concluded by the Brazilian Ministry for the Environment (MMA) in 2007. Although the findings here are based exclusively on de Brito's (NGO) position, her responses give an in-depth explanation. The interview with de Brito was mainly focused on biodiversity issues and the processes

which the draft of ZAE Cana had undergone before it came into formal existence in 2009. As shown in Table 5.1, de Brito was secretary for biodiversity and forests at MMA from 2008 until the end of 2009 and, during this time, she participated in the elaboration of ZAE Cana.

Maria de Brito argued that, during the elaboration of ZAE Cana, different agendas from various institutions and policy-makers in Brazil, e.g. economic groups, the rural caucus and environmentalists, made it impossible for the government to reach consensus and please all the parties involved. According to de Brito, the Map was not included for two reasons. Firstly, since the Map came into existence in 2004, it has not been updated as often as the changes to Brazil's land use and occupation. Maria de Brito illustrates this Map's first flaw:

> If we analyse specific areas of the Map, there may be anthropogenic activities which have started there and changed the features of those areas. So it means that MMA was not able to revise and show all the areas of the Map that had been modified by different uses and occupations of Brazil's land by the time ZAE Cana came into existence in 2009. de Brito (NGO)

Secondly, de Brito asserted that the Map cannot indicate in a highly precise way where sugarcane crops should be avoided. One example of this is the incapacity of the Map to limit expansion of sugarcane crops within exact X or Y metres from one of its environmentally sensitive areas.

Maria de Brito argued that these two reasons which prevented the Map from being included in ZAE Cana's policy were caused by lack of financial resources available for the MMA and an insufficient number of experts to update the Map on an ongoing basis.

5.2.2 Consequences of ZAE Cana not including the Map

As discussed, the lack of an up-to-date and detailed geographic survey is the major reason for ZAE Cana not including the Map. Despite these flaws, limiting the expansion of sugarcane near or within areas of biodiversity conservation is acknowledged by some participants to be important (Secaf and Maia (Ind); de Brito (NGO); Guardabassi (Con)). Hence, consequences are likely to occur given that ZAE Cana does not address the Map.

The first consequence that de Brito (NGO) discussed refers not only to environmental issues, but also to unnecessary public expenditure and government myopia:

> Maybe it was better not to create the Map and to invest the money and time in something that would indeed be used by policy-makers. The government has been myopic, valuing more short-term revenue gains, i.e. economic profits from the sugarcane ethanol sector, than the natural capital that is beyond monetary calculation. This natural capital refers to water of good quality, nutrient-rich soil, biodiversity, and so on. de Brito (NGO)

In terms of specific environmental consequences, de Brito (NGO) contended that pressure on endangered fauna and flora species is likely to occur as sugarcane crops expand near or within areas of the Map, and added:

> Despite the fact that the Map has its weaknesses in terms of detail and periodicity of upgrading, ZAE Cana could have, at least, stated that expansion of sugarcane crops near or within the Map should avoid, mitigate or remedy adverse environmental impacts. de Brito (NGO)

Secaf and Maia (Ind) argued that although the Map is excluded, they believe that as soon as the Brazilian government establishes new areas for biodiversity conservation within the zone of ZAE Cana, these conservation areas would override ZAE Cana.

But this argument is challenged when compliance with the Brazilian Forest Code, which also includes in its goals conservation of biodiversity, is analysed. Carvalho (Gov) stated that, in general, the Forest Code is not respected by producers including producers of sugarcane in the state of São Paulo.

> If it [the Brazilian Forest Code] was respected, 20% of each rural property would be set aside as Legal Reserve and other areas, for example riparian vegetation and top of hills, would be more often preserved as Areas of Permanent Preservation. Carvalho (Gov)

In spite of the many cases of sugarcane producers not complying with the Brazilian Forest Code in the state of São Paulo, this state aims, through its own sugarcane zoning, to protect areas of biodiversity importance. Guardabassi (Con) and Carvalho (Gov) stated that unlike ZAE Cana, the São Paulo State Sugarcane Agroecological Zoning (hereafter state zoning) takes into account the limits imposed by areas considered of high biodiversity importance. Carvalho explained that the focus given by the state zoning on biodiversity conservation has been supported by the Biota-FAPESP Programme.[24] The comparison between ZAE Cana and the zoning established by the state of São Paulo provides some insights into ZAE Cana and what can be improved in this national policy.

5.2.3 The State Zoning

Carvalho (Gov) explained that in order to gain a wide perspective on sugarcane ethanol expansion in the state of São Paulo, the Governor of this state set up a committee on bioenergy in 2007. This committee consisted of a multidisciplinary group including the Secretariat of Agriculture, the Secretariat of Water Assets and the Secretariat for the Environment. This committee conducted an analysis of the various bottlenecks for bioenergy in the state of São Paulo such as research and

[24] The Biota-FAPESP Programme maps and analyses the origins, diversity and distribution of the flora and fauna of the state of São Paulo. It also evaluates the possibilities of sustainable use of plants or animals with economic potential and assists in the formulation of conservation policies on forest remnants.

development, human resources, logistics, and the effects of mechanisation on employment. However, due to the relevance of environmental sustainability for the image of the sugarcane sector, Carvalho argued that the committee was supposed to concentrate the most on environmental issues, in particular sustainable use of water, regeneration of riparian vegetation and biodiversity conservation.

According to de Brito (NGO), by the time the committee was organized, the government needed to better manage the expansion of sugarcane in the state of São Paulo.

> When I worked in the São Paulo State Secretariat for the Environment in 2007, there were many sugarcane companies seeking resources consents for various areas of the state. Biodiversity issues, for example, were hardly put on the table to be discussed. de Brito (NGO)

In this context of rapid sugarcane expansion and uncertainties about where this expansion would actually take place, in 2008 the committee on bioenergy created the São Paulo State Sugarcane Agroecological Zoning (hereafter state zoning). Carvalho (Gov) stated that the state zoning is aimed at controlling sugarcane expansion in São Paulo, which, as noted in Chapter 3, is the largest producer of Brazilian sugarcane ethanol.

5.2.4 Effectiveness of the State Zoning

The issue of whether sugarcane has been cropped outside the state zoning was addressed to six participants (Guardabassi (Con), Carvalho (Gov) and Nachiluk, Castanho, Olivette, and Camargo (Gov)). By the time of the fieldwork they were involved in the specific analysis of the expansion of sugarcane crops in the state of São Paulo.

The interview with Nachiluk et al. (Gov) discussed two studies conducted by these participants.[25] As noted in the literature review, these studies estimate that sugarcane crops have mostly, i.e. nearly 70 per cent, expanded within inactive, unproductive, or low quality, pasture lands in the state of São Paulo. Nachiluk et al. contended that this expansion has largely complied with the state zoning.

Nevertheless, Guardabassi (Con) stated that there are cases in the state of São Paulo where sugarcane is cropped on riparian vegetation and areas of Legal Reserve. This information corroborates the statement about sugarcane producers infringing the Brazilian Forest Code provided above by Carvalho (Gov). But also according to Guardabassi (Con), many sugarcane producers have restored and/or protected the riparian vegetation of their properties in order to respect the state zoning. This respondent added:

> Pressure from countries that have imported Brazilian sugarcane ethanol has been a great driver for the sugarcane companies in the state of São Paulo to comply with the state zoning. Guardabassi (Con)

There are two other drivers, however, for sugarcane companies in the state of São Paulo to comply with the state zoning, and these drivers are outside the scope of ZAE Cana. This means that ZAE Cana has fewer tools to be implemented than the state zoning does. Carvalho (Gov) contended that on top of the state zoning itself, there is the Green Ethanol Project (*Projeto Etanol Verde*). This project implements an environmental protocol established by the government of São Paulo along with sugarcane companies and requires, among other things, compliance with the state zoning. The second driver that is currently outside the scope of ZAE Cana is due to the Resource Consent Bill 6.077 of 2009 not having been passed. The government of the state of São Paulo has the power, based on its state legal framework, to decline

[25] The two studies are Camargo et al. (2008) and Olivette et al. (2011). Both are discussed in the literature review in Chapter 4.

resource consents if producers plan on expanding outside the state zoning and the ability to decline these consents every two years (Carvalho (Gov)).

5.2.5 Comparing ZAE Cana and the State Zoning: Conclusion

The first conclusion is that the government of the state of São Paulo has more instruments available to implement its state zoning than each state of Brazil does to implement ZAE Cana.[26] These instruments are the Green Ethanol Project, which has been signed by sugarcane producers responsible for 97 per cent of the total production in the state (SMA, 2011), and the possibility to decline resource consents on the grounds of the state zoning. According to Secaf and Maia (Ind), the São Paulo state zoning has been put into effect as companies seek environmental licensing.

Rosa (NGO) contended that when the expansion of sugarcane crops in São Paulo state takes place near an area designated for the protection of biodiversity and which is shown by the state zoning, producers have to show measures to avoid, mitigate or reduce environmental impacts. This is not the case for ZAE Cana. In this context, Rosa, in alignment with de Brito's (NGO) viewpoint, suggested that ZAE Cana should require measures to avoid, mitigate or remedy environmental impacts when sugarcane producers expand their crops near or within the areas shown by the Map.

The second conclusion obtained from the interviews and analysis of data suggested by Carvalho (Gov), Guardabassi (Con), Manzatto (Gov) and Rosa (NGO) was that the state zoning permits more areas for the expansion of sugarcane crops than ZAE Cana permits in this state. Rosa (NGO) explained the following in regard to this difference in area:

[26] As discussed above, the only practical way to enforce ZAE Cana, to date, is through the Federal Decree 6.961 of 2009, which forbids public and private financing to projects that plan on expanding sugarcane crops outside its zone.

> It is due mainly to the different land slopes established by each sugarcane zoning, i.e. 20% set up by the state zoning and 12% by ZAE Cana. Because sugarcane can expand on areas with a declivity of up to 20% according to the state zoning, this zoning allows more areas for sugarcane crops.
>
> Rosa (NGO)

Carvalho (Gov) contended that technology in the state of São Paulo allows harvest machines to function on land with slope beyond 12% as established by ZAE Cana, and added:

> I hope that ZAE Cana will be amended to allow sugarcane crops on areas with slope greater than 12%, agreeing with the state zoning, which allows crops on lands with slopes of up to 20%. Carvalho (Gov)

Nevertheless, Manzatto (Gov) stated that ZAE Cana establishes a land slope of 12% because this number has to do with classic mechanisation and explained the following:

> Most of the areas in the state of São Paulo have a land slope of 10%, and many areas with the slope above this are located in Areas of Permanent Preservation, mainly riparian vegetation. This prevents or hinders mechanisation in areas with slope above 12%. Companies are not likely to invest in areas with slope above 12% due to high costs involved. Manzatto (Gov)

Additionally, Manzatto (Gov) contended that there is competition between sugarcane and forest production (wood for cellulose and energy), and even pasture land. Manzatto argued that areas with slope greater than 12% will be primarily occupied by the forestry and cattle ranching sectors rather than sugarcane.

The discrepancy in land slopes between the state zoning and ZAE Cana causes a considerable difference in the land area that can be used for sugarcane expansion in

the state of São Paulo. The state zoning allows 18.29 million hectares and ZAE Cana allows 14.95 million hectares (SMA, 2011; Manzatto, 2009). Regardless of the difference in the amount of land that can be used for sugarcane crops in the state of São Paulo allowed by the state zoning and ZAE Cana, both of these policies allow large additions to sugarcane land. Nevertheless, four participants (Carvalho (Gov), Manzatto (Gov), and Secaf and Maia (Ind)) contended that the total areas set aside by the state zoning and ZAE Cana will not be fully converted to sugarcane. The next section summarises participants' views in regard to the area likely to be occupied by sugarcane crops in the state of São Paulo and, more broadly, in Brazil.

5.2.6 Future land use for sugarcane crops

The estimates presented on this topic, as in the literature review, refer to sugarcane crops for the production of sugar and ethanol. However, Moreira and Chiodi (Con) contended that because nearly 60 per cent of sugarcane produced is currently used for the production of ethanol, it can be argued that around 60 per cent of the sugarcane area may be used for ethanol production in the future if market and technology remains the same.

Guardabassi (Con) explained that the capacity of financial investment is the major driver for companies to expand the sugarcane ethanol sector. In addition, Secaf and Maia (Ind) stated that in 2010 ethanol (hydrous and anhydrous ethanol) consumption in Brazil surpassed the consumption of gasoline while nevertheless using only 1.5 per cent of Brazil's arable land for sugarcane crops.[27] When asked about actual numbers in regard to the total area used by sugarcane crops by 2020**,** Secaf and Maia (Ind) stated the following:

[27] However, in 2010 and also 2011 Brazil had to import corn ethanol from the US to supply national demand (BiofuelsDigest, 2011). See footnote no. 4.

> We cannot ensure precise numbers based on robust analyses. The national and international market oscillates a great deal. However, we can show that from 2005 to 2009, the sugarcane ethanol sector increased its production 10% a year, while since 2009 the sector has increased 3% a year. But this increase is not only due to expansion in sugarcane areas, but also gains in productivity.
>
> Secaf and Maia (Ind)

Although Secaf and Maia (Ind) entered the caveat in regard to market uncertainties, these interviewees believe that the area of sugarcane crops in Brazil may reach nearly 12 million hectares by 2020, compared with 9 million hectares in 2011. This expansion implies a growth rate of around 2-3% per year. Additionally, these interviewees stated the following doubts about rigid growth projection:

> The 64 million hectares allowed by ZAE Cana for the expansion of sugarcane crops in Brazil is impossible to take place in the next decade. Sugarcane companies are incapable of augmenting their productions that much in a matter of 5-10 years. Secaf and Maia (Ind)

On top of market trends and the capacity for investment of the sugarcane sector, Carvalho (Gov) stated that other economic activities play a major role in the use of arable land and, therefore, influence the expansion of sugarcane crops. The participant added:

> Setting aside 18.29 million hectares [the total established by the state zoning] for sugarcane crop expansion does not mean that sugarcane will occupy this whole area, unless people decide to drastically increase the consumption of, or just eat, sugar and rely only on sugarcane ethanol as fuel. Carvalho (Gov)

According to the estimate of Carvalho (Gov), the sugarcane area in the state of São Paulo may reach up to 7 million hectares by 2020, compared with 5 million hectares in 2010. Carvalho stated that this estimate is limited by competition for land for other

agricultural activities such as cellulose, food and cotton, producing products that are also valuable for the market and society.

Likewise, Manzatto (Gov) contended that although ZAE Cana sets aside 64 million hectares for sugarcane expansion in Brazil, it does not mean sugarcane crops will occupy the whole area. Manzatto estimates, like Secaf and Maia (Ind), that sugarcane crops may occupy around 12 million hectares in Brazil by 2020.[28] In addition, Manzatto expects that Brazil will develop second generation sugarcane ethanol through the use of bagasse, i.e. dry fibrous waste left after sugarcane is crushed. This development would allow gains in productivity and, hence, lessen the necessity for sugarcane crops to expand on new areas (Manzatto (Gov)).

The interview with Moreira and Chiodi (Con) focused on the article "Simulating Land Use and Agriculture Expansion in Brazil: Food, Energy, Agro-industrial and Environmental Impacts", which had the collaboration of the participants and is discussed in the literature review. As discussed above, sugarcane crops may occupy from 10.551 million ha to 11.575 million hectares by 2022. These numbers are lower and more precise than the 12 million hectares identified by Secaf and Maia (Ind) and Manzatto (Gov). However, all of these estimates converge into one common conclusion: the increase in sugar and ethanol production in Brazil will require a considerable amount of new land, i.e. circa 3 million hectares, in the near future, but considerably less than the area identified by the ZAE Cana zoning.

5.3 Legal and policy analysis of ZAE Cana

5.3.1 Monitoring and enforcement of ZAE Cana

According to Guardabassi (Con), the most important way to implement ZAE Cana is through monitoring and enforcement. This participant added:

[28] This estimate is based on a range of studies carried out by institutions including EMBRAPA, for which Manzatto (Gov) works. The studies take into account gains in productivity, an increase in consumption and the possibility of exporting to other countries.

> Brazil has neglected the enforcement of many of its laws. In this context, the Brazilian government has to be aware of the importance of ZAE Cana not being neglected. Guardabassi (Con)

In regard to the specific rule of ZAE Cana which excludes areas of native vegetation from the expansion of sugarcane crops, de Brito (NGO) holds a sceptical viewpoint in terms of the enforcement of this policy:

> The enforcement of this rule [protection of native vegetation] is hard to be realised by ZAE Cana. This is because there is native vegetation in private properties, and the Forest Code allows landowners to deforest their lands up to certain amounts depending on the region in Brazil. Thus, the enforcement of ZAE Cana depends on robust and ongoing monitoring for a country with a continental size. de Brito (NGO)

As noted in the responses given by Guardabassi (Con) and de Brito (NGO) above, there are difficulties involved in enforcing ZAE Cana when the government is the only agency responsible for this enforcement. Therefore, the participants were asked about certification systems where the private sector is an important player in enforcing various criteria of sustainability. Different responses were given and they are summarised next.

On one hand, Secaf and Maia (Ind) stated that certification systems have been required by importing countries of Brazilian sugarcane ethanol. Thus, the Brazilian Sugarcane Industry Association (UNICA) has worked with the Bonsucro, which is one of the certification systems accredited by the European Union, one of the largest external market consumers of Brazilian sugarcane ethanol (Secaf and Maia (Ind)).

> Certification systems are important tools to fulfil the criteria of sustainability established by different policies such as the EU Renewable Energy Directive of 2009. This scenario of certification systems is still in its initial stage, but the trend is to grow in the next few years and the implementation of ZAE Cana could be benefited by this growth. Secaf and Maia (Ind)

Additionally, Manzatto (Gov) contended that, on top of the limitations imposed by ZAE Cana, e.g. protection of relevant biomes, native areas and prevention of competition with food production, there are also international pressure and sustainability requirements through certification systems. According to Manzatto, these certification systems have played a significant role in terms of the market image of Brazilian ethanol and in terms of incentives for sustainability.

On the other hand, Nachiluk et al. (Gov) argued that certification systems, such as those of the Roundtable on Sustainable Biofuels, instead of systematically monitoring social and environmental impacts, have only assessed the quality of biofuels, neglecting production processes. In addition, Nachiluk et al. contended that most of the sugarcane ethanol companies in Brazil have responded to market signals rather than acting on an authentic concern about social and environmental aspects of sustainability.

5.3.2 Expansion of sugarcane crops and compliance with ZAE Cana

Under this theme we discuss the responses of the participants in regard to the capacity of ZAE Cana to avoid the expansion of sugarcane crops outside its zoning, and the likely locations in which this expansion may take place. When asked to point out regions that are likely to be occupied by the expansion of sugarcane crops, Manzatto (Gov) stated:

> Projecting land use in specific regions requires [knowledge of] other factors which are not established by ZAE Cana. These factors include logistics and infrastructure to transport the ethanol to ports, the cost of land to be bought or leased, and other market factors which are outside the scope of ZAE Cana.
>
> Manzatto (Gov)

Nevertheless, Manzatto (Gov) contended that because ZAE Cana indicates suitable lands for sugarcane expansion - and this is crucial for companies to make decisions - the market is unlikely to expand outside ZAE Cana. Additionally, Manzatto stated a belief that the Brazilian government already has enough means to implement ZAE Cana. This interviewee stated:

> The Resource Consent Bill 6.077 of 2009, which sets rules for resource consents dealing with the expansion of Brazilian sugarcane production and empowers public authorities to punish illegal expansions out of ZAE Cana, **does not need to be passed**. The philosophy of ZAE Cana has already been consolidated. I cannot imagine any national or international entrepreneur producing sugarcane outside ZAE Cana.
>
> Manzatto (Gov) [emphasis added]

Guardabassi (Con) argued that prohibition of financing to sugarcane expansion outside ZAE Cana is already a strong tool to avoid irregular expansion. Guardabassi argued that in order to understand likely areas where sugarcane may be cropped in the future, it is necessary to analyse costs and benefits of this expansion. The participant contended the following:

> The price for acquiring land in the state of São Paulo has become quite expensive against the price in other states such as Mato Grosso do Sul and Goiás. However, there is the cost of infrastructure to transport and distribute sugarcane ethanol that is produced. This cost is higher where land is usually cheaper. Guardabassi (Con)

Carvalho (Gov) contended that, to date, the states where the greatest expansion of sugarcane has taken place are Mato Grosso, Mato Grosso do Sul, Goiás, and Minas Gerais, all located in the South-Central of Brazil. The high costs for acquiring land in the state of São Paulo, where more than 20 per cent of its territory is already used for sugarcane crops, plays a major role in this trend (Carvalho (Gov) and Guardabassi (Con)).

Manzatto (Gov) highlighted infrastructure being developed in the sates of Piauí, Tocantins and Bahia, which are located in the North and Northeast regions of Brazil. But as discussed above, sugarcane production is primarily located in the South-Central region. Manzatto (Gov) explained why sugarcane crops have concentrated more in this region:

- The best soil and climate are located in this part of Brazil.
- Not only does it have the strongest consumers market, but it also has the best infrastructure in terms of transport, e.g. highways, waterways and pipelines and ports.

Similar to the results shown in the literature review, all the participants contended that the expansion of sugarcane crops has mainly occurred in areas used for non-energy crops and, primarily, pasture land, and this is the main trend for the future. However, Moreira and Chiodi (Con) entered an important caveat:

> Pasture lands are not necessarily cheaper than other lands used by non-energy crops. In addition, some pasture lands have a poorer quality compared to other lands. Thus, although sugarcane crops have expanded mostly on pasture lands [in the South-Central region], it does not mean that this trend is general in Brazil. Moreira and Chiodi (Con)

On top of pasture lands not being necessarily cheaper than other lands used for other purposes as discussed by Moreira and Chiodi (Con), there are specific disincentives

in ZAE Cana which may discourage the expansion of sugarcane crops into pasture lands. These disincentives are discussed at the end of the next section.

5.3.3 Strengths and shortcomings of ZAE Cana in terms of direct LUC

Besides the fact that ZAE Cana does not address the Map, other aspects of ZAE Cana are discussed here. A summary of what most of the participants argued (Manzatto (Gov), Nachiluk et al. (Gov), Secaf and Maia (Ind), Moreira and Chiodi (Con), Guardabassi (Con), Rosa (NGO), and de Brito (NGO)) in terms of the expansion of sugarcane crops is captured in the following statement by Secaf and Maia (Ind):

> Even before ZAE Cana came into existence in 2009, the general trend of the expansion of sugarcane crops was to occupy *degraded* areas. Therefore, ZAE Cana just reinforces what has occurred before it came into existence.
>
> Secaf and Maia (Ind)

The term *degraded* refers, primarily, to areas previously used for pasture and non-energy crops. However, ZAE Cana does not explicitly classify the term *degraded*. For example, Agricola, Silva and Sauer (2010) show that although sugarcane crops have indeed expanded mostly over areas already opened for pasture and non-energy crops, many of these areas, which are called *degraded*, are very fertile and close to water assets and infrastructure. According to de Brito (NGO), the problem with the fact that ZAE Cana does not classify the term *degraded* is the broad scope of areas of pasture and non-energy crops allowed by ZAE Cana as *degraded*. Thus, sugarcane crops could occupy some of the best lands. Secaf and Maia (Ind) stated the following:

> There is no consensus about the term *degraded*. Even FAO [Food and Agriculture Organisation] states that there is not a single definition for *degraded* areas. But in general people define this term as areas with low levels of productivity based on national averages. Secaf and Maia (Ind)

Another problem of classification refers to the term *native vegetation.* As discussed above, ZAE Cana requires that sugarcane crops not expand into areas of *native vegetation*. Maria de Brito (NGO) contended the following:

> To date, there is only the legal framework of the Atlantic Forest biome which deals with *native vegetation*. This legal framework requests regulations to render more precise the definition of *native vegetation*, which comprises primary and secondary vegetation at advanced, medium and initial stages of regeneration in the Atlantic forest biome. de Brito (NGO)

Nevertheless, there is no regulation defining the term *native vegetation* for the Cerrado biome, where most of the expansion of sugarcane crops is expected to take place. Even though ZAE Cana, on top of *native vegetation*, excludes areas of *reforestation* from its zoning, and this could facilitate the identification of areas to be excluded from sugarcane expansion, de Brito (NGO) stated:

> Lack of definition of *native vegetation* and areas of *reforestation* becomes even worse when sugarcane producers do not seek resource consents for expanding their crop areas or when Environmental State Councils are not able to systematically conclude whether an area is indeed of *native vegetation*.
>
> de Brito (NGO)

The two problems discussed above by de Brito (NGO) address the fact that the Resource Consent Bill 6.077 of 2009 has not been passed. This fact prevents ZAE Cana from being implemented when sugarcane producers seek resource consents. In

addition, the lack of classification of the terms discussed above may make more difficult the identification of specific areas established by ZAE Cana. Maria de Brito stated that these problems may result in poor monitoring and enforcement of ZAE Cana.

As discussed above, though, Manzatto (Gov) contended that the bill 6.077 of 2009 does not need to be passed. He stated that the instrument created by the Federal Decree in 2009, i.e. the requirement to withhold credit to companies that plan on expanding outside ZAE Cana, is enough to prevent companies from infringing the zoning. Manzatto added:

> About 5 or 6 projects to expand sugarcane crops outside ZAE Cana have been cancelled by their own companies. They would have the right to expand because they could have sought resource consents before ZAE Cana came into existence in 2009. The entrepreneurs have given up on the projects mainly because they would not be able to receive credit from financial institutions in an eventual expansion after 2009. Manzatto (Gov)

Based on the response given by Manzatto (Gov) in regard to the bill 6.077 of 2009, the conclusion is that not only could ZAE Cana be enforced without relying on this bill, but also that sugarcane producers have accepted and followed ZAE Cana as it is. However, a study by the Biofuel Watch Centre (2009) shows that politicians and private investors have lobbied for the bill 6.077 of 2009 not to be passed. When asked about this study, Manzatto stated the following:

> There is indeed a political movement which aims to prevent the bill from being passed. This movement comprises politicians from the Upper Paraguay Basin region [one of the biomes excluded by ZAE Cana] and other politicians from the Northeast of Brazil. These politicians complain about ZAE Cana banning the expansion of sugarcane crops in their regions and the economic impact that may result. Manzatto (Gov)

According to Manzatto (Gov), the reasons for ZAE Cana excluding these regions are twofold. Firstly, the Brazilian government aims to decrease the use of water for the production of ethanol. In fact, ZAE Cana points out areas with good precipitation levels. Secondly, the Brazilian government aims to reserve water for the production of food. Thus, many areas in the Northeast region of Brazil, which is a dry region and requires irrigation, and in the Upper Paraguay Basin, which has great availability of underground water, have been excluded from the zoning of ZAE Cana.

ZAE Cana focuses primarily on pasture lands for the expansion of sugarcane crops. Indeed, of the total 64 million hectares established by ZAE Cana, 37 million hectares are pasture lands. Nevertheless, Guardabassi (Con) contended that ZAE Cana does not address the physical or technical measures for pastural practices to increase productivity and limit land use for cattle so that sugarcane can expand within the 37 million hectares. This participant added:

> To date, Brazil has an average of 0.98 head of cattle per hectare. However, ZAE Cana does not establish how much this average needs to increase in order to avoid indirect land-use change effects as pasture lands are converted into sugarcane crops. Guardabassi (Con)

Guardabassi (Con) did a rough calculation of productivity gain needed for pasture lands to accommodate the expansion of sugarcane. She counted how many hectares are currently used for pasture land, i.e. around 200 million hectares in Brazil, then deducted 37 million hectares; and compared this result (an area of 163 million hectares) with the number of cattle currently stocked in Brazil, i.e. nearly 196 million. She concluded that the gain in stocking level would not be substantial, i.e. it would go from 0.98 head of cattle per hectare to about 1.2 heads.

Nevertheless, lack of criteria in ZAE Cana in regard to physical or technical instruments for cattle farmers to increase productivity and, hence, avoid opening new land areas for pasture may cause adverse indirect LUC. This is because cattle

farmers, rather than keep producing in a smaller area as the expansion of sugarcane crops takes place, may deforest land areas elsewhere.

5.4 Analysis of indirect land-use change

5.4.1 Indirect land-use change and ZAE Cana

As discussed above, ZAE Cana is a policy focused solely on the sugarcane sector and, hence, does not address adverse impacts caused by indirect LUC. However, it is highly relevant to investigate side effects regarding the replacement of areas of pasture and non-energy crops because ZAE Cana allows the expansion of sugarcane crops primarily in these areas.

Secaf and Maia (Ind), Guardabassi (Con), Moreira and Chiodi (Con), and Nachiluk et al. (Gov) contended that effects caused by indirect LUC due to sugarcane expansion causing the displacement/extension elsewhere of other forms of agriculture are poorly understood at present. But these participants stated that data have shown that Amazon deforestation is caused by other activities, such as illegal logging and cattle ranching, that are not linked to the expansion of sugarcane crops. These data are discussed in the Section 4.2 above.

Secaf and Maia (Ind) contended that UNICA acknowledges that any agricultural activity may cause adverse indirect effects. However, these participants argued that it is crucial for the sugarcane ethanol sector and experts from various areas to understand how the indirect LUC is actually occurring. In addition, Secaf and Maia contended that gains in productivity will be the main tool to avoid indirect LUC. These participants argued that the Brazilian Climate Change Policy, for example, establishes low-carbon policy measures, which include doubling the cattle ranching productivity within an area of 15 million hectares by 2020. According to Secaf and Maia, this policy alone would open 15 million for the expansion of sugarcane ethanol.

But Secaf and Maia (Ind) also stated that monitoring and enforcement of Brazilian Environmental Law in general is fundamental to avoid deforestation due to activities being replaced by sugarcane crops. These participants emphasised the following:

> Brazil has reduced its level of deforestation. In fact, Brazil achieved in 2010 its lowest levels of deforestation in the Amazon rainforest since the country started to monitor its levels of deforestation in this biome and enforce more the law.
>
> Secaf and Maia (Ind)

In order to address indirect LUC, Secaf and Maia (Ind) argued, it has to be dealt with at the national or even international level. These participants recommended that the Brazilian government create, on top of ZAE Cana, agroecological zonings for other cultures including soybeans and cattle ranching, which are the activities that occupy the most land in Brazil. In reply to the question of whether the Brazilian Forest Code could not be relied on to compensate for the lack of other agroecological zonings and, hence, controlling indirect LUC, Secaf and Maia stated:

> This [relying on the Forest Code] is not necessarily the case as the Forest Code defines rules for individual properties, whereas agroecological zonings are instruments of integrated national public policy. Therefore, these other agroecological zonings would be more effective to control the expansion of different agricultural activities. Secaf and Maia (Ind)

5.4.2 Locations of indirect LUC

The study "Simulating Land Use and Agriculture Expansion in Brazil: Food, Energy, Agro-industrial and Environmental Impacts", in which Moreira and Chiodi (Con) participated, suggests that the greatest availability of land for agriculture expansion is located in the Northern Amazon and parts of the Cerrado biome. Moreira and Chiodi expressed doubt that sugarcane crops were pushing cattle ranching into these areas in the Northern Amazon and parts of the Cerrado biome:

> One thing is the theory and the other is the practice. Theoretically, indeed, Searchinger et al. (2008) state that indirect LUC is likely to occur as the production of biofuels increases. However, in practice pasture lands or non-energy crops may not be pushed into new areas.
>
> Moreira and Chiodi (Con)

Moreira and Chiodi (Con) discussed three scenarios which may take place in practice:

> (1) Only horizontal expansion takes place - cattle farming and non-energy crops are pushed by sugarcane crops into new areas;
>
> (2) Both horizontal and vertical expansion - the latter happens when activities increase their productivities and require limited expansion, or none, into new areas;
>
> (3) Only vertical expansion takes place.

Moreira and Chiodi (Con) contended that vertical expansion is the most frequent scenario to have taken place in the South-Central of Brazil. These participants stated that, based on the estimates of ICONE, the increase in productivity primarily in the cattle farming sector is what has occurred the most.

> One of the most interesting things that have occurred and what ICONE has proved to be true is sugarcane companies buying or leasing pasture lands so cattle farmers receive capital to invest in the technology of cattle confinement. The new technological methods include new types of fodder and modern types of fertilisation and liming.
>
> Moreira and Chiodi (Con)

But Moreira and Chiodi (Con) also contented that it is impossible to guarantee that horizontal expansions have not occurred and will not occur as gains in productivity depend on financial investment, which can be too costly and less advantageous than expanding in new land areas.

Nachiluk et al. (Gov), based on their study by Olivette et al. (2011), showed that there are three different scenarios in regard to sugarcane productivity from 2009-2030 in Brazil. Nachiluk et al. said that it is quite difficult to estimate which scenario is the most likely to take place:

> We have already shown three scenarios to avoid imprecision, but we could eventually calculate the average among the three. In addition, sugarcane ethanol companies have invested in research and development of second and third generations of ethanol, but it is hard to foresee when they will be brought about.
>
> Nachiluk et al. (Gov)

Nachiluk et al. (Gov) were asked whether sugarcane crops would be expanding horizontally, i.e. increasing their area of production, even when technological improvements of productivity take place with ethanol of second and third generations. Nachiluk et al. answered: "On the contrary, with gains in productivity, sugarcane would be much more likely to have just a vertical expansion."

5.5 Legal and policy analysis of indirect LUC

5.5.1 Measures to avoid detrimental impacts caused by indirect LUC

This section presents practical measures discussed by some participants (Manzatto (Gov), Rosa (NGO) and Moreira and Chiodi (Con)) and which Brazil has focused on to avoid detrimental indirect LUC caused by the expansion of sugarcane crops. Section 5.4 above presented three relevant measures to avoid detrimental indirect LUC discussed by Nachiluk et al. (Gov), Secaf and Maia (Ind), and Moreira and Chiodi (Con). These three measures are:

(1) Fostering gains in productivity;

(2) Monitoring and enforcement of Brazilian Environmental Law in general;

(3) Implementation of agroecological zonings for other activities such as meat and soybean production.

Manzatto (Gov) contended that Brazil has invested in and focused on increasing agricultural and livestock productivity, and primarily cattle ranching activity. According to Manzatto, to date, Brazil can augment sugarcane production through an increase in productivity rather than relying solely on using new lands. This participant cited the Low Carbon Agriculture Programme (*Programa ABC*), which is currently the main policy in the agriculture and livestock sector to increase the production of food in a sustainable way, reducing GHG emissions. Manzatto stated:

> The ABC programme aims, among other things, to recover degraded pasture lands, intensification of cattle productivity, activities rotation (cattle ranching along with other agricultural activities or reforestation). Altogether, the ABC Programme has allowed the Brazilian government to fulfil its voluntary commitment to reduce GHG emissions. Manzatto (Gov)

Nevertheless, Rosa (NGO) contended that the private initiative which deals with the agricultural and livestock sectors is always weighing the costs and benefits between investing in productivity gains and opening new areas. Rosa said that if livestock or crop producers are pressured by sugarcane expansion and they have to choose between increasing their productivity and opening new areas, they may deforest if it is the cheapest option. Rosa added:

> It is important to emphasise that sugarcane is not the only sector that pressures other activities into new areas. On the contrary, sugarcane is just one *piece* on the *board*, which also has soybeans, citrus and so on. Thus, what can really prevent indirect LUC are policies aimed at controlling expansions caused by each activity into the agricultural and livestock sectors. Rosa (NGO)

Moreira and Chiodi (Con) were asked whether certification systems, such as the Roundtable on Sustainable Biofuels, are likely to monitor and prevent indirect LUC caused by the expansion of sugarcane crops. These participants stated, “Due to poor

methods to individualise and assess indirect LUC, certificate systems may not provide pragmatic results and may not be feasible in a market sense."

Rosa (NGO) discussed some practical measures which may work hand in hand with ZAE Cana to prevent indirect LUC. Rosa cited the Round Table on Responsible Soy Association (RTRS). This is a multi-stakeholder initiative which aims to facilitate a global dialogue on soy production that is economically viable, socially equitable and environmentally sound. According to Rosa, some companies in Brazil follow this initiative and people involved in this initiative have also carried out a study to develop a map of areas in the Cerrado biome of biodiversity importance.[29] Likewise, Rosa contended that the Brazilian government, along with many soybean companies and some NGOs including Greenpeace, set up in 2006 an agreement which has established a moratorium on the expansion of soybeans in the Amazon rainforest. Rosa stated that this moratorium has contributed to decreasing the extent of deforestation in this biome. In addition, Moreira and Chiodi (Con) stated that this moratorium may prevent sugarcane from pushing soybeans into the Amazon rainforest.

5.6 Technology analysis: Methods to increase agricultural productivity

The last section above presented some measures which may contribute to avoiding detrimental indirect LUC. One of these measures includes fostering gains in productivity. This section presents specific methods aimed at increasing productivity and, hence, decreasing the need of expanding the agricultural frontier.

Moreira and Chiodi (Con) contended that one of the most important achievements in terms of technological improvements in the sugarcane sector is energy cogeneration

[29] This map may come into existence in 2012 and would update the Map of the National Project of Conservation and Sustainable Use of the Brazilian Biological Diversity (Probio). Companies in Brazil that have followed the RTRS include Maeda S.A. Agroindustrial and Grupo André Maggi (RTRS, 2012).

used by sugarcane mills, with sale of the surplus that resulted from this cogeneration. According to Moreira and Chiodi, it is not very expensive to improve the capacity of machines to cogenerate, e.g. going from a 20 bar heater to one of 60 bars is relatively cheap and provides great opportunities for cogeneration. But as to second generation sugarcane ethanol,[30] Moreira and Chiodi are more hesitant:

> It is clear that producing second generation sugarcane ethanol will take a while as first generation still needs improvements. Indeed, first generation sugarcane ethanol needs higher productivity and optimisation of harvesting technology to avoid wasting important inputs. Moreira and Chiodi (Con)

Secaf and Maia (Ind) provided similar comments to Moreira and Chiodi (Con) in terms of sugarcane ethanol of second generation:

> Predicting when sugarcane ethanol of second generation will come into existence is hard as it depends on the feasibility of the cost and benefits in a complex market. Thus, UNICA understands that due to market uncertainties, it is better not to invest in second generation ethanol as much as productivity improvements of first generation ethanol. Secaf and Maia (Ind)

However, Secaf and Maia (Ind) contended that in the last five-ten years, the sugarcane ethanol sector in general has doubled its productive capacity. For example, the sector could produce 3,500 litres of ethanol per hectare of sugarcane cropped before major improvements; whereas now the centre-south of Brazil average is 7,000 litres per hectare. In addition, the Brazil Sugarcane Technology Centre (CTC) aims to create technology which would allow sugarcane ethanol producers to double again

[30] The same fuel might be classified as first- or as second-generation, depending on whether the determining criterion is the maturity of the technology, the greenhouse-gas emissions balance or the applied feedstock (IEA, 2010, p 361). To date, sugarcane ethanol is produced from cane stalks. Sugarcane ethanol of second generation requires cellulosic conversion technologies to turn cane straw and bagasse into ethanol (Neves et al. 2011).

the productivity of the sugarcane ethanol sector, reaching 14,000 litres per hectares in the next five years.

Secaf and Maia (Ind) were asked to provide some insights into the fact that many transnational companies such as Shell, Bunge and British Petroleum have invested in the sugarcane ethanol sector in Brazil. These participants answered that this is a positive trend as many Brazilian companies, which are called brown-field companies due to their old industrial technology, have been enabled to invest in expensive machinery to optimise their production of ethanol.

> The high foreign investments in the Brazilian sugarcane ethanol sector do not mean transnational companies will rule and own the entire Brazilian sector. This is because 60% of the costs for sugarcane ethanol production are concentrated in the agricultural stage, which most often foreigners are not specialising in and where Brazil dominates the know-how. And the foreign investments have allowed the sugarcane ethanol sector to remain stable.
>
> Secaf and Maia (Ind)

Guardabassi (Con) contended that the use of Genetically Modified Organisms (GMOs) is an option to increase sugarcane ethanol productivity and avoid using new land areas. However, this participant emphasised that this option should be adopted only if exclusively used for the production of Brazilian sugarcane ethanol and not for food.

Manzatto (Gov) stated the following about the use of GMOs in the sugarcane sector to increase productivity:

> The current reality most often involves varieties of transgenic sugarcane resistant to water deficit. Additionally, 80 per cent of Brazilian soybeans are transgenic, and Brazil has also produced transgenic corn and aims to release, in the near future, transgenic beans and cotton. This is the next phase after the Green Revolution. Manzatto (Gov)

Nevertheless, de Brito (NGO) contended that lack of robust scientific studies, the precautionary principle and royalties that are charged for the use of transgenic seeds, are all issues that need to be taken into account in analysing the use of GMOs. Maria de Brito's view was that the Brazilian government has to focus on these issues before taking any decision in regard to the use of transgenic sugarcane.

Chapter 6

Discussion

The aim of this study was to analyse the effectiveness of ZAE Cana to avoid detrimental LUC in terms of GHG emissions and biodiversity degradation. The analysis of effectiveness used the literature, official data and information from key stakeholders. This chapter first discusses the main findings presented above, which answer the objectives One and Two of this study, i.e. analysis of direct and indirect LUC. This chapter then discusses objectives Three and Four. As shown in Section 1.2.2, objective Three sought to explore the strengths and shortcomings of ZAE Cana. Objective Four sought to understand what may be improved in ZAE Cana in order to avoid detrimental direct and indirect LUCs caused by the expansion of Brazilian sugarcane crops.

6.1 Direct land-use change

This thesis focuses on Brazilian sugarcane ethanol production. As discussed above, though, most of the mills are capable of producing both sugar and ethanol. Thus, detrimental LUC may be caused by the expansion of sugarcane for sugar and/or ethanol production. Nevertheless, the literature and official data discussed above show that the expansion of the sugarcane area in Brazil has been mainly motivated by the increase in Brazilian sugarcane ethanol consumption since 2003 (see, for example, Section 3.1). The year 2003 marked the launching of the first flex-fuel car on the domestic market and a significant increase in sugarcane ethanol exports (MAPA, 2009b).

The issue of LUC caused by the expansion of sugarcane crops in Brazil encompasses social, economic and environmental impacts. Social impacts involve, for example, indigenous peoples and small farmers being pressured by the expansion of sugarcane crops on large farms controlled by companies and large farmers (Filho, 2009).

Economic impacts, which go hand in hand with social impacts involve, for example, an increase in rural unemployment due to mechanisation and land displacement (Júnior, Melo and Mendonça, 2007). Environmental impacts involve, for example, river and aquifer pollution due to discharge of vinasse (a sugarcane by-product), and GHG emissions and biodiversity degradation due to deforestation of native vegetation (Cordeiro, 2008; Agricola, Pietrafesa and Sauer, 2010). As discussed above, this thesis focuses on environmental impacts caused by the expansion of sugarcane crops in Brazil and, more specifically, GHG emissions and biodiversity degradation due to this expansion.

6.1.1 GHG emissions

Most of the projections discussed in the literature review and findings from fieldwork show similar results in terms of the location of past expansion of sugarcane crops. Figure 4.1 shows that in the period from 2001 to 2006 in the state of São Paulo pastureland, cropland and other areas corresponded to nearly 69, 20, and 1.1 per cent of almost 1 million hectares subsequently occupied by sugarcane crops. In addition, Table 4.2 shows that the expansion of sugarcane crops in the period 2002-2006 in Brazil took place primarily (~71 per cent) in pasturelands. Although some of the expansion occurred in native vegetation areas, data on the expansion of sugarcane crops in the last decade indicates that less than 2 per cent occurred in these areas (see Section 4.1.1). Most of the projections discussed above estimate that the location of the expansion of sugarcane crops in the future is most likely to occur in areas currently used for crops and, primarily, pastures. The Brazilian Bioethanol Science and Technology Laboratory (CTBE) contends that when sugarcane replaces areas occupied by annual cultures such as soybeans, the impact on GHG emissions is neutral. When sugarcane replaces perennial cultures such as coffee and orange, the emissions of GHG increase; and this increase is even greater when sugarcane replaces native vegetation. The only scenario where GHG emissions decrease is when sugarcane replaces pastureland (CTBE, 2011). Therefore, GHG emissions due

to direct LUC caused by the expansion of sugarcane crops in Brazil show positive results as most of this expansion occurred and may occur in pasturelands.

Nevertheless, the expansion of sugarcane has caused biodiversity impacts and this may be aggravated in the near future. It is important to note that GHG emissions due to direct LUC are usually calculated on a national scale, i.e. an aggregation of the general expansion of sugarcane in Brazil. In other words, a small expansion of sugarcane crops in native lands, and high expansion in pasturelands, can show positive results in terms of overall GHG emissions. However, biodiversity conservation is significantly impacted when sugarcane crops deforest native lands, even on a small scale.

6.1.2 Biodiversity degradation

Agricola, Silva, and Sauer (2010, p 9) state that "analysing the production of ethanol and deeming it as sustainable, based only on calculations of GHG emissions compared to fossil fuels, is silly and ingenuous". In fact, the sustainability concept is not limited to the reduction of GHGs as it involves, among other issues, conservation of biodiversity and vital resources such as water, soil and air.

Figure 4.3 shows that about 99.8 per cent of sugarcane crops in Brazil are located over 2,500 kilometres from the Amazon rainforest. As noted in Section 4.1.2, however, little or no attention has been given to past and current clearing caused by sugarcane crops in the Atlantic Forest and the Cerrado savannah biomes. These biomes are the two biodiversity hotspots in Brazil. During the colonisation period and the National Alcohol programme (1975-1990) large areas of native land in the Atlantic Forest biome were cleared for sugarcane crops. Macedo et al. (2007) state that the agricultural expansion cycle (including sugarcane) in the Atlantic Forest biome preceded concerns about ecological preservation. Indeed, it was only in the second half of the 1980s that strong demands for new policies, on the grounds of environmental concerns, started to increase in Brazil (Alston and Mueller, 2007). For example, only from 1989 was it required that the area and location of Legal Reserves

(areas to be set aside according to the Brazilian Forest Code) be registered on the land title and notarised. Although important acts to protect the environment were made a long time ago, e.g. the Forest Code in 1965 and the National Environmental Policy in 1981, even at the time of their inception these acts were totally neglected, or constantly overridden by other motivations than environmental concerns.

But even with growing concerns about environmental sustainability, there are currently large areas of sugarcane being cropped, and potential threats of sugarcane expansion, in environmentally sensitive areas. Sections 4.12 and 5.2.2 discussed that there are large areas of sugarcane on Areas of Permanent Preservation, primarily riparian vegetation, and Legal Reserve. Marcelo Goulart, a state prosecutor from São Paulo, contends that problems caused by sugarcane crops in the Ribeirão Preto municipality, for example, one of the largest producers of sugarcane ethanol in Brazil, encompass burnings and degradation of Areas of Permanent Preservation and Legal Reserve (BWC, 2009). Figure 4.2 illustrates that biodiversity degradation can occur as a consequence of the expansion of sugarcane crops causing direct deforestation. Since the primary focus of this research is on land-use change caused by the expansion of Brazilian sugarcane crops, the harvesting process and post-agricultural stages have been excluded from Figure 4.2. However, the practice of sugarcane burning (see Picture 6.1) is potentially harmful for human health, emits GHGs, increases the soil erosion rate and may damage nearby forests, impacting biodiversity (Smeets et al. 2006).

Picture 6.1: Image of sugarcane being burnt in Brazil

Source: NGO ECOA * Policies in Brazil, including ZAE Cana, aimed to ban the practice of sugarcane burning are discussed in Section 6.3.

Picture 4.2 in Section 4.1.2 above shows the threat of sugarcane crops occupying forest remnants in the Atlantic Forest in the Biodiversity Corridor of the Northeast (CBNE) region of Brazil. In addition, as discussed in Section 3.2, more than 20 per cent (5.4 million hectares) of the territory of the state of São Paulo, where 60 per cent of the national sugarcane ethanol is produced, is occupied by sugarcane. Silva et al. (2007), analysing seven watersheds located in the state of São Paulo where pastures and sugarcane are the main activities, show that 75 per cent of the riparian vegetation has been destroyed. When riparian vegetation, i.e. a reservoir of biodiversity and a buffer against sedimentation of water bodies, is removed, the detrimental impacts of sugarcane cultivation and ethanol production on aquatic systems are exacerbated (Martinelli and Filoso, 2008). In this context, the detrimental consequences of the expansion of sugarcane crops on the biodiversity of the Cerrado biome are expected to be more noticeable at the local level (WWF, 2008). The Cerrado biome is located

in the South-Central region of Brazil, where the state of São Paulo lies, and is considered the expansion frontier of sugarcane crops (see Section 3.2.1).

6.2 Indirect land-use change

ZAE Cana is a policy focused solely on the sugarcane sector and, hence, does not address adverse impacts caused by indirect LUC. However, ZAE Cana allows the expansion of sugarcane crops primarily in areas currently used for pasture and croplands. Table 3.1 shows that soybeans, corn and pastures occupy much more land than sugarcane crops. In addition, it was discussed in Section 4.2 that there are difficulties in isolating the contribution of each agricultural activity to the overall indirect LUC effect. Indirect LUC is market driven, reflects global interactions, and is spatially and time dependent. For example, Figure 4.6 shows that Amazon deforestation has been caused by a complex set of social and economic factors unrelated to the expansion of sugarcane crops. These factors include lack of clear property rights and enforcement of the law, illegal logging and cattle ranching, and poverty. Despite this complexity and further uncertainties, the likely side effects which arise from the replacement of areas of pasture and non-energy crops by the expansion of sugarcane crops were discussed in Sections 4.2 and 5.4. Nassar et al. (2010), in a detailed study, estimate that the conversion of native vegetation caused indirectly by sugarcane in the period of 2005-2008 was nearly 20 times greater than the conversion caused directly (see Section 4.2). Section 4.2 also discussed that indirect LUC caused by the increase in sugarcane ethanol production in Brazil in the future is highly likely to be taking place.

Participants in the present study Moreira and Chiodi (Con) stated that vertical expansion of agriculture is the most frequent scenario occurring in the South-Central region. These participants contended that there has been a widespread increase in productivity primarily in the cattle farming sector. Nevertheless, Moreno (2010) argues that extensive cattle farming is used in Brazil to assert land ownership and is a strategy to incorporate degraded areas, public or under dispute, and this is how

agribusiness most often works (see Section 4.3.1). Undoubtedly, there have been many disputes about land ownership in Brazil. According to the Brazilian Institute for Settlement and Agrarian Reform (INCRA, 2003), there is a high degree of land ownership concentration in the country (see Table 6.1).

Table 6.1: Concentration of Brazilian Land Holdings, 2003

Groups of total numbers (in hectares)	Properties	% of Properties	Total area in hectares	% of area	Average area in hectares
Less than 10	1.338.711	31,6%	7.616.113	1.8%	5.7
From 10 to 25	1.102.999	26,0%	18.985.869	4.5%	17.2
From 25 to 50	684.237	16,1%	24.141.638	5.7%	35.3
From 50 to 100	485.482	11,5%	33.630.240	8.0%	69.3
From 100 to 200	284.536	6,7%	38.574.392	9.1%	135.6
Form 200 to 500	198.141	4,7%	61.742.808	14.7%	311.6
From 500 to 1000	75.158	1,8%	52.191.003	12.4%	694.4
From 1000 to 2000	36.859	0,9%	50.932.790	12.1%	1.381.8
From 2000 to 5000	25.417	0,6%	76.466.666	18.2%	3.008.5
5000 and more	6.847	0,1%	56.164.841	13.5%	8.202.8
Total	4.238.421	100,0%	420.345.382	100,0%	

Source: INCRA (2003); cited in Oliveira (2009)

However, Brazil has indeed invested in gains in productivity. The sugarcane sector, for example, augmented the production of ethanol per hectare in the last 5-10 years (see Section 5.6). In this context, the major measures to avoid indirect LUC in Brazil were discussed above. They refer to fostering gains in productivity; monitoring and enforcement of Brazilian Environmental Law; and implementation of agroecological zonings for other activities such as meat and soybean production. These measures are further discussed in Section 6.4 as the fourth objective of this thesis is focused on ways to avoid direct and indirect LUCs.

6.3 Strengths and shortcomings of ZAE Cana

As discussed in Section 1.1, there is an economic factor playing a major role in the creation of ZAE Cana. In order to break the barriers imposed by the socio-

environmental certification systems proposed by current or potential importing countries of Brazilian sugarcane ethanol, Brazil decided to establish ZAE Cana in 2009. The former Minister for the Environment, Carlos Minc, stated in 2009 that Brazilian sugarcane ethanol would be "100 per cent green" with the measures established by ZAE Cana (Valor, 2009). However, Section 4.3 discussed some of the ZAE Cana's potential shortcomings. These potential shortcomings were also discussed by the participants in Section 5.3.3. It appears that the immediate economic aim to overcome non-tariff barriers may be outweighing long-term environmental considerations. But economic aims and environmental considerations are not necessarily opposed. Indeed, Section 5.1 discussed that while ZAE Cana identifies suitable areas for sugarcane expansion, which is valuable for investors, it also protects environmentally sensitive areas such as the Pantanal wetlands, Amazon rainforest and native vegetation.

Nevertheless, it was discussed in Chapter 3 that a bill was recently proposed (February 2012) by a Federal Deputy to halt the effects of ZAE Cana. The argument of the Deputy is that ZAE Cana has been put into effect by an autonomous decree, i.e. a decree that regulates content which in turn is not established in any act. The Deputy contends that the Brazilian Constitution prohibits the executive from making autonomous decrees. Thus, the Federal Decree 6.961 of 2009, which is the current and only law regulating ZAE Cana, would have to be revoked if the bill is passed, or if the decree is considered unconstitutional by the judiciary. The Deputy used some arguments to support his bill that need further analysis. The first argument is that the federal government, by putting into effect ZAE Cana, without any act allowing it to do so, has exceeded its legitimate power. However, there are acts above ZAE Cana allowing for its legality and constitutionality (see hierarchical pyramid in Figure 3.7). The second argument is that the federal government has not provided any chance for the National Congress and, indirectly, civil society to participate in the process of prohibiting sugarcane in the Amazon rainforest, Pantanal wetlands and Paraguay Upper Basin. The Deputy represents the state of Pará, which lies within the Amazon rainforest and is one of the six states totally excluded from the suitable areas for

sugarcane expansion. It appears that the requirement to withhold credit to companies that plan on expanding outside ZAE Cana has generated controversy. In addition, the information provided by the participant Manzatto (Gov) that the requirement to withhold credit is enough to prevent companies from infringing the zoning has, to some extent, been proved correct (see Section 5.3.3). The third argument provided by the Deputy is that the federal government does not have any scientific study to justify the exclusion of the Amazon rainforest, Pantanal wetlands and Paraguay Upper Basin. This argument neglects evidence of the significant importance of these environmentally sensitive areas. However, this argument suggests that ZAE Cana is more focused on 'green washing', and avoiding non-tariff barriers, than on avoiding real environmental damages.

Section 3.4 discussed the importance of, and motivations to create, ZAE Cana which was officially announced by the Brazilian government in 2009. This announcement encompasses the strengths of ZAE Cana in Figure 6.1 below. Some of the participants emphasised these strengths by saying that ZAE Cana is an important tool for the environment as it limits the expansion of sugarcane crops into native areas and relevant biomes (see Section 5.1). This aspect of ZAE Cana is important for protecting biodiversity and avoiding GHG emissions. However, the fact that the Resource Consent Bill 6.077 of 2009 has not been passed may weaken this protection. As discussed above, the issue of whether ZAE Cana can prevent sugarcane crops from expanding out of the ZAE Cana zoning is a key question given the ability of companies to raise their own financing. The financial incentive in ZAE Cana established by the Federal Decree 6.961 of 2009 may not be determinative as this rule is an indicative tool rather than punitive. Although the participant Manzatto (Gov) argued that the passage of the Resource Consent Bill 6.077 of 2009 is irrelevant for the implementation of ZAE Cana, other factors discussed below corroborate the significance of this bill.

ZAE Cana excludes the expansion of sugarcane crops in Brazil where land slope is above 12%. The objective of this specific rule is to ban the practice of sugarcane

burning, which is used, primarily, to facilitate manual cutting. According to ZAE Cana, the areas that currently can be mechanised are those where land slope is up to 12% (Manzatto, 2009). This limitation is due to the technology of current harvest machines and, hence, cost-effectiveness faced by sugarcane producers. However, the participant Carvalho (Gov), for example, contended that technology in the state of São Paulo allows harvest machines to function on land with slope greater than 12%. In this context, as ZAE Cana does not address established areas (pre-2009) and areas with land slope above 12%, the burden of phasing out sugarcane burning in Brazil lies primarily on state policies. The state of São Paulo, for example, through the State Law 11.241 of 2002 along with the Environmental Protocol signed in 2007 by sugarcane industries, aims to phase out sugarcane burning. This state policy aims to phase out sugarcane burning by 2014 in mechanised areas, i.e. where land slope is up to 12%, and by 2017 in non-mechanised areas, i.e. land slope above 12%.[31] Approximately 45% of the sugarcane area in the state of São Paulo was burned before harvesting in the 2010/2011 harvest (São Paulo State Secretary for the Environment - SMA, 2011). This percentage is significant as it corresponds to about 2.3 million hectares.

In Brazil, it is common for states or municipalities to first develop legal rules dealing with their regional or local realities and then for the federal government to develop a legal framework to standardise these fragmented rules. This occurred with the state of São Paulo developing its sugarcane state zoning in 2008, and then the federal government developing ZAE Cana in 2009. However, Section 5.2.5 discussed some discrepancies between the state zoning and ZAE Cana. They refer to the following points:

- The land slopes on which sugarcane crops can expand, i.e. slopes up to 20% according to the state zoning and 12% to ZAE Cana. This specific

[31] Alves (2008) argues, however, that the Environmental Protocol signed in 2007 in the state of São Paulo is not compulsory and does not have legal status. Thus, the objective of phasing out sugarcane burning by 2014 and 2017 may not be realised.

discrepancy in land slope causes different areas to be allowed for sugarcane expansion.

- The government of the state of São Paulo has more instruments available to implement its state zoning than each state of Brazil does to implement ZAE Cana.
- Unlike ZAE Cana, the state zoning takes into account the limits imposed by areas considered of high biodiversity importance.

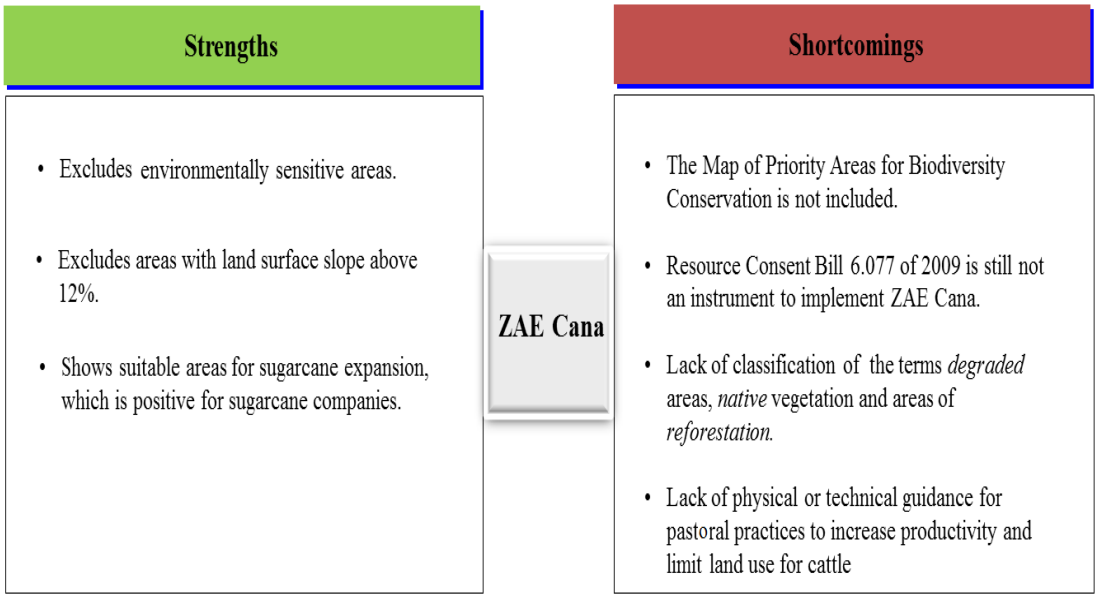
The regulatory discrepancy between ZAE Cana and the state zoning may eventually be the cause of inconsistencies. To date, these inconsistencies may cause confusion in granting credit for sugarcane producers willing to expand their areas. For example, a project on steep land may comply with the state zoning, but not with ZAE Cana. Although the Federal Decree 6.961 of 2009 forbids public and private financing to projects that plan on expanding sugarcane crops outside ZAE Cana, sugarcane producers may litigate by saying that they comply with the state zoning. In this context, if the Resource Consent Bill 6.077 of 2009 is passed into law, it would revoke the São Paulo state legal framework in regard to the size of the area to be used for sugarcane expansion, hence, reducing the area. This is because the bill would become a federal act, which is hierarchically above state laws. In addition, the areas considered of high biodiversity importance which are protected by the state zoning would be maintained in case the Resource Consent Bill 6.077 of 2009 is passed into law. Although ZAE Cana does not address the Map for sugarcane expansion in Brazil, the state zoning could fill the gap within the state of São Paulo. Therefore, areas of biodiversity importance in the state of São Paulo could be included in ZAE Cana's policy. This is because in Brazil there is a principle in environmental law called the 'principle of prohibition of environmental retrocession' (MPF, 2011, pp. 40-44). According to many legal precedents and policy-makers, this principle has to be observed when a new law which does not expressly revoke another law is made and it is less environmentally stringent (MPF, 2011). This is the

case with the Resource Consent Bill 6.077 of 2008 and the rules of biodiversity conservation in the state of São Paulo implementing the state zoning.

Another aspect of ZAE Cana discussed above refers to the lack of classification of the terms *degraded* areas, *native* vegetation and areas of *reforestation*. According to de Brito (NGO), the problem that may arise due to the broad scope of areas of pasture and non-energy crops classified as *degraded* is that sugarcane crops could replace food production in some of the best agricultural lands. Agricola, Silva and Sauer (2010) show that many areas called *degraded* are, on the contrary, very fertile and close to water assets and infrastructure. In addition, lack of classification of these terms may make more difficult the identification of specific areas established by ZAE Cana. The Resource Consent Bill 6.077 of 2009 has a significant relevance here. For example, according to Article 6 of the bill, the Ministry of Agriculture and Food Supplies (MAPA) would be responsible for certifying that sugarcane expansion does not affect food production or food security. This has direct implications for the term *degraded*. MAPA would need to better define *degraded* areas as it would have to certify that sugarcane crops are not expanding into food-productive land areas. Therefore, the bill could induce MAPA to render more precise the term *degraded* and state environmental councils could further regulate *native* vegetation and areas of *reforestation* as sugarcane producers seek resource consents.

This section has discussed some of ZAE Cana's strengths and shortcomings. These aspects are summarised in Figure 6.1 below. There is one aspect shown in Figure 6.1 which was not discussed here, but is included in the next section. This aspect refers to the fact that ZAE Cana does not address physical or technical measures for pastoral practices to increase productivity and limit land use for cattle.

Figure 6.1: Summary of strengths and shortcoming of ZAE Cana



6.4 Avoiding direct and indirect land-use changes

This section addresses measures to avoid direct and indirect LUC which have been observed throughout this study. These measures are discussed next.

Fostering gains in productivity

Section 5.3.3 discussed the fact that ZAE Cana does not address means to increase cattle productivity. According to Guardabassi (Con), policy-makers have relied on the increase in cattle herd stocking rate so that pasture lands can make available up to 37 million hectares for the expansion of sugarcane crops. While ZAE Cana is silent in regard to how gains in productivity may take place, it appears that this shortcoming of ZAE Cana can be managed by other policies. Indeed, the Low Carbon Agriculture programme (*Programa ABC*), which is discussed by Manzatto (Gov) in Section 5.5.1, is currently the main policy in the agriculture and livestock sector to increase the production of food in a sustainable way, reducing GHG emissions. In addition, Secaf and Maia (Ind) discussed the Brazilian Climate Change Policy, which establishes low-carbon policy measures, including the aim to double

cattle ranching productivity within an area of 15 million hectares by 2020. Nevertheless, it is important to note that intensification of pastures through use of industrial feedlots and supplemental feeding of grains may cause detrimental side effects. These are the main measures adopted by the Brazilian Agricultural Research Corporation (EMBRAPA) to rehabilitate degraded pastureland. The likely side-effects include increased use of antibiotics, faster degradation of some pasture, and potentially polluting aggregation of waste (Carter, 2009).

Section 5.6 discussed specific methods aimed at increasing productivity in the sugarcane sector and, hence, decreasing the need for expanding the agricultural frontier. These methods refer to second generation sugarcane ethanol; technology which would allow sugarcane ethanol producers to double the productivity of first generation sugarcane ethanol; and the use of Genetically Modified Organisms (GMOs). To date, investment in technology to increase productivity of first generation ethanol seems to generate the most cost-effective outcome. In addition, lack of robust scientific studies on the use of GMOs, the precautionary principle and royalties that are charged for the use of transgenic seeds, are all issues that need to be taken into account in analysing the use of GMOs. According to de Brito (NGO), the Brazilian government should focus on these issues before taking any decision in regard to the use of transgenic sugarcane.

Monitoring and enforcement of Brazilian Environmental Law

Section 3.4 discussed the National System of Conservation Units (SNUC) Act, the Brazilian Forest Code, and the São Paulo Sugarcane Agroecological Zoning. These laws can work along with ZAE Cana as they are aimed at conservation and preservation of the environment, and sustainable development. In addition, Section 5.2.4 discussed the Green Ethanol Project, which is part of the São Paulo state zoning policy to control the expansion of sugarcane crops. The Green Ethanol project aims, among other things, to conserve and regenerate nearly 262,000 hectares of riparian vegetation (SMA, 2011). Riparian vegetation is considered an Area of Permanent Preservation by the Forest Code. Thus, sugarcane producers, in restoring and/or

protecting riparian vegetation, have complied with both the Forest Code and the state zoning.

Nevertheless, Legal Reserves, which are established by the Forest Code, are outside the scope of the Green Ethanol project and, hence, of the state zoning. In addition, there is no specific timeframe for sugarcane companies to regenerate their areas of riparian vegetation in the state of São Paulo. This means that companies may procrastinate, or never accomplish, regeneration of riparian vegetation. Likewise, this regeneration within sugarcane areas in the state of São Paulo totals only 20 per cent of an area of 1.4 million hectares of degraded riparian vegetation (SMA, 2011). This relatively low proportion of regeneration means that reported effects of degradation of riparian vegetation on, for example, animal communities, e.g. a decrease in small-mammal species richness, have been or are likely to be only partly dealt with (Martinelli and Filoso, 2008).

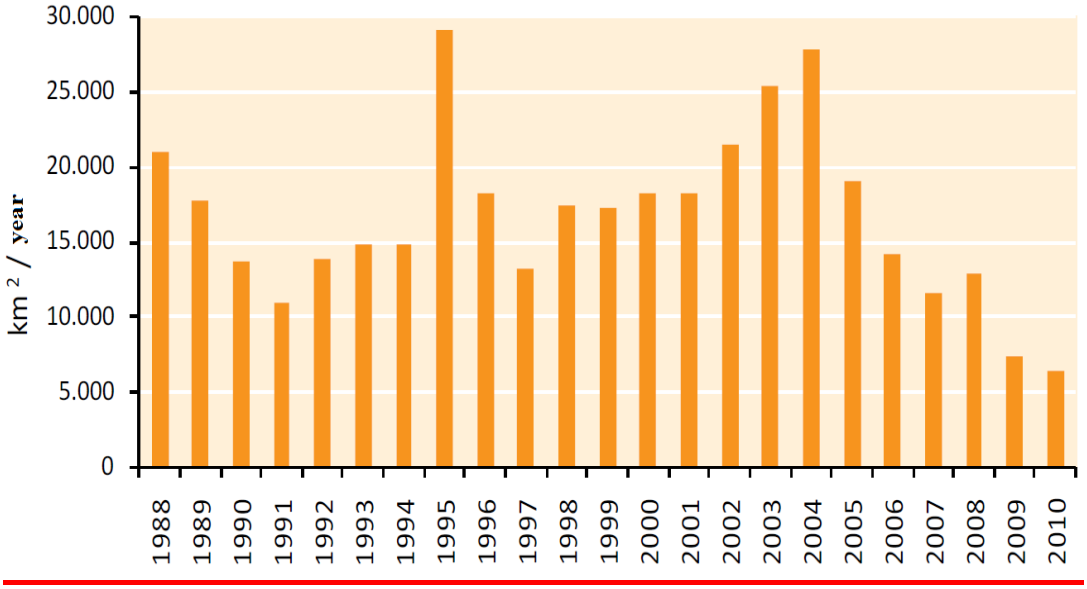
Section 3.4 discussed the proposal to amend the Forest Code. The debates around this proposal provide important insights into the implementation of ZAE Cana. An argument as to the reason for the proposed amendments was provided by Manzatto (Gov). He contended that Brazil has 500 years of history in regard to occupation and use of the land. Manzatto holds the view that the different policies that have been implemented in this regard have to be taken into account when analysing the current environmental legislation such as the Brazilian Forest Code. For example, the Brazilian government at one stage supported the introduction of agricultural activities into Areas of Permanent Preservation (APPs), e.g. sugarcane in the Northeast region of Brazil; rice and fruits in the South; and coffee in the state of Minas Gerais. Thus, Manzatto contended that it is crucial to address the evolution and modifications which Brazilian agriculture has undergone when the government develops agroecological zonings such as ZAE Cana.

Sparovek et al. (2012) estimate that of a total area of APPs of 103 million hectares in Brazil, 44 million hectares is used for crop production or as pastures, i.e. land uses

that do not comply with the current Brazilian Forest Code. Likewise, the area which would need to enter into compliance with the Legal Reserves requirements is approximately 43 million hectares. Therefore, Sparovek et al. (2012) estimate that, in a hypothetic situation of full compliance with the current Brazilian Forest Code, 87 million hectares (44 Mha APPs + 43 Mha Legal Reserves) of agricultural land would have to be reconverted to natural vegetation. However, they argue that the process of full compliance would likely induce substantial leakage where unprotected natural vegetation may become converted to agricultural land, reducing the conservation benefits of full compliance. In this context, one important solution would be to preserve lands that currently host natural vegetation. The goal of ZAE Cana to avoid sugarcane expansion into native land and areas of reforestation, and the possibility of pastures and non-energy crops being pushed into native areas require ongoing monitoring and enforcement of Brazilian Environmental Law in general.

Nevertheless, given these magnitudes, it is clear that monitoring and enforcement of the integrity of the current Brazilian legal framework is a necessary measure, but not sufficient to avoid more deforestation in Brazil (Carter, 2009). Carter (2009) contends that the problem is that the government most often demands the maintenance of forest reserves yet offers very low support when this regulation is challenged. He states, "As it [the Brazilian Forest Code] is right now there is nothing to keep forest standing because the law does not catch you in time and you can always bribe your way out of it if you do get caught." But Carter's statement may be unduly pessimistic. The Brazilian government was able to decrease deforestation in the Legal Amazon as indicated by satellite images which have been used to monitor implementation of the law. Figure 6.2 shows the rate of deforestation (square kilometre per year) in the Legal Amazon since 1988 when satellite was introduced. Although there have been high increases in deforestation in some years, since the government started to further enforce the law in 2004, the rates have significantly decreased.

Figure 6.2: Rates of deforestation in the Legal Amazon, since 1988



Source: National Institute of Space Research (INPE, 2010); MMA (2010)

In this sense, it appears that monitoring and enforcement, together with market forces operating with certification of products, all play a role in preserving forest remnants and should be implemented in an integrated way. Oliveira and Bacha (2003) conclude that legislation alone is incapable of overcoming market pressures such as demand for agricultural products and companies seeking profit maximisation. Certification systems were discussed with some of the participants in Chapter 5. The opinions regarding the effectiveness of certification systems showed contrasting results. On one hand, some participants contended that certification systems are important tools to fulfil the criteria of sustainability established by different policies such as the EU Renewable Energy Directive of 2009. Manzatto (Gov) contended that certification systems play a significant role in terms of the market image of Brazilian ethanol and in terms of incentives for sustainability. On the other hand, Nachiluk et al. (Gov) contended that instead of systematically monitoring social and environmental impacts, certification systems have only assessed the quality of biofuels, neglecting social and environmental aspects of sustainability.

Implementation of other agroecological zonings

As shown in Table 3.1, other economic activities in Brazil including soybeans, maize and cattle ranching occupy much more land than sugarcane crops. The 64 million hectares worth of area suitable for sugarcane expansion, as indicated by ZAE Cana, relies on land currently used, primarily, for soybeans, maize and pasture. Additionally, sugarcane is not the only sector that pressures other activities into new areas. In this context, the participants Secaf and Maia (Ind) and Rosa (NGO) recommended that the Brazilian government create, on top of ZAE Cana, agroecological zonings for other cultures. These other agroecological zonings could be more effective to control the expansion of different agricultural activities, rather than relying exclusively on the Brazilian Forest Code and the National System of Conservation Units (SNUC) Act. Indeed, Secaf and Maia (Ind) contended that "agroecological zonings are instruments of integrated national public policy.".

While other agroecological zonings may have similar weaknesses to those of ZAE Cana, and this would require ongoing improvements, the development of other zonings may allow for a better integration between market and environmental concerns. Like ZAE Cana, these zonings could assess the best areas for the production of different agricultural products, while excluding environmentally sensitive areas.

6.5 Limitations of this study and further research

Throughout this study's literature review and reporting of findings from fieldwork, projections on the expansion of sugarcane crops, i.e. likely locations and amount of land required out to 2030 for this expansion in Brazil, are discussed. But these projections are inevitably estimations and, hence, prone to variations as future demands for and investments in Brazilian sugarcane ethanol change. Drivers of change include financial crises, consumer' behaviour change, weather conditions, and so on. However, major findings and the recommendations generated from this study are not solely based on projections around the expansion of Brazilian

sugarcane ethanol. On the contrary, the legal and political analysis of this thesis is largely independent of the exact numbers; such projections are, rather, important means to generate understanding of the broad trends and magnitudes relevant to the implementation of ZAE Cana.

The dynamic context of Brazilian sugarcane ethanol prevents the elaboration of a static theory. For example, the bill proposed by the Federal Deputy in February 2012 may lead to the repeal of ZAE Cana, and other developments would no doubt follow, so that further discussions would need to be developed. However, this thesis discusses empirical and theoretical data that may contribute for future studies. In addition, the fundamental understandings generated in this thesis may be useful for other studies that analyse environmental policies not only in Brazil, but in other countries also. This thesis has also provided an approach which can be adapted to regulatory analysis of environmental issues arising as the Brazilian agricultural sector evolves in future. The analysis of direct and indirect LUC, and the framework for considering strengths and shortcomings could be used, for example, in an analysis of soybeans expansion in Brazil.

This study has analysed the expansion of sugarcane in Brazil from an environmental perspective. But for decision-makers to ensure energy sources are thoroughly sustainable, they also have to take into account social equity, which requires a focus on the distributional consequences of environmental decisions, and economic justice (Adger, 2002). In other words, sustainable governance must also consider socio-economic aspects. Nevertheless, by focusing on GHG emissions and biodiversity degradation, which are primarily within an environmental scope of sustainability, this thesis has been able to develop an in-depth study and contribute to filling the knowledge gap regarding these aspects.

Because this study has focused on Brazil, many sources referred to here are in Portuguese. This may make it more difficult for researchers without any knowledge in the Portuguese language to further explore the results discussed in this thesis. The

use of tools such as Google translator, as well as contacting the author and/or people who speak Portuguese, can overcome this barrier.

Chapter 7

Conclusion

This thesis has analysed whether or not ZAE Cana is capable of preventing adverse land-use change (LUC) caused by the expansion of sugarcane. The aim was to develop knowledge on the extent to which ZAE Cana can contribute to reducing, or avoiding, adverse environmental impacts in terms of GHG emissions and biodiversity degradation, taking into account both direct and indirect effects of LUC.

The key findings of this thesis can be summarised as follows. Firstly, despite the limited land area that sugarcane for ethanol occupies in Brazil, this area is expanding and, at least at the local scale, is placing pressure on the environment. Sugarcane crops occupy 9 million hectares of Brazil's land. This represents only around 1 per cent and 2.6 per cent of Brazil's total land and arable land, respectively. Sugarcane for ethanol occupies 5.4 million hectares of Brazil's land. This represents only about 0.6 per cent and 1.6 per cent of Brazil's total land and arable land, respectively. These amounts are not as high as the areas occupied by pasture, corn and soybeans. These activities occupy about 200, 24 and 14 million hectares of Brazil's land, respectively. However, projections are that the sugarcane area will expand due mainly to growing national and international demand for sugarcane ethanol. This expansion may result in an additional area of sugarcane (for both ethanol and sugar) of around 3 million hectares by 2020. In addition, it may be misleading to analyse the impacts of sugarcane crops on a national scale. More than 20 per cent (5.4 million hectares) of the territory of the state of São Paulo, where 60 per cent of the national sugarcane ethanol is produced, is occupied by sugarcane. The detrimental impacts of the expansion of sugarcane crops on the environment are already more noticeable at the local level, and are expected to become more so (see Sections 4.1.2 and 6.1.2).

Secondly, most of the literature reviewed and information from the participants are optimistic in regard to GHG emissions due to direct LUC caused by sugarcane expansion. This is because such expansion is likely to follow the last decade's trends in terms of LUC, i.e. displacement of areas of existing crops and, primarily, pasture. But it can be misleading to analyse the impacts of sugarcane crops using an aggregate measure as the calculation of GHG emissions most often does. The expansion of sugarcane has caused biodiversity impacts and these may be aggravated in the near future, as sugarcane crops cause deforestation of native lands, even on a small scale. Biodiversity impacts are more likely to occur in the Cerrado savannah and Atlantic forest biomes, the two biodiversity hotspots in Brazil. This is because sugarcane crops are located, and are more likely to expand, within the area of these two biomes, where biodiversity is increasingly valuable.

The analysis of indirect impacts of LUC caused by the expansion of sugarcane is, to date, a complex task. Indirect LUC is market driven, reflects global interactions, and is spatially and time dependent. There are difficulties in isolating the contribution of each agricultural activity to the overall indirect LUC effect. Sugarcane is not the only sector that pressures other activities into new areas. However, although studies show that increased cattle herd stocking rates and crop yield improvements were able to prevent indirect deforestation, sugarcane expansion caused indirect LUC in the decade prior to this research (see Section 4.2). In addition, many studies contend that indirect LUC caused by the increase in sugarcane ethanol production in Brazil is highly likely to be taking place (see also Section 4.2).

Thirdly, and of central importance in the present study, ZAE Cana may play a significant role in avoiding unsustainable expansion of sugarcane crops. The 'environmental goal' of ZAE Cana is positive in the sense that it excludes environmentally sensitive areas including the Amazon rainforest and Pantanal Wetlands. Avoiding deforestation in these areas means conservation of biodiversity and reduction of GHG emissions.

Nevertheless, ZAE Cana needs improvements. There is a strong case for the Resource Consent Bill 6.077 of 2009 being passed into law. The only practical way to enforce ZAE Cana, the Federal Decree 6.961 of 2009, which forbids public and private financing to projects that plan on expanding sugarcane crops outside the ZAE Cana zone, may not be determinative. The bill would provide tools (administrative, civil and criminal punishments) for the enforcement of ZAE Cana. In addition, the bill would require environmental councils and the Ministry of Agriculture and Food Supplies (MAPA) to better define the terms *degraded* areas, *native* vegetation and areas of *reforestation*. Policy-makers dealing with a lack of robust definition of these terms, in the absence of this bill, may overlook the expansion of sugarcane crops into the best agricultural lands.

The fact that ZAE Cana does not address the Map of Priority Areas for Biodiversity Conservation is a significant issue in itself. Effective regulation would require sugarcane producers to mitigate and/or remedy adverse environmental impacts when expanding near or within the area of the Map. The São Paulo State Sugarcane Agroecological Zoning takes into account areas considered of high biodiversity importance. In order to avoid uncertainties, litigation and environmental damages, it makes sense for ZAE Cana to incorporate this state policy for the area of sugarcane expansion in the state of São Paulo. Additionally, it would be desirable for other states in Brazil, e.g. Mato Grosso do Sul and Goiás, where sugarcane expansion is likely to be significant in the near future, to develop biodiversity policies like the one in São Paulo (see footnote 24 on the Biota-FAPESP Programme).

Within the 'agricultural policy' goal of ZAE Cana, the aim to direct sugarcane expansion into areas with land surface slope less than 12% may allow for environmental benefits. The aim of this rule is to allow for increased mechanical harvesting and, hence, to avoid sugarcane burning. The practice of sugarcane burning emits GHGs, increases the soil erosion rate and may damage nearby forests, impacting biodiversity. In addition, some participants in the present study contended that identifying suitable areas for sugarcane expansion is positive for the market.

Besides land surface slope, ZAE Cana identifies areas with suitable soil and climate for sugarcane cultivation, without full irrigation (see Section 3.4).

On top of monitoring and enforcement of other legal frameworks, including the Brazilian Forest Code, to control indirect LUC, there is also a case for the use of market instruments to discourage deforestation. Such instruments can create a strong stimulus for entrepreneurs to preserve natural habitats. However, monetising the ecological value of standing forest may cause detrimental side effects. For example, people may decide to deforest in those areas where the market is not operating (creating a 'leakage' effect). Notwithstanding, market instruments, if used along with sufficient regulatory policies, and bolstered by sound monitoring, may represent a useful way forward.

The agroecological nature of ZAE Cana reflects a mix of market and regulatory environmental policies. This makes ZAE Cana a necessary policy measure to reduce, or avoid, biodiversity degradation, GHG emissions and other environmental impacts caused directly by sugarcane expansion. But, as discussed, there are relevant shortcomings of ZAE Cana and ZAE Cana alone is not adequate to mitigate the significant impact on LUC caused by other agricultural activities. Therefore, ZAE Cana is not a sufficient policy to reduce, or avoid, the range of impacts of LUC caused by expansion of sugarcane for ethanol. Consideration should be given to developing agroecological zonings for other activities such as cattle farming, soybeans and corn, to control detrimental indirect LUC.

Appendices

Appendix A: Further description of the participants and their institutions (Relevance of them for the study)

CATEGORY ONE: Government officials

1- **Luiz Ricardo de Viegas de Carvalho –** Director of the Department of Sustainable Development of the São Paulo State Secretary for the Environment and Manager of the Green Ethanol Project of the State of São Paulo.

The São Paulo State Secretary for the Environment coordinates, formulates, approves, executes, evaluates and updates the São Paulo State Environmental Policy. The secretary also issues environmental resource consents, and monitors environmental impacts.

The Green Ethanol Project (*Projeto Etanol Verde*) is carried out by the Government of the State of Sao Paulo along with sugarcane producers and aims to promote sustainability of the sugarcane ethanol sector.

Webpage: http://www.ambiente.sp.gov.br/

2- **Celso Vainer Manzatto -** Chief Executive of the Brazilian Agricultural Research Corporation (EMBRAPA).

Embrapa is an institution linked to the Ministry of Agriculture and Food Supplies (MAPA). Embrapa and MMA were the major institutions responsible for assessing areas suitable for the expansion of sugarcane and for the creation of ZAE Cana.

Webpage: http://www.embrapa.br/english

3- **Katia Nachiluk, Eduardo Castanho, Mario Olivette, and Felipe Camargo** - Experts (Economists and Agronomist Engineers) at the São Paulo State Institute of Applied Economics (IAE).

IAE, within the São Paulo´s Agency for Agribusiness Technology (APTA), linked to the Department of Agriculture and Provision (SAA), is responsible for researching, analysing, generating and disseminating statistical data as well as economic information to comply with the demands of agriculture and society.
Webpage: http://www.iea.sp.gov.br/out/index.php

CATEGORY TWO: Independent consultants with Brazilian sugarcane ethanol expertise

4- **Patricia Guardabassi** - Researcher of the National Reference Center on Biomass (CENBIO).
CENBIO is a group of research in bioenergy located at the São Paulo University, in the Electro technics and Energy Institute (IEE). CENBIO aims to promote the development of research activities and the disclosure of scientific, technologic and economic information to make feasible the use of biomass as an efficient energy source in Brazil. CENBIO has been focused on the development of studies and projects aiming at the use of biomass, and promoting the interchange among Brazilian and foreign institutions of technical information and economic, social and environmental results of biomass technologies uses for energetic ends.
Guardabassi has published more than five articles about the sustainability of Brazilian sugarcane ethanol in important journals. On top of providing relevant information for this study, she recommended the participants Marcelo Moreira and Luciane Chiodi.

5- **Marcelo Moreira and Luciane Chiodi -** Researchers at the Institute for International Trade Negotiations (ICONE)
ICONE is a non-profit agribusiness think-tank that functions as a base for the definition of public policies and negotiating positions in international trade and other areas that influence agricultural production and trade.
ICONE has five working fields
- Trade policy and international negotiations

- Emerging economies and agriculture trade
- Agricultural modelling and projections, and land-use
- Agriculture, trade and sustainability
- Market intelligence

ICONE is currently involved in projects and research on biofuels, land-use change, greenhouse gas emissions, and certification and private standards for trade. ICONE is also concerned with themes like the impacts that the abovementioned have on climate change.

Webpage: http://www.iconebrasil.org.br/en/

Category Three: Industry representatives

6- **Beatriz Secaf (Environmental Scientist) and Luana Maia (Institutional Relations Chief)** - Experts at the Brazilian Sugarcane Industry Association (UNICA).

UNICA represents the main ethanol companies from the Centre-South Brazil UNICA represents 124 sugar and ethanol mills in the South-Central region. The production of the UNICA members represented about 44% of the ethanol and 51% of the sugar in Brazil in the 2009/2010 harvest.

Webpage: http://english.unica.com.br/

Category Four: NGO Representatives (NGO)

7- **Maria Cecilia Wey de Brito** - General Secretary of the World Wide Fund (WWF) Brazil and former secretary for biodiversity and forests at the Brazilian Ministry for the Environment when ZAE Cana was created in 2009

WWF's way of working combines global reach with a foundation in science, involves action at every level from local to global, and ensures the delivery of innovative solutions that meet the needs of both people and nature.

Webpage: www.wwf.org.br

This interview was conducted due to the participant's expertise, rather that the institution she works for. As shown in Table 5.1, de Brito was secretary for biodiversity and forests at MMA from 2008 until the end of 2009 and, during this time, she participated in the elaboration of ZAE Cana. In addition, she worked in the São Paulo State Secretariat for the Environment in 2007

8- **Edegar Rosa** - Member of the World Wide Fund (WWF) Brazil

Edegar Rosa was recommended by Maria de Brito due to his expertise in the Brazilian sugarcane ethanol sector. Before working for WWF, Edegar Rosa worked for about 5 years with certification systems for the export of Brazilian meat, soybeans, sugarcane, and other products. The company of certification systems with which he worked was the first one in Brazil to assess the sustainability of sugarcane ethanol that was exported to Europe. This work was done in conjunction with the English company Green Energy.

Appendix B: Interview schedule

This research project focuses on the two following questions:

Is ZAE Cana capable of ensuring conservation of native biomes and environmentally sensitive areas as production of Brazilian sugarcane ethanol increases and causes direct land-use change? Additionally, how likely is ZAE Cana to prevent adverse side effects caused by indirect land-use change particularly deforestation of native biomes and environmentally sensitive areas?

Answering these two questions necessitates breaking them down into four objectives. Each objective has questions that are loosely based around the ten meta-questions below:

1- Analysis of direct impacts caused by land-use change (Objective one):

- What are the consequences of the fact that ZAE Cana has not considered the Map of Priority Areas for Biodiversity Conservation?

- Has sugarcane been cropped in prohibited zones since the state of Sao Paulo passed its sugarcane agroecological zoning in 2008?

2- Analysis of indirect impacts of land-use change arising from ethanol production to date and in future (Objective two):

- Have bioethanol crops already pushed rangeland and non-energy crops into areas of native ecosystems in the state of São Paulo?

- Taking into account different estimations regarding sugarcane ethanol increase, how much land currently used for pasture and non-energy crops is likely to be replaced?

- Is this replacement likely to take place in native biomes or environmentally sensitive areas?

3- Legal analysis of previous questions (Objective three):

- Based on the results obtained from the previous questions, what are the strengths and shortcomings of ZAE Cana?

- What needs to be improved in order to avoid detrimental LUC?

- How thoroughly is the Brazilian government likely to monitor and enforce ZAE Cana?

4- Non-legal analysis (Objective four):

- What are appropriate policies to be implemented in order to avoid detrimental impacts caused by indirect land-use change from sugarcane expansion?

- In what way might ZAE Cana be amended to minimise perverse indirect land-use change?

Appendix C: Human Ethics Committee Documents

a) Human Ethics Committee Approval

TE WHARE WĀNANGA O TE ŪPOKO O TE IKA A MĀUI
VICTORIA
UNIVERSITY OF WELLINGTON

MEMORANDUM

Phone 0-4-463 5676
Fax 0-4-463 5209
Email Allison.kirkman@vuw.ac.nz

TO	Mateus de Castro Almeida
COPY TO	Ralph Chapman
FROM	Dr Allison Kirkman, Convener, Human Ethics Committee
DATE	28 April 2011
PAGES	1
SUBJECT	**Ethics Approval: 18454 Analysing the Brazilian Sugarcane Agroecological Zoning: Is this government policy capable of avoiding adverse effects from land-use change?**

Thank you for your application for ethical approval, which has now been considered by the Standing Committee of the Human Ethics Committee.

Your application has been approved from the above date and this approval continues until 28 February 2012. If your data collection is not completed by this date you should apply to the Human Ethics Committee for an extension to this approval.

Best wishes with the research.

Allison Kirkman

Human Ethics Committee

b) Information for Research Participants

March 2011

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Dear Project Participant,

You are being asked to take part in an interview for a research study based at Victoria University of Wellington, New Zealand. The project is analysing strengths and weaknesses of the Brazilian Sugarcane Agroecological Zoning (*Zoneamento Agroecológico da Cana* - ZAE Cana) mainly through interviewing public officials and experts in the private sector.

Purpose of the Study

The study will answer the following major question:

Is ZAE Cana capable of ensuring conservation of native biomes and environmentally sensitive areas as production of Brazilian sugarcane ethanol increases and causes direct land-use change? Additionally, how likely is ZAE Cana to prevent adverse side effects caused by indirect land-use change particularly deforestation of native biomes and environmentally sensitive areas?

This interview research is one part of the study. The other principal research method used in this study is document analysis. The study is seeking informed views from a range of policy advisers and experts.

Use of results from the interviews

The results collected will orientate the recommendations and conclusions of my project. Additionally, the results might be reported in papers submitted for publication in academic journals and presented at conferences.

List of the participants

I am interviewing a range of experts at various institutions, including the following:

- the São Paulo state secretary for the environment
- the National Reference Center on Biomass (CENBIO)
- the Brazilian Agricultural Research Corporation (EMBRAPA)
- the Institute for International Trade Negotiations (ICONE)
- the Institute of Applied Economics (IEA)
- the Brazilian Sugarcane Industry Association Institute of Applied Economics (UNICA)
- the World Wide Fund (WWF) Brazil

Contacts through email and phone will be done in order to ensure that the participants have the expertise to inform this project, that they represent the organisation, and that both the participants and organisations endorse their participation.

What is involved if you agree to participate?

- If you agree to participate in this interview, you will be asked to respond to various questions relating to the theme of this research.
- You will also have an opportunity to provide additional comment.
- I expect that your participation will not exceed 60 minutes
- You will receive a copy in Portuguese of this Information Sheet, the Consent Form, and the Indicative Questionnaire

Timing and location of interviews

It is expected that the interviews for this research project will take place during the May-July 2011 period, in Sao Paulo and Rio de Janeiro -- in Brazil.

Confidentiality

The Informed Consent Form (attached) asks you whether you require confidentiality or not. Depending on whether or not you require confidentiality, please select and indicate the relevant statement by ticking the appropriate box on the Consent Form.

Right of Withdrawal

At any time from the day you accept to participate in this project until before the data collection and analysis is completed, you will have the right to withdraw or refuse to answer any question(s). In order for you to withdraw or refuse to answer, please let me know by contacting me from the contact details provided on this information sheet.

Provision of Feedback

You have the right to ask to check the interview transcript, and will be able to provide any corrections at any time, prior to final analysis of data.

Storage and Disposal of Data

You will be asked whether you are content for your remarks to be digitally recorded. Access to the written and any electronic material will be restricted to my supervisor, Ralph Chapman, and I. All written material will be kept in a locked file, and all electronic material will be password protected. Two years after the conclusion of the research, any written interview note will be destroyed and the audio recordings of the interviews will be electronically wiped.

Community Access to Research Results

In order to ensure that the results of this research project are accessible to the participants, a summary of the completed research output will be available. You may request it by indicating so on the 'Informed Consent Form' (attached), or on later request (email to MateusPost@hotmail.com).

Ethics approval

The Victoria University of Wellington Human Ethics Committee has granted ethical approval for this research.

If you have any other questions about this project, please feel free to ask me now, or contact me later, from the contact details provided on this information sheet.

Thank you for participating.

Sincerely,

Mateus Almeida
Masters Student
Environmental Studies
School of Geography, Environment and Earth Sciences

c) Declaration of consent from Participant

1 I have been given adequate information relating to the nature and objectives of this research project, and I have understood that information. I have been given the contact details of Researcher Mateus Almeida and his supervisor, Associate Professor Ralph Chapman, so I can ask questions about any aspect of the project if I wish. I understand that my remarks will be digitally recorded and the transcript of my remarks will be available to me should I wish to check it. I understand that I may choose to withdraw myself (or any information I have provided) from this project at any time from the day I accept to participate in this project until before the data collection and analysis is completed. I understand that if I withdraw from the project, any data I have provided will be destroyed.

2 Please tick the box which you prefer:

(a) I consent to the answers I give being attributed to ***me***, as a member of the organisation I work for: ☐

Or (b) I consent to the answers I give being attributed only to the ***organisation*** I work for, but not attributed to me personally: ☐

3 Please tick the box which you prefer:

(a) I consent to the interview being digitally recorded: ☐

Or: (b) I agree to the interview but I do ***not*** consent to the interview being digitally recorded: ☐

4 Please tick the box which you prefer:

(a) I wish to read any **comments** attributed to me ***before*** a paper based on the research is published: ☐

Or (b) I do not wish to read any comments attributed to me before any paper based on the research is published: ☐

5 I understand that the information I have provided will be used for this research project and that a summary report and any article published in a journal will be sent to me, if requested. I understand that the questionnaires will be destroyed within two years of the completion of the project.

I agree to take part in this research.

Signed: Date:

Name of participant:

(*Please print clearly)*

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